STUDIES ON THE SYSTEMATICS, BIOLOGY AND FISHERY OF RAINBOW SARDINES, *DUSSUMIERIA* SPP., FROM INDIAN WATERS

THESIS
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DOCTOR OF PHILOSOPHY

BY
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D E C L A R A T I O N

I hereby declare that this thesis entitled "Studies on the systematics, biology and fishery of rainbow sardines, Dussumieria spp., from Indian waters" has not previously formed the basis of the award of any degree, diploma, associateship, fellowship or other similar titles or recognition.

Ernakulam
April, 1983.

(P.N. RADHAKRISHNAN NAIR)

C E R T I F I C A T E

This is to certify that the thesis entitled "Studies on the systematics, biology and fishery of rainbow sardines, *Dussumieria* spp., from Indian waters" is the bonafide record of the work carried out by Shri P.N. Radhakrishnan Nair under my guidance and supervision and that no part there of has been presented for any other Degree.

Ernakulam,
April, 1983.

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PREFACE

Rainbow sardines of the genus Dussumieria, belonging to the family Dussumieriidae, are small pelagic fishes forming a fairly good, though not abundant, seasonal fishery all along the coasts of India inhabiting the coastal waters. There have been some earlier reports on such individual aspects as their systematics, distribution, abundance, osteology and a few biological factors but no attempt has been made towards a comprehensive study of this group. Two species of rainbow sardines are known to occur in the Indian seas and while a knowledge about their biology would be useful from the fishery point of view, it was also thought a study of their systematic position, especially regarding the identity of the two species which had raised doubts among earlier workers, would lead to a better understanding of the group as a whole. This thesis is mainly based on my studies during the period from April 1969 to March 1971 with a continued investigation of fishery aspects till December 1975, from the Gulf of Mannar and the Palk Bay around Mandapam area, on the south-east coast of India. Thus the work deals with the systematics, biology and fishery of rainbow sardines of Indian seas.

This work was initiated in February 1969, when I joined the Central Marine Fisheries Research Institute at Mandapam Camp as a Senior Research Scholar of the Ministry of Education and Social Welfare, Government of India. The scholarship was for a period of 3 years. Research work was initiated under the guidance and supervision of Dr. R.V. Nair who suggested the research problem. The collection and analysis of the data was completed during the scholarship period itself. Subsequently in January 1972, I joined as a Research Assistant in the Central Marine Fisheries Research Institute at Mandapam Camp and since then the work was pursued on the biology and fishery of several groups of fishes such as anchovies, lizard fishes, carangids, oil sardine and lesser sardines under various research projects. All these years' research experience has immensely helped me to acquire more knowledge in the field of fishery biology investigations and in turn in the finalisation of this thesis. The collection, analysis, interpretation of data and illustrations presented in the text are my own.

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A C K N O W L E D G E M E N T

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I am also thankful to Dr. S.Jones and Dr. S.Z. Qasim, the former Directors of this Institute for the facilities extended in their official capacities during the course of this work. Thanks are due to the late Dr. K.V. Sekharan, Scientist of this Institute, for the valuable suggestions and encouragement he gave time to time.

I extend my thanks to the Ministry of Education and Social Welfare, Government of India, New Delhi, for awarding me a Senior Research Scholarship during the tenure of which the present investigation was conducted.

P.N. RADHAKRISHNAN NAIR

CONTENTS

CHAPTER 1

INTRODUCTION

Rainbow sardines of the family Dussumieriidae are small pelagic fishes widely distributed in the tropical and temperate regions of the Indo-Pacific. In India, these fishes, though common all along the coasts, occur only in some parts in fishable magnitude. The Gulf of Mannar and the Palk Bay, around Mandapam area on the south-east coast of India, are two such centres where rainbow sardines form a good fishery.

Till the end of 19th century only systematics studies were prevalent on rainbow sardines and in the early part of this century came the work of Ridewood (1904) on the cranial osteology of Dussumieria acuta and Delsman (1925) on the embryology and larval development of Dussumieria hasseltii from Java sea. Another work to be mentioned from abroad is that of Tham Ah Kow (1950) on the food and feeding habits of D.hasseltii from Singapore straits.

From Indian waters the earliest work — on some aspects of biology of rainbow sardine — was that of Devanesan and Chacko (1944) who studied briefly the bionomics and the eggs and larvae of D. hasseltii. This was followed by the work of Devanesan and Chidambaram (1948 & 1953) giving short accounts of the bionomics, fishery and economic importance of the rainbow sardine of Madras coast in general. Sekharan (1949) studied the feeding and maturity in relation to fat content in musculature of D. acuta. Chacko (1949 & 1950) made some observations on the food and feeding habits and eggs and larvae respectively, of D. hasseltii from the Gulf of Mannar, while Vijayaraghavan (1951 b) studied the food of D. acuta. Later, Bapat (1955) described the eggs and larvae of Dussumieria sp. from the Gulf of Mannar and the Palk Bay. Krishnamurthi (1957) investigated the magnitude of the fishery of D. hasseltii in Rameswaram Island. Dharmamba (1959) gave a short account of the maturation and spawning of D. hasseltii from Lawson's Bay (Waltair). Venkataraman (1960) made brief mention of the food and feeding habits and Srinivasa Rao (1964) of the food and feeding habits and of the diurnal variation in the nature of the food of D. hasseltii. Basheeruddin and Nayar (1961) collected the larvae of D. hasseltii from Madras waters and correlated the availability with its spawning season. Kuthalingam (1961) described the eggs and larvae of D. acuta from Madras coast and traced the development up to 56th day after hatching and he also studied the feeding habits of the juveniles. Mahadevan and Chacko (1962) gave a general account of the biology of D. hasseltii from the Gulf of Mannar. Very recently Nair (1973) reviewed the hitherto available information on rainbow sardines in his monograph on "Indian sardines".

The various investigations mentioned above on rainbow sardines are only short accounts limited mainly to one or the other aspects of biology, such as food and feeding habits, spawning season or description on larvae and early development. Moreover, the identity of the two species of Dussumieria had also been confusing to most of the earlier workers on biology and systematics. Hence it was felt desirable to undertake a detailed investigation on the systematics, different aspects of the biology and the fishery of rainbow sardines of India. The present study was initiated in April 1969 under the supervision of Dr. R.V. Nair, then the Senior Research Officer of Central Marine Fisheries Research Institute at Mandapam Camp and later its Director.

Since the first record of the genus Dussumieria by Valenciennes from Bombay in 1847, several authors have added many species to the genus, which include D. acuta Valenciennes (1847), D. elopsoides Bleeker (1849), D. hasseltii Bleeker (1850, locality, Batavia) and D. elopsoides Gunther(1868).

The presence of several species in the genus, with a little or no differences to demarcate one from the other, led to a confusion in the systematics of this group as a whole and this condition prevailed till the pioneering work of Bleeker (1872) who suggested that there are only two species, namely *D. acuta* Valenciennes and *D. hasseltii* Bleeker. Chabanaud (1933) added a new species to the genus, namely *D. productissima*, which, according to Fowler (1941) may belong to the family Atherinidae. Following Bleeker (1872), Day (1889) and Weber and de Beaufort (1913) recognised only two species under the genus *Dussumieria*, viz. *D. acuta* Valenciennes and *D. hasseltii* Bleeker and all others were treated as synonymous with either of these two species. Even after this, confusion on the identity of the two species prevailed, due to the fact that the variation in the number of lateral line scales, was considered as the most distinguishing specific character. But the scales are unfortunately highly deciduous and hence unreliable. The specimens caught are invariably found without the full complement of scales, thus rendering any observation on scales of doubtful value (Devanesan and Chidambaram, 1953). Delsman (1925) also faced the same difficulty and further felt that the other differences in the characters of these two species are slight and only of relative value. According to Whitehead (1963) in the majority of the descriptions it is rarely stated whether the scale count was an actual one based on the specimens examined or merely followed previous descriptions. On account of these doubts Whitehead (1963), while studying the systematics of this group, brought all the species of the genus *Dussumieria* described hitherto under one species, *D. acuta* Valenciennes and stated that any variation in the characters can clearly be correlated with geographical distribution. But in the present work the author disagrees with the above observation of Whitehead, and has re-established the two species namely *D. acuta* Val. and *D. hasseltii* Blkr. which can easly be distinguished by their differences in body shape and several other characters, both morphometric and meristic. The author collected specimens of these two species from the same locality, the Gulf of Mannar and the Palk Bay, and also from some other selected centres along the southern coast of India, and studied their morphometric and meristic characters applying standard statistical methods. He could observe that many of these characters showed distinct variation in these two species. Detailed statistical treatment of the above aspects and the reasons for keeping these two species, *D. acuta* and *D. hasseltii*, separate, are furnished in Chapter 3 of the thesis dealing with the systematics of rainbow sardines.

In the following five chapters the biological aspects such as food and feeding habits, reproduction, early development age and growth, length-weight relationship and relative condition factor of rainbow sardines, with special reference to D. acuta, are dealt with in detail. The significance of the studies on food and feeding habits of a fish has been recognised by the earlier workers on fishery biology and it became an accepted fact that the distribution and fluctuation in the availability of food organisms of a species are important factors that may affect its behaviour in respect of its migration, growth, condition, breeding, shoal formation and even the fishery. With due consideration to these aspects, the food and feeding habits of D. acuta were studied. The stomach contents were analysed qualitatively to know the major food items and quantitatively to assess their relative abundance and seasonal variation in different localities in two consecutive years from April 1969 to March 1971. The day and night samples were analysed separately to know whether this fish exhibited any diurnal variation in its feeding habits. Comparisons of the stomach contents of D. acuta from the Gulf of Mannar and the Palk Bay, and also between the two years were made. The food items in various size-groups were analysed separately. The condition of feed, feeding habits and selectivity were also studied. The feeding habits of D. hasseltii, based on the limited samples collected from different places were also investigated for a comparison. The results of all these studies are furnished in Chapter 4.

The biological factors connected with the reproduction of *D. acuta*, recognising the significance of such knowledge in successful management of its fishery, were investigated and the results are projected in Chapter 5. This includes descriptions on the structure of gonads and the classification of their maturity stages. Based on the ova diameter studies and the seasonal variation in the maturity stages, the spawning season and the frequency of spawning were assessed. The state of maturity was also determined by estimating the gonado-somatic index of the fish. The size at first maturity was determined to assess the age at first maturity. Based on the counts of maturing and mature ova, those destined to be spawned in the current spawning season, the fecundity of the fish was estimated and its relation with factors such as length of fish, weight of fish and weight of ovary, was studied. The pattern of sex-ratio of *D. acuta* in different months and different size groups was also investigated in detail.

In Chapter 6 the early development of *D. acuta* is described and discussed. This study was based on artificial spawning of the ripe males and females and subsequent fertilisation of the eggs aboard a fishing vessel operated off Mandapam in the Palk Bay. The fertilised egg and its development, hatching process and the hatched out larva in various stages of development upto the 48-hour-old, are described in the text. Since no other account on artificial spawning and fertilisation is available on marine fishes in India, this successful attempt is the first of its kind, that too in a fish like D. acuta which is quite sensitive and dies quickly when captured.

The estimation of age and growth of a fish is necessary in solving many biological problems, such as longevity, maturity and time of spawning, estimation of mortality, survival rate, etc., all of which are essential information for a rational exploitation of the stock. With this in view, an attempt has been made to estimate the age and growth of D. acuta using the indirect and statistical methods such as Petersen's method of length-frequency analysis and probability plot method of Cassie (1954). The hard parts like otoliths and scales were also subjected to study. Theoretical growth was estimated by fitting von Bertalanffy's growth equation to the results obtained from Petersen's method. The growth parameters were estimated by arithmetic and graphical methods. Based on the results of these age and growth studies, the age composition of the commercial catch by different gears were estimated to know about the important age-groups constituting the fishery. The results of all these observations are dealt with in Chapter 7.

The length-weight relationship of D. acuta was calculated with two objectives, firstly as a means of inter-conversion and secondly, to calculate the 'condition factor'. Separate length-weight equations were derived for indeterminates, for females and for males and, through the covariance test, the significance of variation of the regressions of these categories were tested. The length-weight relationship of D. hasseltii was also studied for comparison. Utilising the length-weight equation the relative condition factor of D. acuta was calculated. The geometrical means for different size groups and for immature and mature categories in different months were estimated and the fluctuations studied. The results of these observations form the contents of Chapter 8.

The information collected on the fishery of rainbow sardines of the Gulf of Mannar and the Palk Bay are presented in Chapter 9. The crafts and gears employed in this fishery are described. The observations on fishing seasons, trend of fishery, disposal of catch and catch data over a period from April 1969 to December 1975, are incorporated in the text. Chapter 10 of the thesis deals with the summary of the results of all these investigations and in Chapter 11 the references cited in the text are presented.

Tables, figures and photographs, wherever necessary to substantiate the conclusions drawn from these investigations, are also incorporated at the appropriate places in the text.

CHAPTER 2

MATERIAL AND METHODS

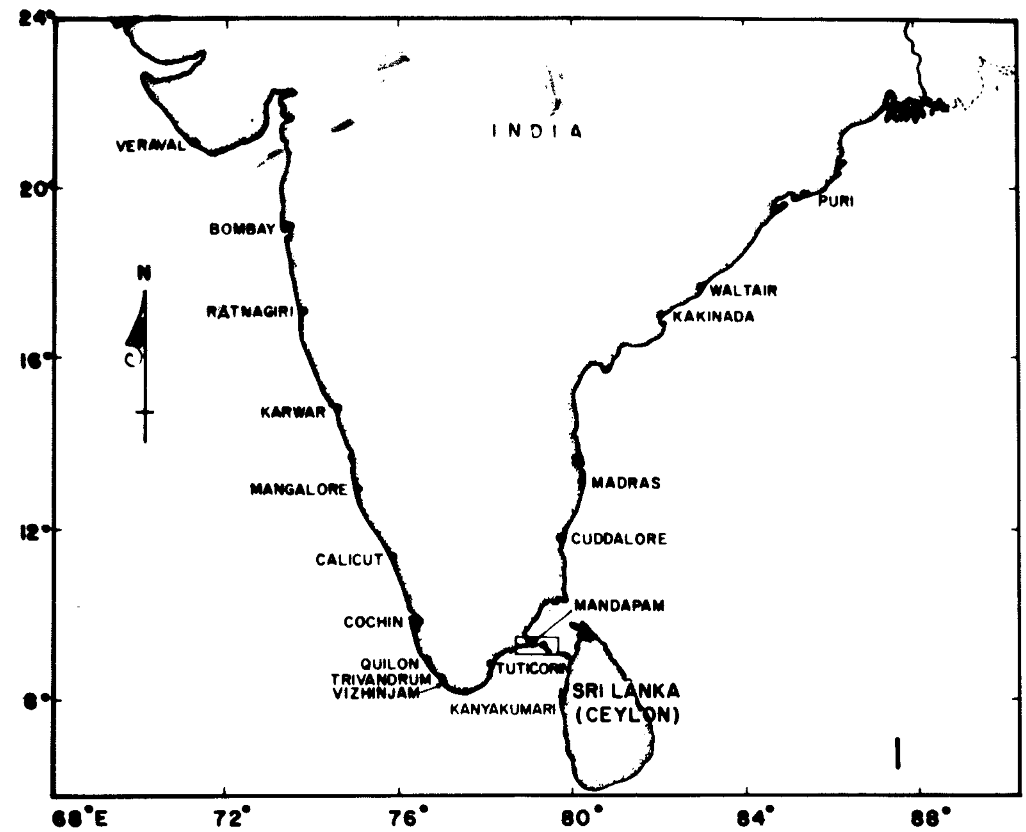
The material for the present study was collected during April 1969 to March 1971 by regular sampling of the commercial catches at various fish landing centres in and around Mandapam along the Gulf of Mannar and the Palk Bay. The important collection centres on the Gulf of Mannar side were Ervadi, Kilakkarai, Periyapatanam, Muthupettai, Pudumadam, Vedalai and Mandapam on the mainland; Pamban, Kundugal Point and Rameswaram Road on the Rameswaram Island. On the Palk Bay side the centres were Devipattanam, Panaikulam, Athankarai, Dhargavalasai and Mandapam on the mainland; Pamban, Rameswaran and Dhanushkodi on the Island (Pl. I, Fig.2).

For the studies on systematics, in addition to the above centres, samples of rainbow sardines were collected from Madras, Cuddalore, Tuticorin, Kanyakumari, Vishinjam, Cochin, Calicut and Mangalore (Pl.I,Fig. 1) either personally

PLATE I

Fig. 1 Map of South India showing important fishing centres and centres from where samples of rainbow sardines were collected. It also shows the Research Centres/Units of Central Marine Fisheries Research Institute.

Fig. 2 Map showing important landing centres in and around Mandapam and Rameswaram from where regular samples of rainbow sardines were collected for biological studies.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VIZHINJAM
KANYAKUMARI
TUTICORIN
MANDAPAM
CUDDALORE
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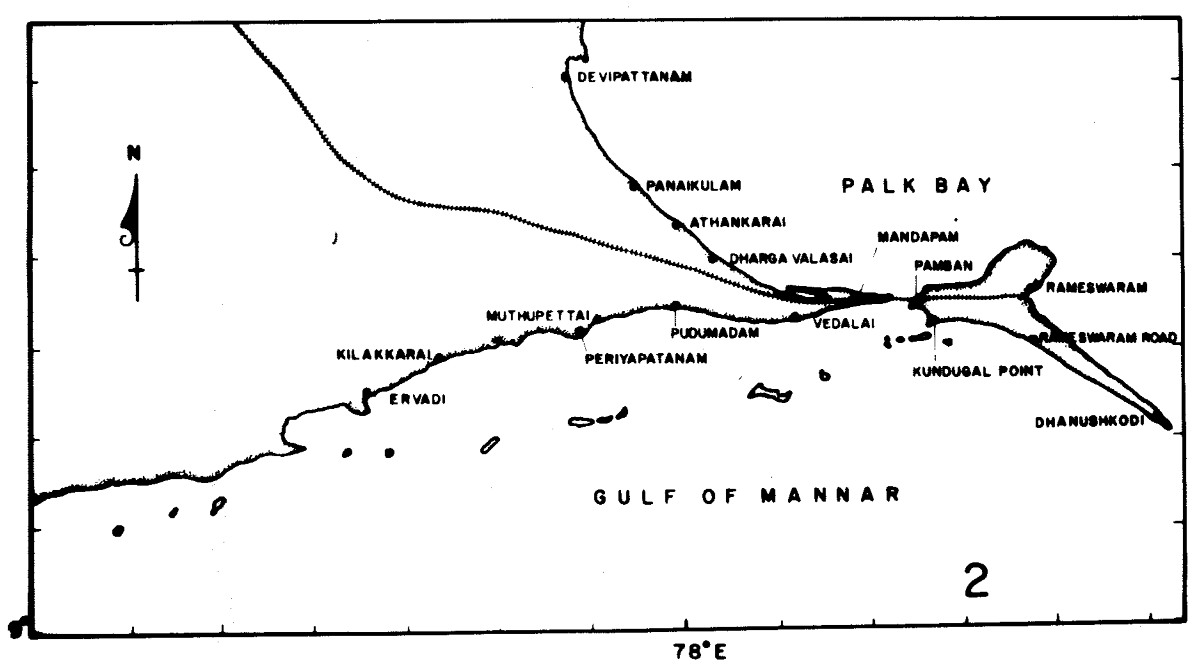
DEVIPATTANAM
PANAIKULAM
PALK BAY
ATHANKARAI
MANDAPAM
DHARGA VALASAI
PAMBAN
RAMESWARAM
RAMESWARAM ROAD
MUTHUPETTAI
PUDUMADAM
VEDALAI
KILAKKARAI
PERIYAPATANAM
KUNDUGAL POINT
ERVADI
DHANUSHKODI
GULF OF MANNAR
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PLATE. I

on through colleagues in the Central Marine Fisheries Research Institute sub-stations/units (some of them are shown in Pl. I, Fig.1) at these centres. Out of the total samples, 25 specimens each of D. acuta and D. hasseltii, collected from different centres and preserved in 5% formalin, were utilised for systematics studies. The material included both the sexes and their morphometric measurements and meristic counts were taken carefully. The measurements are defined as follows:

1. Total length	Distance from tip of snout to tip of upper lobe of the caudal fin.
2. Fork length	Distance from tip of snout to the fork of caudal fin.
3. Standard length	Distance from tip of snout to mid-base of caudal fin where a slightly dark vertical line is visible on preservation.
4. Head length	Distance from tip of snout to hind edge of operculum on a mid-lateral line.
5. Snout length	Distance from tip of snout to front margin of eye.
6. Maxillary length	Distance from tip of snout to posterior tip of maxilla.
7. Eye diameter	Horizontal diameter of eye.

8. Pre-dorsal length — Distance from tip of snout to anterior margin of the insertion of dorsal fin.

9. Pre-pelvic length — Distance from tip of snout to anterior margin of the insertion of pelvic fin.

10. Pre-pectorial length — Distance from tip of snout to upper edge of the anterior margin of the insertion of pectoral fin.

11. Pre-anal length — Distance from tip of snout to anterior margin of the insertion of anal fin.

12. Caudal fin length — Distance between the base of caudal fin, where a dark vertical line is visible across the caudal peduncle, to the tip of the upper lobe of caudal fin (the difference between total length and standard length).

13. Depth of head — Dorso-ventral distance of head at the posterior border of eye.

14. Depth of body — Dorso-ventral distance of body at the anterior margin of dorsal fin.

15. Depth of caudal peduncle — Dorso-ventral distance of caudal peduncle at the base of caudal fin.

16. Stomach length — The distance from the anterior end of the oesophagus to the posterior tip of stomach caecum of a completely empty and shrunken stomach.

17. Stomach caecum length — Distance from the posterior angle of the starting of pyloric stomach to the posterior tip of the caecum of a completely empty and shrunken stomach.

The number of gill rakers on the upper and lower limbs of the left outermost arch were counted. The number of pyloric caecae were counted carefully after taking the gut out of the body cavity. The vertebrae were counted by removing the flesh on left side of the fish all along the length of the body making the vertebral column visible for counting. The exposed side of the vertebral column was further cleaned using 5% potassium hydroxide solution and the number of vertebrae were counted with the help of a magnifying glass and a needle. The body proportions were expressed as percentage of total length for fork length and standard length, and of standard length for all other characters. The proportions of snout length, maxillary length, eye diameter and depth of head were further studied as percentage of head length also. Using standard statistical methods the range, mean, standard deviation, standard error and range of overlapping of morphometric and meristic characters of the two species were estimated. Regressions of the morphometric characters of the two species were estimated by least square method and the significance of deviation of these regressions were tested by means of analysis of covariance.

The samples of *D. acuta* used for biological studies were collected at random from the commercial catches landed in shore-seine, gill net and trawl net. During the period from April 1969 to March 1971, on an average 7 samples, each consisting of 12 to 15 fishes, were examined every month. During the 24 months' period samples were available in all the months from the Gulf of Mannar side, while from Palk Bay side no samples were available in May and December 1969, February, May and October 1970 and January 1971. A total of 2247 specimens, ranging in size from 46 to 156 mm total length, was analysed during this period. On the sampling days, additional length measurements of 50 to 100 fishes were taken, whenever available, in the field itself for length frequency analysis. The specimens were preserved in 5% formalin in the field after making an incission on the ventral side. Later, in the laboratory, they were weighed and measured for length; the sex and state of gonadial maturity (as defined by Lovern and Wood, 1937) were recorded. The length and weight were noted in millimetres (mm) and grams respectively. The stomach and the gonads were then removed and preserved in 5% formalin in separate tubes with a label indicating the place and date of collection, time of capture, type of gear used and sample number, for later analysis in detail.

Various methods are employed in the study of food and feeding habits of fishes (Pillay, 1952). Unlike other larger carnivorous fishes, the quantity of food of D. acuta is very little which makes it difficult to determine the actual volume by displacement method. Therefore, the volumetric points method (Pillay, 1952) was employed. Since it has been pointed out by Natarajan and Jhingran (1961) that the occurrence method or volumetric method alone will not give a correct idea of the importance of the individual food items, both occurrence and volume were taken into account. The analysis was done by the method of 'Index of Preponderance' as suggested by the above authors, employing the formula $\frac{VO}{\text{Sum } VO} \times 100$, where 'V' and 'O' are percentage volume and percentage occurrence of a food item respectively. The extent of feeding was determined by the degree of distension of the stomach and the amount of food contained, and was expressed as 'gorged', 'full', '3/4 full', '1/2 full', '1/4 full', 'little' and 'empty' with 100, 80, 60, 40, 20, 10 and 0 points assigned respectively. Depending on the relative volume of the items, points were given for each. From these values, volume for each item was calculated. The percentage volume of each food item was found from the total volume of all the stomach contents in each month. Similarly, the percentage occurrence of different items was determined from the total number of occurrence of all items in each month. The 'Index of Preponderance' was taken to indicate the food preference of D. acuta.

To ascertain the condition of feed in various months, the degree of fulness of the stomach of each fish was noted. A stomach was designated as 'gorged' when it was tightly packed with food items, its wall appearing very thin and transparent. A 'full' stomach was the one that was normally filled with food, its wall appearing thin. It was ranked as '3/4 full' when it was in a partly collapsed condition. Similarly they were classified as '1/2 full' and '1/4 full' depending on the relative fulness and the space occupied by the contents. The state of stomach was termed 'little' when the contents occupied less than a quarter of the capacity of the full stomach. Those stomachs, where there was absolutely nothing inside, were termed as 'empty' and in such cases the stomachs were shrunken and the walls were thick with prominent inner folds. The percentage occurrence of these categories were computed from the total number of stomachs examined in a month.

Each stomach was cut open and the contents were washed into a petri dish. The various components of the food items were observed under a binocular microscope and identified upto species or genus or family, depending on the completeness of the organisms and the extent of digestion. In cases where the digestion had progressed to an advanced stage or where the food items were in a highly mutilated condition, making the identification of food elements difficult, the content was treated as 'digested matter'. Fragments of crustacean appendages and other body parts were grouped as 'crustacean remains'.

For the studies on reproduction of D. acuta, the gonads which were carefully removed from the fish and preserved in 5% formalin, were analysed. The attached fat and the excess moisture from each gonad were carefully removed and the length in millimetre and weight in milligrams were recorded. Since the problem of spawning habits has to be largely approached by such indirect methods as the analysis of growth of ova by measuring the increasing diameter, the method, as developed by Thompson (1915) and successfully employed by subsequent workers like Clark (1925 and 1934), Hickling and Rutenberg (1936), de Jong (1940) and Prabhu (1956) was followed. A small portion of the ovary was removed and teased out into a plankton counting chamber. The ova were carefully separated with fine needle under the dissecting type binocular microscope and spread out evenly in the chamber which was then filled with water allowing the ova to immerse in it thereby avoiding the drying up of ova in the course of measuring. The method of measurement was, in general, similar to that described by Clark (1934), June (1953), Yuen (1955) and others, the micrometer being permanently fixed in horizontal position and the diameter taken parallel to two horizontal guide lines on the slide in whatever axis the ovum lies, as the slide was moved slowly. In addition to the parallel lines of the micrometer, the squares of the plankton counting chamber on which the ova were spread, were found to be helpful in avoiding duplicate measurements of the same ovum. Thus, the diameter of the ovum may be defined as "the distance between two parallel lines running along the two extremities of the ovum perpendicular to the guide lines" (Antony Raja, 1964). As has been observed by Clark (1934), de Jong (1940), Prabhu (1956) and Dharmamba (1959) this method was found to give satisfactory results. A monocular microscope with an ocular micrometer scale was used to measure the ova. The magnification gave a value of 0.0156 mm to each micrometer division (objective 10X and eyepiece 5 X). For easier presentation the diameter of ova is described in micrometer divisions (m.d.) along with the corresponding millimetre conversions.

Different authors had maintained different views regarding the number of ova to be measured from an ovary. Clark (1934) drew her observations based on measurements of 200 ova, whereas Prabhu (1956) considered that measurements of at least 1000 ova were necessary to mitigate the probable error in the representation of various groups of ova. Dharmamba (1959) measured 1000 ova from each ovary. Bunang (1956) was of opinion that at least 2000 to 2500 ova have to be measured in the advance maturing and mature ovaries. Workers like June (1953), Yuen (1955) and Howard and Landa (1958), however, seem to have resorted to measuring lesser number of ova, roughly from 100 to 300, in their investigations involving a large number of ovaries. Antony Raja (1964) compared the frequency distribution obtained from the measurement of 1000 ova and the first 300 ova of the same ovary of oil sardine, Sardinella longiceps and found no statistically significant difference between these samples in any of the ovaries to which tests were applied. Hence in the present study it was found reasonable to restrict the measurements to 300 to 400 ova per ovary, in view of the large number of ovaries to be examined. Ova diameter measurements of 93 ovaries in different stages of maturity were taken for this study.

For fecundity studies 35 mature females of D. acuta, belonging to stages IV, V and VI, ranging in size from 126 to 154 mm total length, were analysed. From known weight of the ovary a portion was removed and weighed. The ova in this subsample was carefully teased out in to a counting chamber. All the yolked ova measuring above 0.5 mm (30 m.d.) diameter were counted under the microscope using the same magnification used in ova diameter studies, i.e. 10 x 5. and the same ocular micrometer. From the number of ova in the subsample the total number of ova in the ovary was estimated by multiplying the number of ova in the subsample by the ratio of the subsample weight to ovary weight.

For sex-ratio studies, since the sex determination by naked eye was rather difficult in fish measuring upto 100 mm, the fish measuring above this only were taken into account. A total of 3288 fish, 1740 during 1969-79 and 1548 during 1970-71, was analysed for this purpose.

The studies conducted hitherto on the eggs, larvae and the early development on marine fishes of India were based on planktonic collections. But the present study on the early development of _D. acuta_ is based on the artificial spawning of the ripe males and females and subsequent fertilisation and rearing of the eggs. During the course of this investigation attempts were made to collect the planktonic eggs and larvae of _D. acuta_ from the Palk Bay utilising the limited facilities provided by the owners of a private fishing boat based at Mandapam. On 2nd of March 1973, on a new-moon night, a trip was undertaken in Palk Bay and trawling was done at a depth of 10.5 meters off Mandapam. The first haul was completed at 21.30 hrs and the catch consisted of specimens of _D. acuta_, both males and females in ripe and oozing stages. Immediately, at 21.40 hours, by gently pressing the belly, the eggs and milt were transferred into a bucket containing filtered sea water. Extreme care was taken not to contaminate the water by the mucus exuding from the belly. More filtered sea water was added to it and this helped in mixing of eggs and milt more freely. More detailed observations could not be carried out on board due to the lack of facilities. By next morning tiny embryos were noticeable in the fertilised eggs which were floating on the water surface. The parent fishes could not be kept alive.

On reaching the laboratory at 09.30 hours on 3-3-1973, the fertilised live eggs were transfered into fresh filtered sea water in a clean, round glass trough of about 25 cm diameter. Thereafter continuous observations were made and the various stages in the development of the embryo were traced till the death of the last larva at 48th hour after hatching. The time of fertilisation was fixed between 21.45 and 22.00 hours on 2-3-1973 and the first larva hatched out in the laboratory after 24 hours of incubation, i.e., at 21.45 hours on 3-3-1973, followed by the hatching of all other eggs within a short duration.

For age and growth studies random samples collected from shore-seine and trawl net catches were used. Since the gill-net is a selective gear, samples collected from that gear were not used. A total of 10362 fishes was analysed for this purpose. From shore-seine altogether 94 samples totalling 8882 fish, on an average 4 samples each consisting of about 95 fish every month, were collected and measured during the period April 1969 to March 1971. During the same period, from trawl nets, 36 samples each consisting of 41 fish, totalling 1480, were measured. Trawl samples were available only for 12 months altogether. Throughout this study, the total length of the fish was measured in millimetre (mm) in fresh condition on the field itself. The age and growth of the fish were determined by Peterson's method of length frequency analysis. For this, the length measurements were grouped into 5 mm size groups with the mid-point representing the particular size group. The size-groups were designated from 1s to 5s and 6s to 10s with the mid-points at 3s and 8s alternately. All samples of a month were pooled to provide a monthly length frequency distribution. The frequency in number was converted into percentage frequency. Probability plot technique of Cassie (1954) was also used to determine the age and growth. For this, the cumulative percentage frequency was calculated from the annual percentage frequency and ploted in Probability graph paper to sort out the annual modes.

Inorder to see whether any of the hard structures of *D. acuta* could be used for age determination, the otoliths of 230 fish of different sizes were removed and examined. Sagitta, the largest piece of the otolith complex, was easily removed from the fish. A fairly deep cut by a sharp scalpal on the skull through the posterior end of the operculum, cutting the otic capsule and subsequent removal of the flap revealed the otolith situated longitudinally in the otic capsule. This was removed carefully by a pair of forceps, cleaned in fresh water, dried and kept in small glass tubes with labels. Later, each otolith was examined under microscope in reflected light. The measurements of the otoliths were taken using an ocular micrometer. Xylol was used as a clearing medium in which the otolith was immersed for examination of growth rings. The scales of *D. acuta* are highly deciduous. So a systematic collection of scales from a particular area was not possible and hence this could not be used for age determination. For sorting out the age composition in the commercial catch the method followed by Fairbridge (1952) was adopted.

For the studies on length-weight relationship and relative condition factor, the total length of fish measured in millimetres and weight taken in grams with 0.1 gm accurracy were utilised. 1634 fishes of *D. acuta* were taken for this purpose. The fishes were broadly grouped into indeterminate - smaller fishes measuring upto 100 mm, where the sexes were not easily differentiable, and determinate - fishes measuring above 100 mm, where the sex differentiation was possible. Further, among the determinate group, the males and females were treated separately. During the year from April 1969 to March 1970, a total of 822 fish - 35 indeterminate, 388 males and 399 females; and during the second year from April 1970 to March 1971, a total of 812 fish - 26 indeterminates, 394 males and 392 females, were utilised for this study. Using the least-square method the regression formulae for each of these categories were derived and these were compared for significance by means of analysis of convariance. The length-weight relationship of *D. hasseltii* was studied based on 110 specimens collected from Cuddalore, Mandapam, Tuticorin, Kanyakumari and Vishinjam.

The relative condition factor 'Kn' of *D. acuta* was calculated using the formula $Kn = \frac{W}{\bar{W}}$. 745 fishes belonging to both the sexes were analysed for this study. Using the length-weight relationship formulae the calculated weight ($\bar{W}$) of the individual fish was determined. The relative condition factor 'Kn' was obtained by dividing the observed weight by calculated weight for individual fishes. The values thus obtained were further grouped according to the size of the fish and the month of capture and the mean 'Kn' was calculated from which the geometrical mean was found for each size group and for each month.

The study on the fishery of rainbow sardines was confined mainly to the data collected from a few centres such as Mandapam, Pudumadam, Muthupettai and Kilakkarai along the Gulf of Mannar coast and Mandapam, Dhargavalasai, Athenkarai and Panaikulam along the Palk Bay coast. These centres cover four types of gear, namely, trawl net at Mandapam; shore seine at Panaikulam, Athenkarai, Dhargavalasai, Muthupettai and Pudumadam; gill net at Kilakkarai and bag net at Mandapam and Kilakkarai. These landing centres were visited once in a week or fortnightly and catch data and samples were collected. Usually all the units operated on the day (if the number was small) or 10% of the units operated (when number of units was large) were observed and the data on total catch of rainbow sardine estimated, multiplying the average catch per unit by the total number of units operated on the day. From the total catch of the observation days the average daily catch was estimated which, in turn, was multiplied by the total number of fishing days in that month to get the monthly estimated catch. Likewise the catch data were collected for a period of nearly 7 years, from April 1969 to December 1975. The information on craft, gear and mode of operations were gathered from the local fishermen.

Apart from the general methodology described above, some aspects which require further elaboration are given in detail in the relevant sections in the text.

CHAPTER 3

SYSTEMATICS

The rainbow sardines, or round herrings, belonging to the family Dussumieriidae are small clupeoid fishes fairly widely distributed in tropical and temperate seas, mainly in the Indo-Pacific region. The Dussumieriidae differs from the Clupeidae by the absence of abdominal scutes, thus having somewhat rounded rather than keeled bellies. Earlier workers like Jordan & Gilbert (1883), Gunther (1868) and Weber & de Beaufort (1913) considered the round herrings as a sub-family of the Clupeidae, but since Jordan (1925) they are usually given family status. However, Svetovidov (1952) retained them in a sub-family of Clupeidae, but the absence of scutes in all but one species (Gilchristella aestuarius) of round herrings led Whitehead (1963) to consider that the evolution of this group pre-dated the evolution of the scuted clupeid groups and he feels that presence or absence of scutes is of such fundamental importance that the round herring should be separated from the clupeids at family level. The recent revision of the family Dussumieriidae was that of Bertin (1943) who recognised two sub-families, the Dussumieriinae and the Spratelloidinae. Whitehead (1963) completely revised the recent round herrings giving a family status to Dussumieriidae following Jordan (1925).

FAMILY DUSSUMIERIIDAE

Diagnosis:

The latest description on the diagnostic characteristics of Dussumieriidae has been given by Whitehead (1963) as follows.

"Clupeoid fishes usually with elongate, fusiform bodies and rounded bellies. One or two abdominal scutes associated with the pelvic fin; pre- or post-pelvic scutes entirely absent except for the former in one instance (Gilchristella aestuarius); neither the pelvic scutes nor, where present, the pre-pelvic scutes are keeled.

Anal fin normally equal to or shorter than dorsal, exceptionally longer. Pelvics slightly in front, below or a little behind dorsal. Pectorals set low on body. Anal always behind dorsal.

Mouth terminal, lower jaw more or less projecting. remaxilla small, edentulous or with a single series of small onical teeth which are often deciduous. Small, conical and ometimes deciduous teeth on dentary, along lower edge of axilla, on glossohyal, suprabasal (where present), esopterygoids and palatine. A well developed posterior upra-maxilla overlapping distal tip of maxilla and produced nteriorly into a pointed shaft; a second, plate-like supra-axilla sometimes present, lying between the shaft and the pper edge of the maxilla.

Hyomandibular with two separate cranial heads articulating with both sphenotic and pterotic; ceratohyal with or ithout indented ventral edge. Branchiostegal rays from six o twenty.

Pseudobranchiae well developed; gill membranes separate, ree from isthmus; gill rakers fine and slender but rarely ore than about forty. Pyloric caecae numerous. Adipose issue often entirely covering eye.

Sensory canals of head well-developed, with superficial amifications extending on to pre-operculum, sub-orbitals, perculum, and sometimes on to maxilla, part of articular and ub-operculum.

Scales cycloid, covering entire body except head, often ighly deciduous; elongate axillary scales in angle of ctoral and pelvic fins and elongate scales on upper and er lobes of caudal. Vertebrae 30 - 56.

Dussumieriidae are small, often brilliantly silvery shes chiefly found in the Indo-Pacific region between itudes 40°N. and 40°S., but with a few species along e Pacific and Atlantic coasts of North America. They e found in costal regions and in estuarine and tidal goons and, although rarely exploited by any large fishery, y are acceptable in some places as food fishes when ght in sufficient number."

"The Dussumieriidae fall into two very distinct groups, e Dussumieriinae, larger fishes with more branchiostegal ys (14-19); and the Spratelloidinae, comprising species ch rarely exceed 110 mm. and have 6 - 7 branchiostegal rays."

y to the Sub-families.

Branchiostegal rays 14 - 19; adult size 100 - 350 mm.; pelvic scute W -shaped; no posterior cranial fronte-nelles in adults; ceratohyal not excavated ventrally; dorsal rays 16 - 21 ..... Dussumieriinae

Branchiostegal rays 6 - 7; adult size 50 - 110 mm.; pelvic scute often with ascending process; a pair of posterior cranial frontanelles in adults of most species; ceratohyal excavated ventrally; dorsal rays 11 - 16 .... Spratelloidinae

Sub-family DUSSUMIERIINAE

Diagnosis:

"Dussumieriid fishes, with 14-19 branchiostegal rays, the first seven to nine attached to the ceratohyal whose ventral edge is not excavated. Pre-maxilla toothed, teeth not deciduous; maxilla with a narrow posterior supra-maxilla whose depth is about half that of the maxilla at its widest point; a second anterior supra-maxilla present in some cases. Ventral scutes absent except for a modified W-shaped scute surrounding the base of the pelvics fins and sometimes a second triangular, plate-like scute immediately behind the pelvics.

No posterior fontanelles in adults, this portion of the skull forming a shallow, triangular depression. Posterior margin of pre-operculum not vertical but inclined forwards, ventral margin of operculum not horrizontal but rising posteriorly.

A small, usually little developed, fleshy eminence on the postero-ventral angle of the cleithrum. Inter-operculum widely exposed in lateral view.

Dorsal rays 16 - 21; anal 9 - 19. Transverse scales body 11 - 15. Vertebrae 52 - 56."

"Two genera, <u>Dussumieria</u> and <u>Etrumeus</u>.

Pelvic fins under dorsal base; two supra-maxillae present; anal rays 14 - 19; exposed portion of sub-operculum sub-rectangular .... <u>Dussumieria</u>

B. Pelvic fins behind dorsal base; a single supra-maxilla; anal 9 - 13; exposed portion of sub-operculum triangular .... Etrumeus"

Genus DUSSUMIERIA Valenciennes

"Dussumieria Valenciennes, 1847, Hist. Nat. Poiss., 20:467 (Type: Dussumieria acuta Val.) Montalbiana Bertin, 1943, Bull. Inst. Oceanogr. Monaco, No. 853:7. (Type Etrumeus (Montalbiana) albulina Fowler, 1934)

Body elongate, more or less compressed. Snout pointed, jaws equal. Two supra-maxillae, each about half the length of the maxilla. Proximal half of maxilla thickened along its dorsal edge, distal half flat, tip of maxilla rounded, almost entire ventral edge bearing small conical teeth. Premaxillae toothed. A single W-shaped scute surrounding base of pelvic fins. Dorsal rays 17 - 21, anal rays 14 - 19, 20 - 34 gill-rakers on lower part of first gillarch. Branchiostegals 14- 20. Vertebrae 54 - 56. Anal well behind the dorsal, whose origin is little nearer the caudal base than the tip of the snout. Pelvic origin below middle of dorsal fin. A slight fleshy eminence on the angle of the posterior margin of the cleithrum (Cleithral flap), not so developed as in Spratelloides, but more developed than that of Etrumeus. Gill filaments of [illegible] arch shortend to accomodate this eminence. Ventral [illegible]in of operculum nearer to horizontal than in *Etrumeus*."

Whitehead (1963) recognised only one species namely [illegible] acuta. Contrary to this, the present author recognises [illegible] species namely *Dussumieria acuta* and *D. hasseltii*.

[illegible]duction to the species of the Genus *Dussumieria* [illegible]nciennes:-

The systematics of the rainbow sardines of the Genus [illegible]mieria Valenciennes had been a confusing problem to many [illegible] earlier and recent workers on systematics. However [illegible] acuta Valenciennes and *D. hasseltii* Bleeker are the two [illegible] accepted species. Fowler (1941) made it clear when [illegible]cluded *D. elopsoides* Bleeker under the synonymy of [illegible] and *D. elopsoides* Günther under *D. hasseltii*. [illegible]ing *D. productissima* Chabanaud, Fowler (1941) states [illegible]llows:

[illegible] has described and figured a fish which he [illegible] to the Genus *Dussumieria*, though its entirely [illegible] appearance suggests the Atherinidae. This is [illegible] the elevated pectoral, the opposed posterior [illegible] dorsal and anal, and advanced ventral. The [illegible] dorsal is unique in that it is well promedium [illegible] body, over the ventral, and composed of a spine [illegible] branched rays. It may be found as follows:

Dussumieria productissima Chabanaud, 1933, Bull. Inst. Oceanogr. Monaco, No.627:4, fig. 3 (tongue) : 4 (gill raker): 5 - 6 (scales) ; 1933, Bull. Soc. Zool. France, 58:289; Gruvel and Chabanaud, 1937, Mem. Inst. Egypte; 35 : 3, fig. 3

Gruvel and Chabanaud say it is more elongate than Dussumieria hasseltii Bleeker, has more numerous gill rakers (28 to 34 in place of 19 to 24), also more numerous anal rays (17 to 19 in place of 16)".

Hence Fowler (1941) does not consider this as a valid species and in the final analysis he considers only two species namely D. acuta and D. hasseltii under the Genus Dussumieria. But Whitehead (1963) brought all these species under the synonymy of D. acuta after examining the holotypes from throughout the range of distribution and established that there is only one species, D. acuta, under the Genus Dussumieria and stated that any variation in the characters can clearly be correlated with geographical distribution.

All the earlier and recent workers on this group from Indian waters had recognised two species from this area (Day, 1865, 1878 & 1889; Munro , 1955; Misra, 1962, Munro 1967; Nair 1973 and those worked on the biology of these two species from Indian waters). Jones and Kumaran (1980) had reported D. hasseltii Bleeker from Laccadive rchipelago. In the landing centres also these can be asily distinguished by their body shape which indicates he side by side occurrence of these two species in the ame geographical area.

According to Bleeker (1872) the main characteristics f the two species of Dussumieria are as follows:

. Dussumieria acuta Valenciennes

Length of the body without caudal 4 times the head; this length 4 - 4/2 times the height of body; length of head 3 to 3/2 times the diameter of the eye. About 40 to 42 scales on a longitudinal row; opposite ventrals at the middle of dorsal.

. Dussumieria hasseltii Bleeker

Length of body without caudal 3 2/3 times the head; this length 5 times the height of body. Length of head 4 times the diameter of eye, about 52 scales on a longitudinal row; opposite ventrals at the posterial middle of dorsal.

From the above description it is clear that D. acuta as shorter head and a broader body than D. hasseltii which, ccording to Bleeker (1872), has more elongated and ylindrical body with a greater head size. From the difference in scale number it may also be assumed that D. acuta has a shorter body length than that of D. hasseltii.

The present author during the course of his study on the biology of D. acuta of Mandapam area, on the southeast coast of India, observed that two species of Dussumieria are distinct in this area which differ from each other in many characters, morphometrically and meristically. One species has a shorter and broader body and identified as D. acuta and the other one is with a longer and cylindrical body identified as D. hasseltii. These two species occur in same areas either in mixed schools or separately and are even caught in the same net during fishing. From the body shape, these two species are clearly and easily distinguishable in commercial catch.

The scales in Dussumieria are highly deciduous and it is very difficult even to get a correct count of the lateral line scales. Whitehead (1963) after examining specimens of all the nominal species hitherto described came to the conclusion that the scale counts are unreliable for separating species and recognised only one species D. acuta. In the present investigations, scale count was not taken into consideration and the main emphasis was in variations in morphometric and meristic characters.

Comparison of *D. acuta* and *D. hasseltii* based on the relationship of their body-proportions and two important meristic counts revealed the following differences.

D. acuta	*D. hasseltii*
1. The maxillary length more than the snout length. The maxilla clearly reaching the front margin of eye.	The length of maxillary equal to or less than the snout length.
2. The origin of dorsal fin 1/2 its eye diameter behind the middle of body.	Origin of dorsal fin clearly an eye diameter behind middle of body.
3. Ventral fin origin more than 3/4 diameter of eye behind a vertical from dorsal orgin.	Ventral fin orgin 1/2 eye diameter behind a vertical from dorsal origin.
4. Depth of head more than double the snout length.	Depth of head less than double the snout length.
5. Depth of body slightly more than head length.	Depth of body much less than head length.
6. Depth of caudal peduncle always more than maxillary length.	Depth of caudal peduncle less than rarely equal to, maxillary length.
7. Length of stomach far less than half the pre-dorsal length.	Length of stomach more than half the pre-dorsal length.

8. Length of stomach caecum equal to maxillary length.	Length of stomach caecum nearly double the maxillary length.
9. Length of caudal fin almost equal its head length and always more than thrice its eye diameter.	Length of caudal fin always less than head length, and nearly thrice its eye diameter.
10. Pre-pectoral length more than thrice that of snout length and equal to thrice the maxillary length.	Pre-pectoral length thrice that of snout length.
11. Pre-anal length slightly less than three times body depth.	Pre-anal length nearly 3 3/4 times body depth.
12. Number of pyloric caecae 30 - 44.	Number of pyloric caecae 54-73.
13. Number of vertebrae 53-54	Number of vertebrae 59-60.

<u>Body proportions</u>:

The range, mean, standard deviation and standard error of 16 morphometric body proportions of <u>D. acuta</u> and <u>D. hasseltii</u> were studied of which two characters were analysed in percentage of total length and the rest in percentage of standard length. Four measurements namely snout length, maxillary length, eye diameter and depth of head were further studied in percentage of head length also. In addition to these, six meristic characters viz. number of sal fin rays, number of pectoral fin rays, number of anal rays, number of gill rackers, number of pyloric caecae number of vertebrae were also examined of which the three characters were analysed in the above line. The ails are given in Table 1 and represented graphically in te II, Figs. 1-23. The percentage occurrence of each cies within the overlapping ratio of body proportions are ven in Table 2. It could be seen that there is no overpping between species in the proportions of fork length.

TABLE 1

A OF MORPHOMETRIC AND MERISTIC CHARACTERS IN D. ACUTA AND D. HASSELTII

	Characters	No. fish	Range of %	Mean %	Standard deviation	Standard Error
	2	3	4	5	6	7
	% of Total length:					
	Fork length					
	D. acuta	25	84.33 - 86.05	84.99	0.4637	0.0927
	D. hasseltii	25	86.06 - 88.82	87.45	0.5917	0.1183
	Standard length:					
	D. acuta	25	77.97 - 80.99	79.72	0.8415	0.1683
	D. hasseltii	25	81.48 - 83.80	82.64	0.7237	0.1447

Continued

...le 1 (Continued)

2	3	4	5	6	7
% of standard length:					
Head length:					
D. acuta	25	23.71 - 26.67	25.30	0.6861	0.1372
D. hasseltii	25	24.00 - 27.68	25.59	0.8709	0.1742
Snout length:					
D. acuta	25	7.56 - 8.85	8.37	0.3812	0.0762
D. hasseltii	25	8.00 - 9.89	8.94	0.5062	0.1012
Maxillary length:					
D. acuta	25	8.18 - 9.80	9.00	0.3907	0.0781
D. hasseltii	25	8.00 - 9.89	8.89	0.5092	0.1018
Eye diameter:					
D. acuta	25	6.96 - 8.16	7.48	0.2976	0.0595
D. hasseltii	25	6.30 - 8.04	7.03	0.4503	0.0901
Pre-dorsal length:					
D. acuta	25	51.06 - 55.93	53.82	1.1688	0.2338
D. hasseltii	25	54.95 - 59.33	57.17	1.0031	0.2006
Pre-pectoral length:					
D. acuta	25	26.09 - 28.32	27.23	0.5326	0.1065
D. hasseltii	25	25.33 - 29.46	27.03	0.9490	0.1898
Pre-pelvic length:					
D. acuta	25	56.70 - 62.61	59.55	1.4504	0.2901
D. hasseltii	25	57.69 - 62.60	60.82	1.0550	0.2110

Continued

Table 1 (Continued)

1	2	3	4	5	6	7
10.	Pre-anal length					
	D. acuta	25	75.53 - 81.31	77.92	1.5328	0.3066
	D. hasseltii	25	76.11 - 80.00	78.07	1.0204	0.2041
11.	Depth of Head:					
	D. acuta	25	16.36 - 18.27	17.31	0.4922	0.0984
	D. hasseltii	25	13.51 - 16.07	15.05	0.5628	0.1126
12.	Depth of Body:					
	D. acuta	25	23.71 - 30.33	26.17	1.6357	0.3271
	D. hasseltii	25	19.15 - 22.73	20.92	0.8578	0.1716
13.	Depth of caudal peduncle:					
	D. acuta	25	9.73 - 11.54	10.44	0.3786	0.0757
	D. hasseltii	25	7.76 - 9.57	8.41	0.4588	0.0918
14.	Length of caudal fin:					
	D. acuta	25	23.53 - 28.26	25.37	1.3588	0.2718
	D. hasseltii	25	18.75 - 22.73	21.01	1.0568	0.2114
15.	Length of stomach:					
	D. acuta	18	19.13 - 22.12	20.48	0.8943	0.2108
	D. hasseltii	18	24.67 - 34.04	29.92	2.0036	0.4723
16.	Length of stomach caecum:					
	D. acuta	18	7.14 - 10.68	8.95	0.9124	0.2151
	D. hasseltii	18	15.04 - 21.37	17.71	1.7923	0.4225

Continued

(Continued)

2	3	4	5	6	7
Head length:					
... length:					
...ata	25	29.17 - 35.71	33.09	1.3690	0.2738
...sseltii	25	32.43 - 37.46	34.94	1.5790	0.3158
...llary length:					
...ata	25	32.14 - 39.13	35.60	1.8719	0.3744
...sseltii	25	31.25 - 38.46	34.70	1.6663	0.3333
...diameter:					
...ata	25	27.59 - 32.00	29.57	1.0370	0.2074
...sseltii	25	25.00 - 29.17	27.43	1.1652	0.2330
... of Head:					
...ata	25	62.50 - 73.91	68.46	2.9164	0.5833
...sseltii	25	54.05 - 62.16	58.77	2.0959	0.4192
... of Gill rakers:					
...ata	25	30.00 - 37.00	34.04	1.3850	0.2770
...sseltii	25	32.00 - 37.00	34.32	1.3684	0.2737
... of pyloric caecae:					
...	25	30.00 - 44.00	35.16	3.7157	0.7431
...ltii	25	54.00 - 73.00	60.36	4.9629	0.9926
... of vertebrae:					
...	25	53.00 - 54.00	53.60	0.5000	0.1
...ltii	25	59.00 - 60.00	59.24	0.4359	0.0872

TABLE 2

OF OVERLAPPING IN THE MORPHOMETRIC AND MERISTIC CHARACTE
.ACUTA AND D.HASSELTII AND THE PERCENTAGE OCCURRENCE OF
FISH WITHIN THE OVERLAPPING RANGE

Characters	Range of overlapping	D. acuta N	%	D. hasselti N	D
2	3	4	5	6	7
...ers in percentage ...al length:					
...k length	Nil	25	-	25	-
...dard length	Nil	25	-	25	-
...ers in percentage ...dard length:					
...d length	24.00 - 26.67	25	96	25	92
...t length	6.00 - 8.85	25	76	25	52
...illary length	8.18 - 9.80	25	100	25	84
... diameter	6.96 - 8.04	25	96	25	60
...dorsal length	54.95 - 55.93	25	16	25	12
...pectoral length	26.09 - 28.32	25	100	25	84
...pelvic length	57.69 - 62.60	25	88	25	100
...anal length	76.11 - 80.00	25	92	25	100
... fin length	Nil	25	-	25	-
... of head	Nil	25	-	25	-

Continued

[illegible] 2 (Continued)

2	3	4	5	6	7
Depth of body	Nil	25	-	25	-
Depth of caudal peduncle	Nil	25	-	25	-
Stomach length	Nil	18	-	18	-
Stomach caecum length	Nil	18	-	18	-
[illegible]cters in percentage [illegible] length:					
Snout length	32.43 - 35.71	25	72	25	76
Maxillary length	31.14 - 38.46	25	96	25	96
Eye diameter	27.59 - 29.17	25	40	25	40
Depth of head	Nil	25	-	25	-
[illegible] characters:					
[illegible] of gill [illegible]	32.00 - 37.00	25	96	25	100
[illegible] of pyloric [illegible]	Nil	25	-	25	-
[illegible] of vertebrae	Nil	25	-	25	-

TABLE 3

[illegible] OF X, Y, X^2, Y^2, AND XY OF MORPHOMETRIC CHARACTERS OF *D. ACUTA* AND *D. HASSELTII*

[illegible]acters	No. fish	X	Y	X^2	Y^2	XY
2	3	4	5	6	7	8
[illegible] length vs. [illegible] length						
. *acuta*	25	3397	2887	464823	335709	395020
. *hasseltii*	25	3731	3263	569493	435705	498116
[illegible] length vs. [illegible]dard length						
. *acuta*	25	3397	2709	464823	295817	370795
. *hasseltii*	25	3731	3084	569493	389290	470829
[illegible]dard length vs. [illegible] length						
. *acuta*	25	2709	685	295817	18905	74754
. *hasseltii*	25	3084	788	389290	25298	99057
[illegible] vs. [illegible] length						
[illegible]	25	2709	226.50	295817	2076.25	24710.00
[illegible]	25	3084	274.00	389290	3045.13	34378.75
[illegible] [illegible] length						
[illegible]	25	2709	243.50	295817	2388.75	26558.50
[illegible]	25	3084	272.50	389290	3012.75	34196.50

Continued

(Continued)

2	3	4	5	6	7	8
[illegible] [illegible]meter						
[illegible]	25	2709	202.50	295817	1652.75	22095.00
[illegible]sseltii	25	3084	215.50	389290	1884.75	27035.50
[illegible] [illegible]al length						
[illegible]	25	2709	1459	295817	85945	159416
[illegible]sseltii	25	3084	1766	389290	128062	223250
[illegible] [illegible]teral length						
[illegible]	25	2709	737	295817	21863	80401
[illegible]sseltii	25	3084	831	389290	28111	104549
[illegible] [illegible]vic length						
[illegible]	25	2709	1615	295817	105397	176526
[illegible]seltii	25	3084	1878	389290	144738	237341
[illegible] [illegible] length						
[illegible]	25	2709	2112	295817	180048	230744
[illegible]seltii	25	3084	2410	389290	238212	304496
[illegible] [illegible] length						
[illegible]	25	2709	688	295817	19050	74978
[illegible]	25	3084	646	389290	17078	81411

Continued

(Continued)

2	3	4	5	6	7	8
XX. of head						
acuta	25	2709	469	295817	8879	51230
[illegible]	25	3084	463	389290	8743	58296
YY. of body						
acuta	25	2709	711	295817	20569	77856
[illegible]	25	3084	647	389290	17253	81880
XX. of caudal [illegible]:						
acuta	25	2709	282.50	295817	3214.25	30816.00
[illegible]	25	3084	258	389290	2705.50	32411.50
YY. [illegible] length						
[illegible]	18	1930	395	208524	8739	42650
[illegible]	18	224	669	286268	25429	85086
[illegible] stomach [illegible] length						
[illegible]	18	1930	173	208524	1693	18707
[illegible]	18	2244	399	286268	9209	51093

Continued

) (Continued)

2	3	4	5	6	7	8
d length *vs.* ut length						
. *acuta*	25	685	226.50	18905	2076.25	6246.50
. *hasseltii*	25	788	274.00	25298	3055.63	8769.75
. *vs.* illary length						
. *acuta*	25	685	243.50	18905	2388.75	6711.50
. *hasseltii*	25	788	272.50	25298	3012.75	8722.00
. *vs.* eye meter						
. *acuta*	25	685	202.50	18905	1652.75	5586.50
. *hasseltii*	25	788	215.50	25298	1884.75	6900.00
. *vs.* depth Head;						
. *acuta*	25	685	469	18905	8879	12945
. *hasseltii*	25	788	463	25298	8743	14862

. = Standard length; H.L. = Head length.

TABLE 4

OF THE ANALYSIS OF COVARIENCE TEST OF MORPHOMETRIC CHARACTERS OF D. ACUTA AND D. HASSELTII

Characters	'B'Values		Results of covarience test			
	D. acuta	D. hasseltii	Difference in slope	At the level of	Difference in elevations	At the level of
length - Fork length	0.8443	0.8791	S	5%	S	1%
length - Standard	0.8325	0.8359	NS		S	1%
...d length - Head	0.2324	0.2090	NS		S	5%
Snout length	0.0733	0.0653	NS		S	1%
Maxillary length	0.0761	0.0657	NS		NS	
Eye diameter	0.0670	0.0510	NS		S	5%
Pre-dorsal length	0.5810	0.6099	NS		S	1%
Pre-pectoral length	0.2378	0.2302	NS		NS	
Pre-pelvic length	0.6717	0.6409	NS		S	5%
Pre-anal length	0.8317	0.8136	NS		NS	
Caudal fin length	0.1878	0.1944	NS		S	1%
Depth of Head	0.1803	0.1334	S	1%	S	1%
Depth of Body	0.3578	0.2335	S	1%	S	1%
Depth of caudal peduncle	0.0900	0.0661	S	5%	S	1%
Stomach length	0.1875	0.2584	S	1%	S	1%
Stomach caecum length	0.0994	0.2073	S	5%	S	1%
...gth - snout	0.2971	0.2896	NS		S	5%
Eye diameter	0.2794	0.2334	NS		S	1%
Maxillary length	0.2912	0.2885	S	5%	NS	
Depth of head	0.6941	0.5828	NS		S	1%

...length; H.L. = Head length; S. = Significant; ...ificant.

length (both in % of T.L.), caudal fin length, head, depth of body, depth of caudal peduncle, length and stomach caecum length (all in % of S.L.). h of head in percentage of head length also does not overlapping. Regarding the pre-dorsal length, it noticed that the percentage of overlapping is consi- less as only 16% of D. acuta and 12% of D. hasselitti for the overlapping range.

of three meristic characters, number of pyloric and number of vertebrae showed clear variation the two species without any degree of overlapping. ber of gill rackers were almost equal in both the

Further, the actual values of different morphometric of the two species were plotted in scatter in Plate III, Figs. 1-11 and Plate IV, Figs. 1-5 regressions fitted using the least square method. length and the standard length were plotted against length and the rest of the characters against the length. Snout length, maxillary length, eye and depth of head were further ploted against the (Pl. IV, Figs. 6-9).

summations of X, Y, X^2, Y^2, and XY are presented . To study the significance of variation in the , analysis of co-variance test was employed for

...aracter of the two species. The 'B' values and the ...lts of significant test of the slop and elevation of ...gressions of thé two species are given in table 4. ...ay be noticed from this table that the difference in ...e of regressions between the species was significant ...egard to total length - standard length, standard ...th - depth of head, standard length - depth of body, ...dard length - depth of caudal peduncle, standard ...th - stomach length, standard length - stomach caecum ...gth and head length - maxillary length. The elevation ...egressions showed significant difference in all the ...acters except for standard length - maxillary length, ...dard length - pre-pectoral length, standard length - ...anal length and head length - maxillary length. The ...ults of these analyses further showed that the differences ...both the slope as well as the elevation of regressions of ...e two species were nonsignificant only in respect of ...e characters namely standard length - maxillary length, ...dard length - pre-pectoral length and standard length - ...anal length. Regarding all other characters either the ...e or the elevation of regressions showed significant ...erences. All these show that these two species are ...ly distinct from each other and cannot be grouped under ...species. Hence re-establishment of D. hasseltti Bleeker ...rated from D. acuta Valenciennes is highly justifiable.

PLATE II

Range, mean, standard deviation & standard error of morphometric and meristic characters of *Dussumieria acuta* and *D. hasseltii*.

Fig. 1	Fork length in percentage of total length.		
Fig. 2	Standard length in percentage of total length.		
Fig. 3	Head length in percentage of standard length.		
Fig. 4	Snout length	,,	,,
Fig. 5	Maxillary length	,,	,,
Fig. 6	Eye diameter	,,	,,
Fig. 7	Pre-dorsal length	,,	,,
Fig. 8	Pre-pectoral length	,,	,,
Fig. 9	Pre-Pelvic length	,,	,,
Fig. 10	Pre-anal length	,,	,,
Fig. 11	Depth of head	,,	,,
Fig. 12	Depth of body	,,	,,
Fig. 13	Depth of caudal peduncle		,,
Fig. 14	Length of caudal fin	,,	,,
Fig. 15	Length of stomach	,,	,,
Fig. 16	Length of stomach caecum		,,
Fig. 17	Snout length in percentage of head length		
Fig. 18	Maxillary length	,,	,,
Fig. 19	Eye diameter	,,	,,
Fig. 20	Depth of head	,,	,,
Fig. 21	Number of gill rakers		
Fig. 22	Number of pyloric caecae		
Fig. 23	Number of vertebrae.		

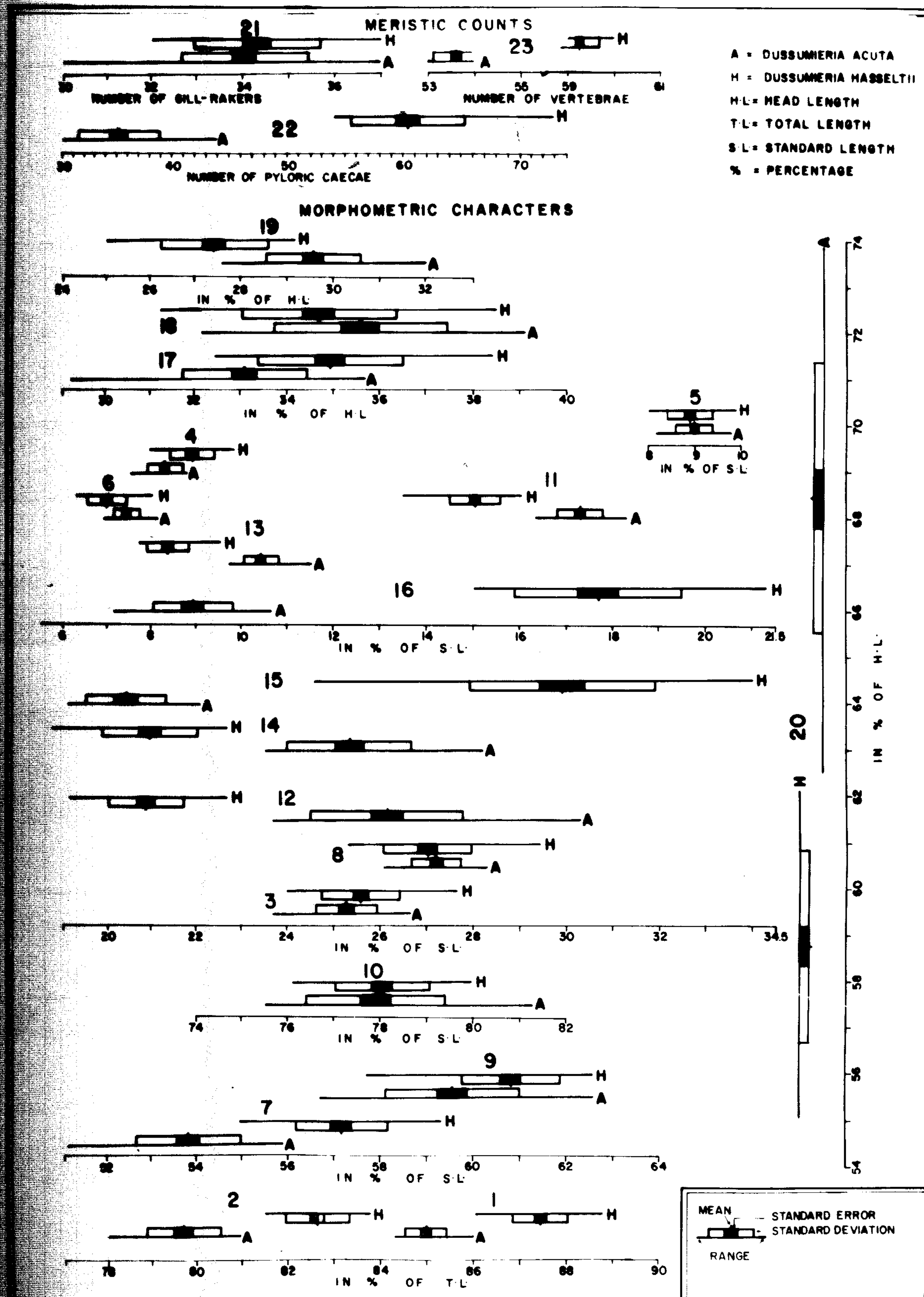

MERISTIC COUNTS
21
23
NUMBER OF GILL-RAKERS
NUMBER OF VERTEBRAE
22
NUMBER OF PYLORIC CAECAE
MORPHOMETRIC CHARACTERS
A = DUSSUMIERIA ACUTA
H = DUSSUMIERIA HASSELTII
H·L = HEAD LENGTH
T·L = TOTAL LENGTH
S·L = STANDARD LENGTH
% = PERCENTAGE
IN % OF H·L
IN % OF S·L
IN % OF T·L
MEAN
STANDARD ERROR
STANDARD DEVIATION
RANGE

PLATE.II

PLATE III

Scatter diagram, fitted with regressions, of morphometric characters of *Dussumieria acuta* and *D. hasseltii*.

Fig. 1	Fork length against total length	
Fig. 2	Standard length	,,
Fig. 3	Head length against standard length	
Fig. 4	Snout length	,,
Fig. 5	Maxillary length	,,
Fig. 6	Eye diameter	,,
Fig. 7	Pre-dorsal length	,,
Fig. 8	Pre-pectoral length	,,
Fig. 9	Pre-pelvic length	,,
Fig. 10	Pre-anal length	,,
Fig. 11	Caudal fin length	,,

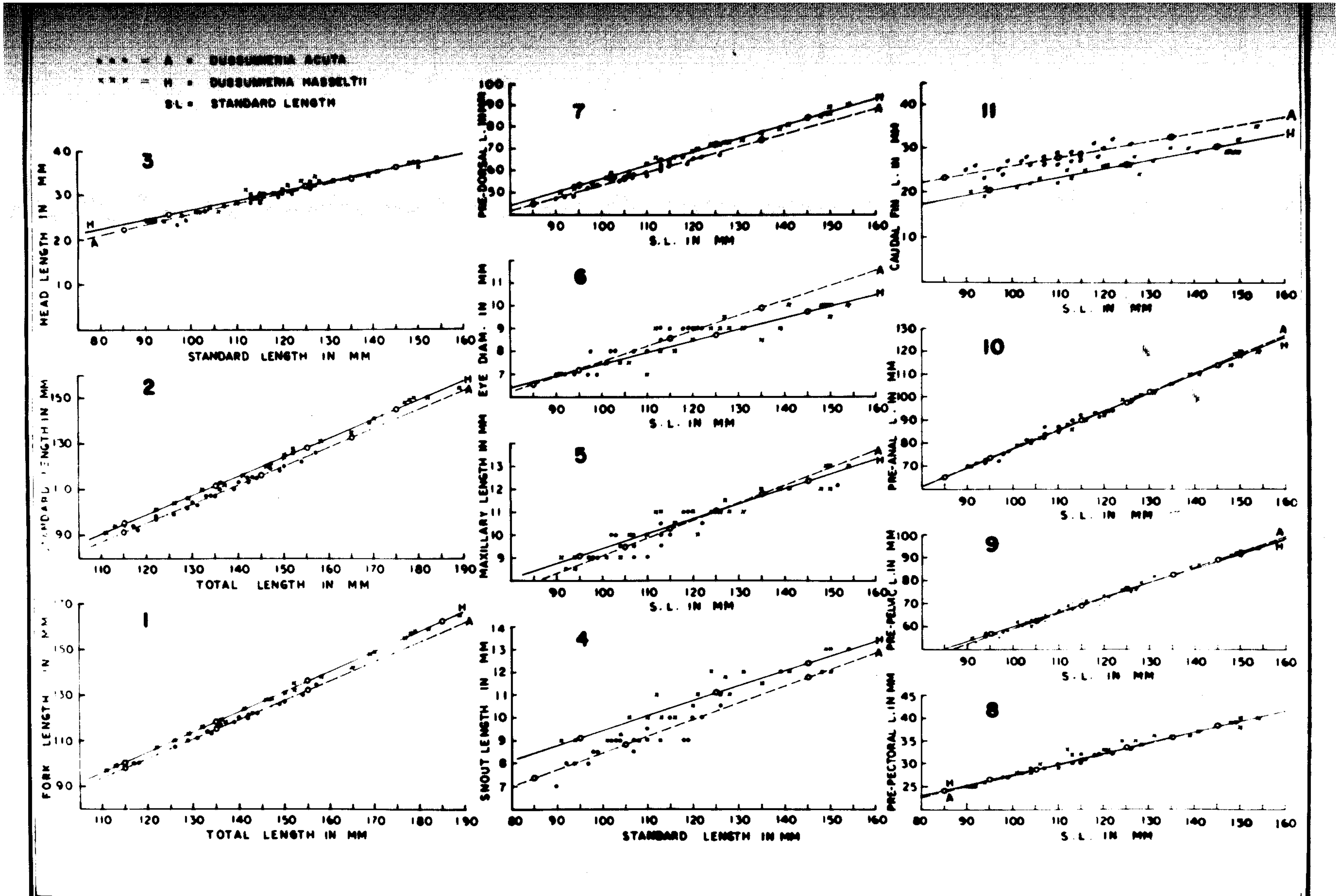

A = DUSSUMIERIA ACUTA
H = DUSSUMIERIA HASSELTII
S.L. = STANDARD LENGTH
HEAD LENGTH IN MM
STANDARD LENGTH IN MM
TOTAL LENGTH IN MM
FORK LENGTH IN MM
PRE-DORSAL L. IN MM
S.L. IN MM
EYE DIAM. IN MM
MAXILLARY LENGTH IN MM
SNOUT LENGTH IN MM
CAUDAL FIN L. IN MM
PRE-ANAL L. IN MM
PRE-PELVIC L. IN MM
PRE-PECTORAL L. IN MM

PLATE III

PLATE IV

Scatter diagrams, fitted with regressions, of various morphometric characters of D. acuta and D. hasseltii.

Fig. 1	Depth of head against standard length	
Fig. 2	Depth of body	"
Fig. 3	Depth of caudal peduncle	"
Fig. 4	Stomach length	"
Fig. 5	Stomach caecum length	"
Fig. 6	Snout length against head length	
Fig. 7	Maxillary length	"
Fig. 8	Eye diameter	"
Fig. 9	Depth of head	"

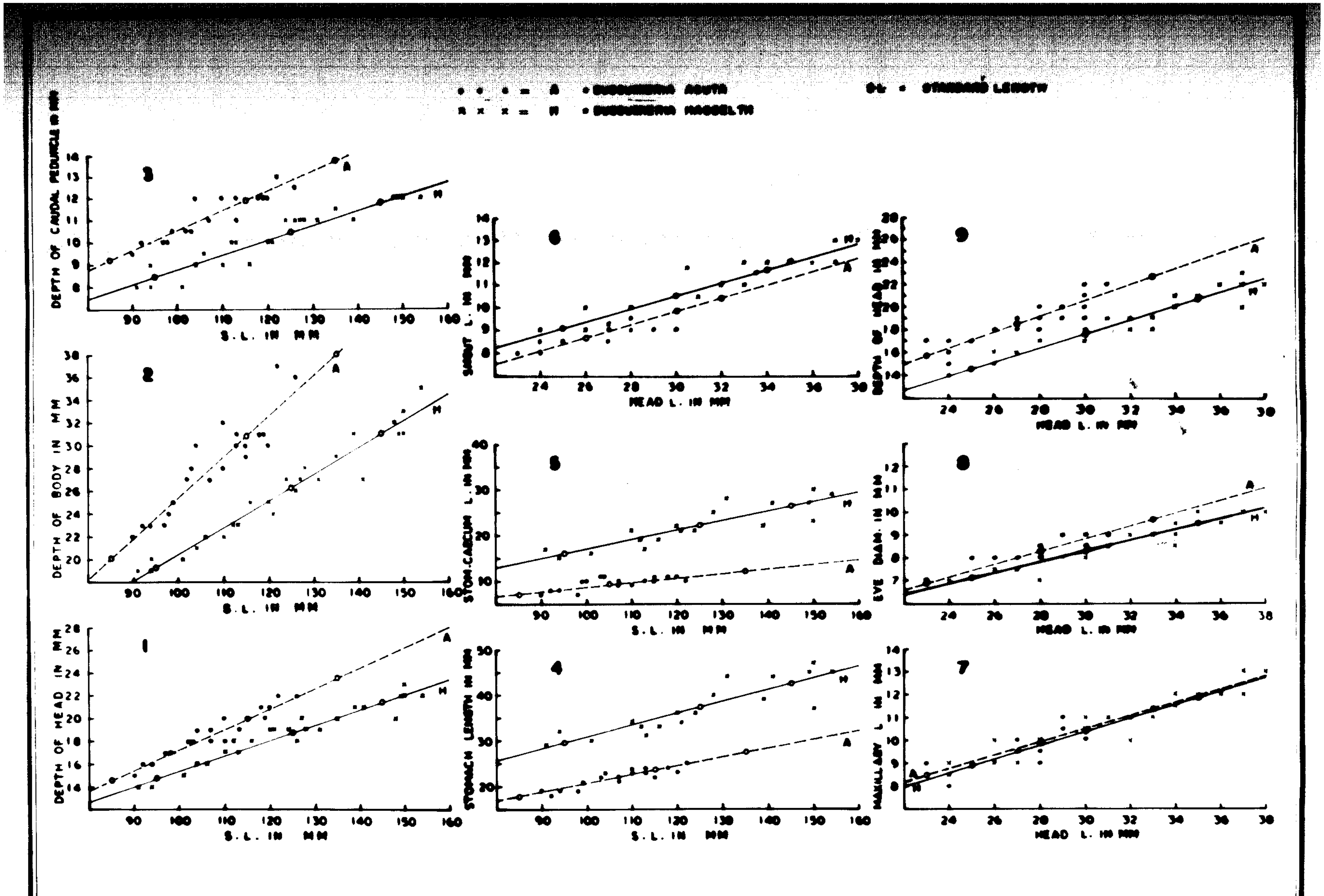

A = A
M = M
SL = STANDARD LENGTH
3
DEPTH OF CAUDAL PEDUNCLE IN MM
S. L. IN MM
2
DEPTH OF BODY IN MM
S. L. IN MM
1
DEPTH OF HEAD IN MM
S. L. IN MM
6
SNOUT L. IN MM
HEAD L. IN MM
5
STOM.-CAECUM L. IN MM
S. L. IN MM
4
STOMACH LENGTH IN MM
S. L. IN MM
9
DEPTH OF HEAD IN MM
HEAD L. IN MM
8
EYE DIAM. IN MM
HEAD L. IN MM
7
MAXILLARY L. IN MM
HEAD L. IN MM

PLATE. IV

...ounts:

... of the six meristic characters studied the ... distribution of four, such as dorsal fin rays, ... fin rays anal fin rays and gill rakers (total number) ... species were analysed statistically to test the ... of proportions, forthwith to determine whether there ... significant variation between the two or not. The ... pyloric caecae and vertebrae which do not show ... of overlapping were not subjected to this test. ... employed was that given by Fisher (1950, p.87) ... as follows:

$$\chi^2 = \frac{1}{\bar{p}\ \bar{q}} \left\{ (a_1\ p) - n_1\ \bar{p} \right\}$$

- = The number of specimens of D. acuta in various counts.
- = proportion of the number in each count of D. acuta in the total for that count for D. acuta (a_1) and D. hasseltti (a_2); i.e. $p = a_1 / a_1 + a_2$.
- = the total number of specimens of D. acuta analysed.
- = the proportion of the number of specimens of D. acuta examined, in the total number of specimens of D. acuta (n_1) and D. hasseltii (n_2) i.e. $\bar{p} = n_1 / n_1 + n_2$.
- = $1 - \bar{p}$

Further the chi-square values and their associated of Freedom (D.F.) and the corresponding probability are tabulated. The results of the analysis of the mentioned four characters are presented in Table 5.

fin rays: In both the species 4 unbranched and 14 to ...ched rays are present, the total range of all the being 18 - 20. The frequency of occurrence of the latter ...n below.

Species	Dorsal fin counts 18	19	20	No. fish examined
D. acuta	1	16	8	25
D. hasseltii	3	20	2	25
Total	4	36	10	50

...lated chi-square value was 5.04 to which the value ...is between 0.05 and 0.10 (Table 5). This shows that ...ations are nonsignificant and cannot be considered as ...le character for differentiating the two species.

...fin rays: In both the species one unbranched ray ... acuta 11 - 12 and in D. hasseltii 11 - 13 branched ... present. The range of total rays belong 12 - 13 for ... and 12 - 14 for D. hasseltii. The frequency is given ... chi-square value was calculated as 1.22 to which value is between 0.2 and 0.3, and hence no significant ...n (Table 5).

...ecies	Number of pectoral fin rays 12	13	14	No. of fish examined
...a	6	19	-	25
...altii	3	20	2	25
Total	9	39	2	50

...n rays: In both the species 3 unbranched rays and 12 - 14 ...d rays are present, the total range being 15 - 17 numbers. ...quency of occurrence is given below.

...	Number of anal fin rays 15	16	17	No. of fish examined
...a	13	9	3	25
...altii	12	11	2	25
...al:	25	20	5	50

... chi-square value was found to be 0.44 to which the ...0.8 - 0.9. The variations were found to be non-signi- ...(Table 5).

...r counts:- The number of gill rakers of the upper and ... limbs of the left outermost gill arch was counted. ...ved frequency for both the species is given below.

	Number of gill rakers								No.of fish examined
	30	31	32	33	34	35	36	37	
a	1	-	1	5	10	5	2	1	25
...tii	-	-	2	5	8	4	5	1	25

TABLE 5

...E VALUES FOR 4 MERISTIC CHARACTERS OF D. ACUTA
...MASSENTII AND THE LEVELS OF THEIR PROBABILITY

...acters	Chi-square value	Degree of freedom	Value of 'P'
...l fin rays	5.04	2	Between 0.05 and 0.10 (NS)
...al fin rays	1.22	1	Between 0.2 and 0. 3 (NS)
... fin rays	0.44	2	Between 0.8 and 0. 9 (NS)
...akers(total)	1.62	5	Between 0.8 and 0. 9 (NS)

... significant.

The chi-square value was found to be 1.62, to which value is 0.8 - 0.9 and hence the variations were ficant (Table 5).

This reveals that the above mentioned four meristic es do not show any significant variation between e species.

Description of species

...ieria acuta Valenciennes 1847. (Pl. V, Fig. 1)

...ieria acuta Valenciennes, 1847, Hist. Nat. Poiss., 20: 467, pl 606 (type locality: Bombay, Coromandel); Canter, 1849, Journ. Asiatic Soc. Bengal, 18: 1268; Jerdon, 1851, Madras Journ. Lit. Sci., 17: 145; Bleeker, 1853, Verh. Batav. Genootsh. 25: 73(reference); ...ner, 1865, Reise Novara, Fische : 330; Day, 1865, Fishes of Malabar: 226; Gunther, 1868, Cat. Fish. Brit. Mus., 7: 466; Bleeker, 1866 - 72, Atlas Ichth. Ind. Neerland., 6:94, pl.(13) 271, fig.1; 1869, ...l. Meded. Akad. Wet. Amsterdam, ser. 2, 2:275; 1874, Nederland. Tijdschr. Dierk., 4: 118; Day, 1878, Fishes of India, pt.4: 647, pl. 166, fig. 4; Bleeker, 1879, Verh. Akad. Wet. Amsterdam, 18: 3; Macleay, 1884, Proc. Linn. Soc. New South Wales, 8: 278; Steindachner, 1907, Denkschr. Akad. Wiss. Wein. math. nat. kl., 71. pt.1: 157; Bean and Weed, 1912,

Proc. U.S. Nat. Mus., 42: 590; Weber, 1913, Siboga Exped., Fische, 57: 3; Weber and Beaufort, 1913, Fishes Indo-Australian Archipelago, 2: 21, fig. 13; Fowler and Bean, 1923, Proc. U.S. Nat. Mus., 62: 2; Hora, 1924, Mem. Asiatic Soc. Bengal, 6: 481; Chabanaud, 1926, Service Oceanogr. Peches Indo-Chine, 1 Note:7; Vinciguerra, 1926, Ann. Mus. Civ. Stor. Nat. Nat. Genova, ser. 3, 10: 622; Fowler, 1928, Mem. Bishop Mus., 10: 30 (copied); Pillay, 1929, Journ. Bombay Nat. Hist. Soc., 33 (2): 355; Tirant, 1929, Service Oceanogr. Peches Indo Chine, 6 Note: 122; Fowler, 1929, Proc. Acad. Nat. Sci. Philadelphia: 598; Deraniyagala, 1933, Ceylon Journ. Sci., 5: 82; Fowler, 1934, Proc. Acad. Nat. Sci. Philadelphia, 86: 69: Roxas, 1934, Philippine Journ. Sci., 55: 251, pl.1 fig.5 (scale): Fowler, 1935, Proc. Acad. Nat. Sci. Philadelphia. 89: 130; 1941, Bull. U.S. Nat. Mus. 13 (100): 570; Bertin, 1943, Bull. Inst. Oceanogr. Monaco, No.83: 3, fig. 1 (scale) and 2; Liang, 1948, Quart. J. Taiwan Mus., 1:2; Monroe, 1955, Marine and fresh water fish, Ceylon: 28; Fowler and Steinitz, 1956, Bull. Res. Counc. Isreal, 5 B (3-4):261.

[redacted]ieria elopsoides Bleeker, 1849, Verh. Batav. Genootsch., 22:12; 1868, Verel. Meded. Akad. Wet. Amsterdam, ser. 2, 2: 294; Günther, 1868, Cat. Fish. Brit.Mus. 7:466.

ns:

iv 14-16; A. iii 12-14; P.i 11-13; V. i 7; G.R.30-37;
tebrae 53 - 54; Pyloric caecae 30 - 44.

percentage of total length: fork length 84.33 - 86.03,
dard length 77.97- 80.99.

percentage of standard length: head 23.71 - 26.67,
36 - 8.85, maxillary 8.18 - 9.80, eye 6.96 - 8.16,
al 51.06 - 55.93, pre-pectoral 26.09 - 28.32, pre-pelvic
2.61, pre-anal 75.53 - 81.31, depth of head 16.36 -
pth of body 23.71 - 30.33, depth of caudal peduncle
1.34, caudal fin 23.53 - 28.26, length of stomach
2.12 (empty and shrunken) and length of stomach ceacum
0.68 (empty and shrunken).

percentage of head length: snout 29.17 - 35.71,
32.14 - 39.13, eye diameter 27.59 - 32.00 and depth
2.30 - 73.91.

maxillary length more than the snout length, the
nearly reaching the front margin of eye. Origin of
1/2 eye diameter behind the middle of body. Ventral
more than 3/4 diameter of eye behind a vertical
origin. Depth of head more than double the snout
dy depth slightly more than head length. Depth of
uncle always more than maxillary length. Length
far less than half the pre-dorsal length and the

equal to maxillary length. Length of caudal fin almost its head length and always more than thrice its eye ... Pre-pectoral length more than thrice its snout and to thrice the maxillary length. Pre-anal slightly less ... times its body depth. Maximum size 167 mm.

... Bluish grey dorsally and silvery white below. A narrow ... band of silvery gray with a golden tinge extends ...ercle to caudal base. Ventral and anal fins white, ... pale with dusky margin on caudal edge. First rays ...l and pectoral dusky. Snout pigmented. Eye white.

...tion: East coats of Mediteranean, Red Sea, Gulf of ... coast of Africa, Madagaskar, Gulf of Iran, India ... west coasts), Ceylon, Malay, Peninsula, Singapore, ... Indies, Philippines, China up to Foochow. ... coastal waters. (Pl. VI).

...eria *hasseltii* Bleeker 1850 (Pl.V, Fig.2).

...eria *hasseltii* Bleeker, 1850, *Tijds. Nederland*, ... 1: 422 (type locality: Batavia, Cheribon, Samarang, ...aya); 1852, *Verh. Batav. Genootsch.*, *24*: 13; 1866-72, ... *Ichth. Ind. Neerland...*, *6*:95, pl.(13) 271, fig.2; ... 1878, *Fishes of India*, pt. 4:647, pl.166, fig.5; ... *Fauna British India, Fishes*, *1*: 399; Jordan and ...rdson, 1907, *Bull. Bur. Fisher.* *27*: 236, 1908;

Bean and Weed, 1912, Proc. U.S. Nat. Mus., 42: 590; Weber and Beaufort, 1913, Fishes Indo-Australian Archipelago, 2:23; Ogilby, 1915, Mem. Queensland Mus., 3: 134; 1916, Mem. Queensland Mus., 5: 98; Fowler, 1918, Copeia, N. 58:62; 1924, Journ. Bombay Nat. Hist. Soc. 30(1): 39; Delsman, 1925, Treubia, 6: 297 (young); McCulloch and Whitley, 1925, Mem. Queensland Mus., 8. pt. 2: 131; Fowler, 1927, Proc. Acad. Nat. Sci. Philadelphia, 79: 256; Fowler and Bean, 1927, Proc. U.S. Nat. Mus., 71: 1; McCulloch, 1929, Australian Mus. Mem., 5: 37; Tirant, 1929, Service Oceanogr. Peches Indo-Chine, 6 Note: 122; Hardenberg, 1931, Treubia, 13, livr. 1:100; Fowler, 1931, Hong Kong Nat. 2: 113; Chevy, 1932, Inst. Oceanogr. Indochine, 19 Note: 8; Herre, 1934, Fishes Herre Philippine Exped. 1931: 14; Roxas, 1934, Philippine Journ. Sci., 55: 252, pl.1, fig. 2 (scale); Roxas and Martin, 1937, Dept. Agr. Comm. Manila Tech. Bull., 6:22 (reference); Herre and Myers, 1937, Raffles Mus. Bull., No.13: 12; Fowler, 1938, List. Fish. Malaya: 24 (reference); 1941, Bull. U.S. nat. Mus., 13 (100): 572; Bertin, 1943, Bull. Inst. Oceanogr. Monaco., No. 853:6, fig. 2; Schultz and Wellander, 1953, Bull. U.S. nat. Mus., No.202:25; Monro , 1955, Marine and Freshwater fish. Ceylon: 28; Fourmanoir, 1961, Mem. Inst. Sci. Madagasker. (F) 4:84, fig. 1.

Dussumieria hasselti Weber, 1913, Siboga Exped., 57, Fische: 3; Hora and Mukerji, 1936, Rec. Indian Mus., 38:18.

Dussumieria elopsoides (not Bleeker) Günther, 1868, Cat. Fish. Brit. Mus., 7:466; Meyer, 1885, Anal. Soc. Espan. Hist. Nat. Madrid, 14: 42; Elera, 1895, Cat. Fauna Filip., 1: 584; Jordan and Evermann, 1902, Proc. U.S. Nat. Mus. 25: 328; Düncker, 1904, Mitt. Natur-hist. Mus. Hamburg, 21: 186; Fowler, 1904, Journ. Acad. Nat. Sci. Philadelphia, ser. 2, 12: 501; Jordan and Seale, 1906, Bull. Bur. Fisher., 26: 5(1907); Jordan and Richardson, 1907, Bull. Bur. Fisher., 27: 236 (1908); 1909, Mem. Carneigie Mus., 4:166 (copied Jordan and Evermann, 1902); Fowler, 1911, Proc. Acad. nat. Sci. Philadelphia, : 205.

Elops javanicus (Kuhl and Van Hasselt) Bleeker, 1866-72, Atlas. Ichth. Ind. Neerland., 6:95.

Dussumieria acuta (part) Day, 1878, Fishes of India, pt.4:647.

Diagnosis:

D iv 14 - 16; A. iii 12-14; P. i 11-13; V. i 7; G.R.32-37; Vertebrae 59-60; Pyloric caecae 54-73.

In percentage of total length: fork length 86.06 - 88.82; standard length 81.48 - 83.80.

In percentage of standard length : head 24.00 - 27.68; snout 8.00 - 9.89; maxilla 8.00 - 9.89; eye 6.30 - 8.04; pre-dorsal 54.95 - 59.33; pre-pectoral 25.33 - 29.46; pre-pelvic 57.69-62.60;

pre-anal 76.11 - 80.00; depth of head 13.51 - 16.07; depth of body 19.15 - 22.73; depth of caudal peduncle 7.76 - 9.57; caudal fin length 18.75 - 22.73; stomach length 24.67 - 34.04 (empty and shrunken) and stomach ceacum length 15.04 - 21.37 (empty and shrunken).

In percentage of head length: snout 32.43 - 38.46; maxilla 31.25 - 38.46; eye diameter 25.00 - 29.17 and death of head 54.05 - 62.16.

The maxillary length equal to or less than snout length, origin of dorsal fin clearly an eye diameter behind middle of body, ventral fin origin 1/2 eye diameter behind a vertical from dorsal origin, depth of head less than double the snout length, depth of body much less than head length, depth of caudal peduncle less than, rarely equal to, maxillary slength, length of stomach ceacum nearly double the maxillary length, length of caudal fin always less than head length and nearly thrice its eye diameter, pre-pectoral length thrice that of snout length and pre-anal length nearly 3 3/4 times body depth. Maximum size 205 mm.

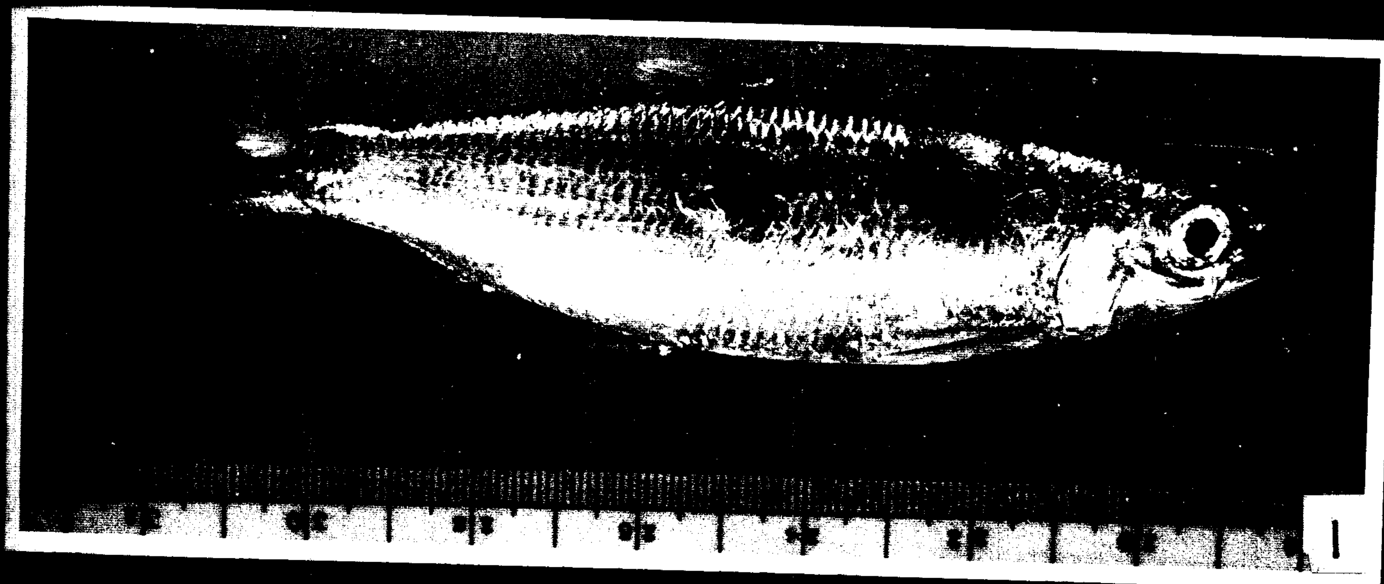
Colour: Upper half dark greenish blue with a narrow lateral band of silvery gray with a golden tinge extending from upper operculam to caudal base. Silvery white on sides and belly. Forkal edge of caudal black. Dorsal and pectoral fins pale but the first ray dusky. Ventral and anal fins white. Upper

PLATE V

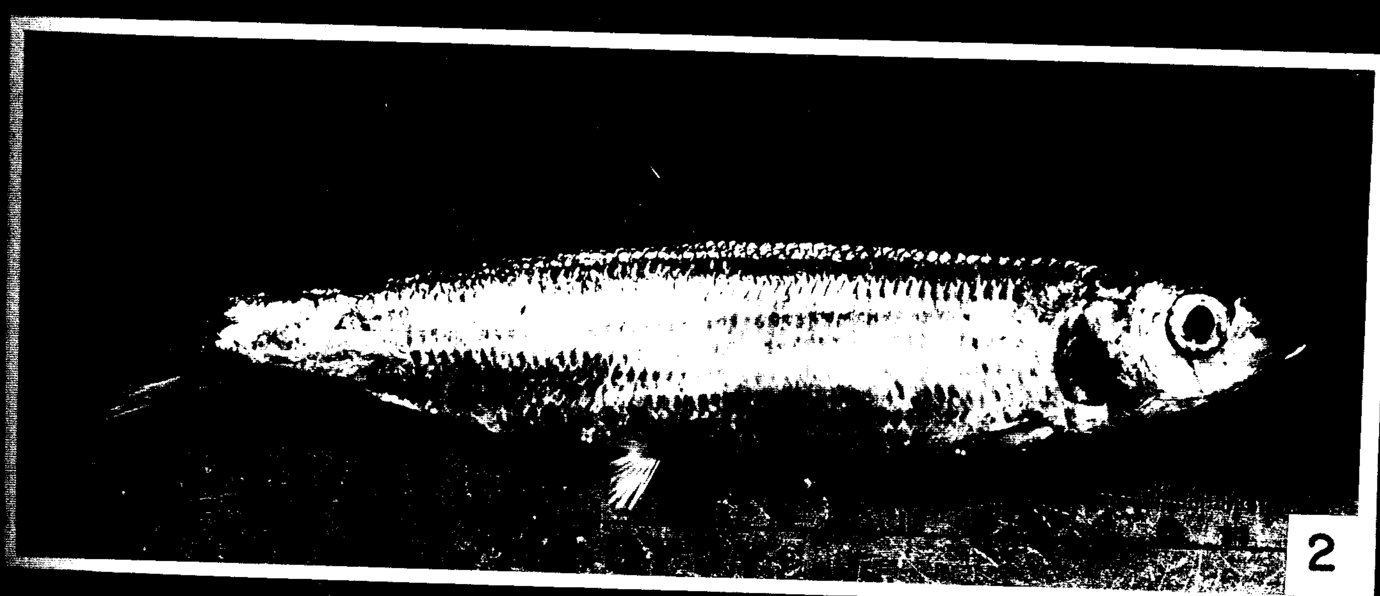
Photographs of two species of *Dussumieria*

Fig. 1 *Dussumieria acuta*

Fig. 2 *Dussumieria hasseltii*



1



2

PLATE. V.

PLATE VI

Map showing the world distribution of *Dussumieria* spp.

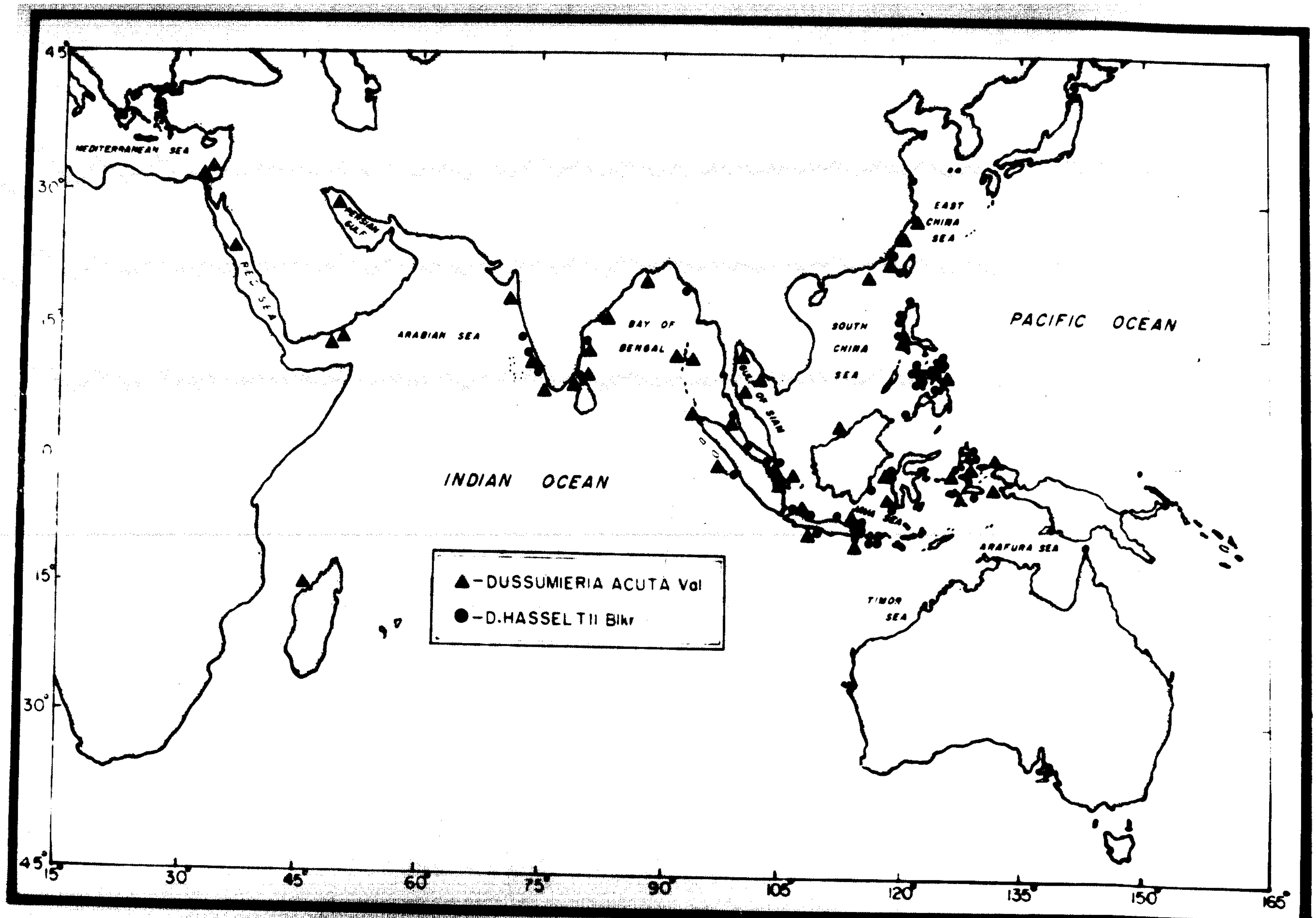

MEDITERRANEAN SEA
PERSIAN GULF
RED SEA
ARABIAN SEA
BAY OF BENGAL
GULF OF SIAM
SOUTH CHINA SEA
EAST CHINA SEA
PACIFIC OCEAN
INDIAN OCEAN
ARAFURA SEA
TIMOR SEA
▲-DUSSUMIERIA ACUTA Val
●-D.HASSELTII Blkr
45°
30°
15°
0
15°
30°
45°
15°
30°
45°
60°
75°
90°
105°
120°
135°
150°
165°

PLATE VI

surface of eye and head emerald green. Snout strongly pigmented. Eye white.

Distribution: East and west coast of India, Ceylon, Burma, Malay peninsula, Singapore, East Indies, Philippines, Formasa (Taiwan), China, Queensland and North East coast of Australia, Inhabits coastal waters. (pl. VI).

Whitehead (1963) in his notes on synonymy of Dussumieria spp. studied mainly four characters, they are (a) body depth, (b) snout length, (c) gill rakers and (d) dorsal rays.

From the scatter diagram on the body depths of specimens measured by Whitehead (1963) it could be seen that the percentage of body depth in standard length had a wide range from 18 to 30 percent. The present observation showed that height of body is a differentiating character of the two species and the range is 23.71 to 30.33% in D. acuta and 19.15 to 22.73% in D. hasseltii (Pl. II, Fig. 12). Based on this if a demarcating line is drawn at 23% in Whitehead's diagram, a clear differentiation could be observed below and above this line. The specimens plotted above this line form a homogeneous group with a limited range of variation which may agree with D. acuta according to the authors observation on Dussumieria from the Gulf of Mannar and the Palk Bay. Similarly the homogeneous group below the line also show a limited range which is in full agreement with that of D. hasseltii.

Regarding the snout length Whitehead (1963) came to the conclusion that this cannot serve as a basis for distinguishing the species. Even then a close study of the histograms of snout length in standard length, given by him, reveals that those specimens which had differential homogenity in body height show some differences with respect to snout length also. In the present work it was observed that the snout length of D. acuta is 7.56 to 8.85% and of D. hasseltii is 8.00 to 9.89% in standard length with an overlapping range between 8.00 and 8.85%. 76% of D. acuta and 52% of D. hasseltii came within this overlapping range (Table 2, and pl.II, Fig.4). This shows that there is slight difference in snout length of the two species but not to the extent to depend on as a specific character. Regarding the gill raker counts, eventhough Whitehead (1963) observed slight difference on few specimens such a difference could not be noted in the present study. The dorsal fin counts also did not show any variation as has been observed by Whitehead. The present author has studied several other characters which show specific distinction between the two species and finally justify the re-establishment of D. hasseltii. Thus two species namely D. acuta and D. hasseltii under the genus Dussumieria are recognised in the present work.

CHAPTER 4

FOOD AND FEEDING HABITS

A great deal of work has been done on the food and eding habits of fishes from Indian waters, some in neral, others in detail. The earlier workers from India this field include Hornell and Nayadu (1923) on rdinella longiceps, Devanesan (1932) on Sardinella hosa, Job (1940) on perches of Malabar coast, dambaram and Venkataraman (1946) on the food fishes the west coast of Madras Presidency and Devanesan and dambaram (1948) on the common food fishes of Madras sidency, while Chacko (1949) gave an uptodate resume work on the subject, in his study on the food and feed- g habits of fishes of the Gulf of Mannar. Later on ailed studies were carried out in this field on a iety of commercially important fishes by Bapat and Bal 50, 1952), Bhimachar and George (1952), Prabhu (1955), (1951, 1952), Bapat et al (1951), Vijayaraghavan (1950, 1951b, 1953a, 1953b), Malhotra (1953), Sarojini (1954), Kuthalingam (1955, 1956), Karekar and Bal (1958), Tampi (1958), Venkataraman (1960), James (1967), and Kagwade (1964) George et al (1971). They discussed the composition of food, its seasonal variations, feeding in relation to availability of food organisms in the environment, feeding habits in relation to sexual cycle, condition of feed, selectivity in feeding and related aspects and drew general conclusions bearing upon the biology of the species concerned. For example, based on the type of food consumed the fishes are broadly classified as plankton feeders, carnivores, omnivores, etc. Among the plankton feeders a few show preference for phytoplankton and yet others prefer zooplankton. Again among the carnivores some are piscivorous, while others are cosmopolitan in their taste. A preference for a favourite food item and consequent limitation of the fishes to strata that form the habitat of these food items again lead to such classifications as surface feeders, column feeders and bottom feeders.

Many have commented on the correlation between the availability of a favourite food item of a particular fish species and the occurrence of the fishery for that species. Nair and Subramanian (1955) studied the relationship between the oil sardine, (*Sardinella longiceps*) fishery of the west coast of India and *Fragilaria oceanica*, a diatom. According to these authors the peak of the oil sardine fishery is reached during or immediately after the peak of *Fragilaria oceanica* bloom in these waters, and came to the conclusion that "one of the major factors governing the fluctuation of the oil sardine is the availability of *Fragilaria oceanica* which is its favourite food". Similarly a relationship has been noticed by Seshappa and Bhimachar (1955) between the Malabar sole, *Cynoglossus semifaciatus* and its preferred food item. *Prionospio pinnata*, a polychaete, and while referring to the movements of this fish into the inshore waters they concluded "that food factor plays an important role in the large-scale appearance of the fish" and "it seems particularly to favour polychaetes usually dominated along this coast by *Prionospio pinnata* during the post monsoon months". Venkataraman (1960) related the abundance of silver-belly and white bait fishery of the Malabar coast during monsoon months to the abundance of their preferred food, the copepods, whose peak occurrence in the plankton in this period led him to infer that they contributed to a considerable extent to the rich fishery of these two fishes. From all these it can be inferred that the study of food of a fish round the year is essential for an understanding of the biology and fishery of the species.

Studies on the food and feeding habits of the Rainbow sardines belonging to the genus *Dussumieria* have been undertaken by several authors. The species involved in the earlier work were *Dussumieria hasseltii* and *D. acuta*. Tham Ah Kow (1950) studied the food and feeding habits of *D. hasseltii* in the course of his investigations on the food and feeding relationships of the fishes of Singapore Straits. Among the Indian workers Devenesan and Chidambaram (1948) made a reference to the food of the rainbow sardines in general in an account of the common food fishes of the Madras Presidency. Others who worked on this aspect of biology are Devanesan and Chacko (1944), Chacko (1949), Venkataraman (1960), Mahadevan and Chacko (1962), Basheeruddin and Nayar (1961) and Srinivasa Rao (1964) in *Dussumieria hasseltii*; and and Sekharan (1949), Vijayaraghavan (1951 b) and Kuthalingam (1961) in *Dussumieria acuta*. Nair (1973) in his monograph on Indian Sardines has reviewed the food and feeding habits of *D. acuta* and *D. hasseltii*. These are largely qualitative analyses of the food constituents of the fish and a detailed account on the food of *Dussumieria*, both qualitative and quantitative, is yet to be had. In the present work feeding habits of Rainbow sardines are studied in detail with special reference to that of *Dussumieria acuta*, the most common species in the Palk Bay and the Gulf of Mannar, in the vicinity of Mandapam, on the southeast coast of India.

4.1. QUALITATIVE ANALYSIS

In general, the food items of Dussumieria acuta were grouped into four main categories such as (1) Planktonic crustaceans both adult and larval forms (2) Larval molluscs (3) Larval and juvenile fishes and (4) Plant material.

Among the planktonic crustaceans the sergestid, Lucifer was found to be the favourite food item of D. acuta. The young ones of the penaeid prawns were identified as belonging to Penaeus spp. and Metapenaeus sp. Mysids of the order Mysidaceae were represented by Mysis. Isopods were identified to the genus Cymodace. Amphipods and euphausids were met with as food item only occasionally. Copepods were represented by Oithona sp., Calanus spp., and Paracalanus sp. Acetes was found occasionally in the diet. Porcellana larva formed one of the food items quite frequently.

Planktonic larvae of crustaceans were quite common in the stomach of rainbow sardine and sometimes they occurred in large number in most of the stomachs. Among them the most important forms were the alima larva of Squilla (stomatopod), the megalopa larva of crabs (family Portunidae), the zoea larvae of prawns, crabs including that of the pea crab, Porcellana (family Porcellanidae) and the phyllosoma larvae of lobsters. Mysis stage of prawns (Penaeus spp., and Metapenaeus spp.) and larva of hermit crabs (Paguridae) e also present in a few stomachs.

The crustacean remains included the broken appendages fragments of the body parts of crustaceans which could be identified. They were present in large number of maches.

The juveniles and larval forms of the teleostean hes were met with in the stomach contents of D. acuta certain months, in large numbers. In most of the cases, to digestion or absence of head the identification of se fishes were not possible. But, most of them which identified were of the genus Stolephorus. In the sent study the fish larvae and juvenile fishes, both tified and unidentified were treated under one common 'fishes'.

Bivalve larvae were observed in two months during period from April 1969 to March 1971 in the stomach few fishes. Gastropod, Spiratella sp., and cephalopod, d, each of which accurred only once in the stomachs of different fishes, were also observed.

'Plant materials', which include unidentified piece grasses and sea weeds, were present in the stomach acuta in certain months. They were considered as of food in view of the fact that they occurred dily and were found in various degrees of digestion.

From the above observations it may be surmised that D. acuta is a zooplankton feeder especially feeding on planktonic crustaceans, both larval forms and adults and on occassions, if available, feeding on bivalve larvae, juvenile fishes, especially Stolephorus sp. and on rare occasions on pieces of plant materials.

4.2. QUANTITATIVE ANALYSIS

The stomach contents of D. acuta were analysed separately for each month, and graded by the method of 'Index of preponderence' and the data presented in Tables 6 - 46. From the Gulf of Mannar the samples were available in all the months for the above period, while from the Palk Bay samples could not be collected in May and December 1969, February, May, September and October 1970 and January 1971.

Quantitative analysis of the stomach contents of D. acuta from the Gulf of Mannar during the period April 1969 to March 1970:

During this period 967 stomachs of fishes from the Gulf of Mannar were analysed and are presented in Table 6 to 17. In the samples from this area the number of stomachs in either 'little' or 'empty' conditions were more as majority of them were from the night catches only.

Crustaceans: As a single food item Lucifer gained the maximum index of 31.5231 and was the predominant item in

May and it was at its lowest in July when it got only 0.0008 indices. Lucifer was not found in the stomachs in August, September, January and February. It formed an important food item in all other months.

Among crustaceans alima larvae of Squilla formed the second important food item, next to Lucifer. It had a maximum of 13.48 percent occurrence in April, attaining an index of 6.7989 and was the dominant food item in this month. It was absent in July, August, November, January and February. The minimum occurrence of 0.95 percent was noticed in the month of June when it got an index of 0.0368.

Zoea larva was noticed in the stomach of D. acuta in very small quantities from April to June with a maximum of 8.06 percent of occurrence in June. It attained a minimum index of 0.0113 in May, while it was absent from July 1969 to March 1970.

Megalopa larva of crab was found to occur only from May to July with a maximum of 4.27 percent in May. Mysis stage of prawns was present in the stomach in the months of May, June, September and December in minor quantities. Pagurid larva occurred only in June and that too in small quantities.

TABLE 6

RELATIVE IMPORTANCE OF FOOD ITEMS IN THE STOMACH CONTENTS OF *DUSSUMIERIA ACUTA* FROM THE GULF OF MANNAR

Location: Gulf of Mannar April 1969 Total No.of Fish: 71

Sl. No.	Stomach contents	Percentage volume (V)	Percentage occurrence (O)	VO	$\frac{VO}{\Sigma VO} \times 100$	Rank
1.	*Lucifer*	6.76	13.48	91.1248	2.6977	3
2.	Alima	17.10	13.48	230.5080	6.7989	2
3.	Zoea	0.12	1.12	0.1344	0.0040	9
4.	'Fishes'	3.95	4.50	13.8250	0.4078	5
5.	Fish scales	0.07	2.25	0.1575	0.0046	8
6.	Crustacean remains	1.02	4.50	4.5900	0.1354	6
7.	Digested matter	66.98	44.94	3010.0812	88.7819	1
8.	'Plant materials'	1.05	3.37	3.5385	0.1043	7
9.	Sand grains	2.95	12.36	36.4620	1.0754	4
	Total	100.00	100.00	3390.4214	100.0000	

TABLE 7

RELATIVE IMPORTANCE OF FOOD ITEMS IN THE STOMACH CONTENTS OF *DUSSUMIERIA ACUTA* FROM THE GULF OF MANNAR

Location: Gulf of Mannar May 1969 Total No. of Fish: 148

Sl. No.	Stomach contents	Percentage volume (V)	Percentage occurrence (O)	VO	$\frac{VO}{\Sigma VO} \times 100$	Rank
1.	*Lucifer*	24.42	21.65	528.6930	31.5231	2
2.	Alima	5.72	7.12	40.7264	2.4283	5
3.	Zoea	0.22	0.86	0.1892	0.0113	10
4.	Megalopa	1.78	4.27	7.6006	0.4532	7
5.	Copepod	0.07	1.99	0.1393	0.0083	11
6.	Mysis larvae	0.02	0.29	0.0058	0.0003	13
7.	Young prawns	0.56	3.99	2.2344	0.1332	9
8.	Crustacean remains	19.94	20.23	403.3862	24.0518	3
9.	Bivalve	0.04	0.29	0.0116	0.0007	12
10.	'Fishes'	15.02	8.26	124.0652	7.3973	4
11.	Fish scales	1.02	3.70	3.7370	0.2228	8
12.	Sand grains	4.45	7.41	32.9745	1.9661	6
13.	Digested matter	26.75	19.94	533.3950	31.8035	1
	Total	100.01	100.00	1677.1582	99.9999	

TABLE 8

RELATIVE IMPORTANCE OF FOOD ITEMS IN THE STOMACH CONTENTS OF DUSSUMIERIA ACUTA FROM THE GULF OF MANNAR

Location: Gulf of Mannar June 1969 Total No.of Fish:144

Sl. No.	Stomach contents	Percentage volume (V)	Percentage occurrence (O)	VO	$\frac{VO}{\Sigma VO} x100$	Rank
1.	*Lucifer*	22.37	18.48	413.3976	14.0507	2
2.	Alima	1.14	0.95	1.0830	0.0368	6
3.	Zoea	0.42	8.06	3.3852	0.1151	4
4.	Megalopa	0.18	0.47	0.0846	0.0029	11
5.	Mysis larvae	0.03	0.47	0.0141	0.0005	13
6.	Isopod	0.04	0.47	0.0188	0.0006	12
7.	Copepod	0.12	3.32	0.3984	0.0135	8
8.	Eupagurid larvae	0.13	2.37	0.3081	0.0105	9
9.	*Porcellena* larvae	0.04	0.47	0.0188	0.0006	12
10.	Young prawns	0.28	2.37	0.6636	0.0226	7
11.	Crustacean remains	13.67	22.28	304.5676	10.3518	3
12.	Fish eggs	0.09	0.95	0.0855	0.0029	11
13.	'Fishes'	1.27	0.95	1.2065	0.0410	5
14.	'Plant materials'	0.04	0.47	0.0188	0.0006	12
15.	Digested matter	59.96	36.97	2216.7212	75.3428	1
16.	Fish scales	0.22	0.95	0.2090	0.0071	10
	Total	100.00	100.00	2942.1808	100.0000	

TABLE 9

RELATIVE IMPORTANCE OF FOOD ITEMS IN THE STOMACH CONTENTS OF *DUSSUMIERIA ACUTA* FROM THE GULF OF MANNAR

Location: Gulf of Mannar July 1969 Total No.of Fish:126

Sl. No.	Stomach contents	Percentage volume (V)	Percentage occurrence (O)	VO	$\frac{VO}{\Sigma VO}$ x100	Rank
1.	*Lucifer*	0.06	1.11	0.0666	0.0008	6
2.	Megalopa	0.06	1.11	0.0666	0.0008	6
3.	Copepode	0.62	1.11	0.6882	0.0079	4
4.	'Plant materials'	0.31	1.11	0.3441	0.0040	5
5.	Fish scales	0.80	2.22	1.7760	0.0204	3
6.	Sand grains	1.61	3.34	5.3774	0.0618	2
7.	Digested matter	96.54	90.00	8688.6000	99.9043	1
	Total	100.00	100.00	8696.9189	100.0000	

TABLE 10

RELATIVE IMPORTANCE OF FOOD ITEMS IN THE STOMACH CONTENTS *DUSSUMIERIA ACUTA* FROM THE GULF OF MANNAR

Location: Gulf of Mannar. August 1969. Total No.of Fish: 65.

Sl. No.	Stomach contents	Percentage volume (V)	Percentage occurrence (O)	VO	$\frac{VO}{\Sigma VO}$ x100	Rank
1.	'Plant materials'	1.54	1.89	2.9106	0.0301	2
2.	Digested matter	98.46	98.11	9659.9106	99.9699	1
	Total	100.00	100.00	9662.8212	100.0000	

TABLE 11

RELATIVE IMPORTANCE OF FOOD ITEMS IN THE STOMACH CONTENTS OF DUSSUMIERIA ACUTA FROM THE GULF OF MANNAR

Location: Gulf of Mannar. September 1969. Total No.of Fish: 59

Sl. No.	Stomach contents	Percentage volume (V)	Percentage occurrence (O)	VO	$\frac{VO}{\Sigma VO}$ x100	Rank
1.	Alima	1.69	2.90	4.9010	0.0835	4
2.	'Fishes'	17.88	14.49	259.0812	4.4117	2
3.	Mysis larvae	0.04	1.45	0.0580	0.0010	6
4.	Fish scales	0.15	1.45	0.2175	0.0037	5
5.	'Plant materials'	0.04	1.45	0.0580	0.0010	6
6.	Crustacean remains	1.35	7.25	9.7875	0.1667	3
7.	Digested matter	78.84	71.01	5598.4284	95.3324	1
	Total	99.99	100.00	5872.5316	100.0000	

TABLE 12

RELATIVE IMPORTANCE OF FOOD ITEMS IN THE STOMACH CONTENTS OF *DUSSUMIERIA ACUTA* FROM THE GULF OF MANNAR

Location: Gulf of Mannar. October 1969. Total No.of Fish: 65.

Sl. No.	Stomach contents	Percentage volume (V)	Percentage occurrence (O)	VO	$\frac{VO}{\Sigma VO} x 100$	Rank
1.	*Lucifer*	21.38	19.05	407.2890	14.6128	2
2.	Alima	0.89	1.19	1.0591	0.0380	9
3.	*Acetes*	2.40	3.57	8.5680	0.3074	6
4.	Young prawns	0.04	1.19	0.0476	0.0017	11
5.	Mysids	0.26	2.38	0.6188	0.0222	10
6.	*Porcellana* larva	0.78	3.57	2.7846	0.0999	7
7.	Euphausid Larva	0.85	3.57	3.0345	0.1089	8
8.	Fish scales	2.24	4.76	10.6624	0.3825	4
9.	Crustacean remains	8.18	16.67	136.3606	4.8923	3
10.	Digested matter	61.78	35.72	2206.7816	79.1756	1
11.	Sand grains	1.20	8.33	9.9960	0.3587	5
	Total	100.00	100.00	2787.2022	100.000	

TABLE 13

RELATIVE IMPORTANCE OF FOOD ITEMS IN THE STOMACH CONTENTS OF *DUSSUMIERIA ACUTA* FROM THE GULF OF MANNAR

Location: Gulf of Mannar. November 1969. Total No. of Fish: 42.

Sl. No.	Stomach contents	Percentage volume (V)	Percentage occurrence (O)	VO	$\frac{VO}{\Sigma VO}$ x100	Rank
1.	*Lucifer*	2.59	3.45	8.9355	0.1179	4
2.	Fish scales	2.96	3.45	10.2120	0.1348	3
3.	Digested matter	87.04	86.20	7502.8480	99.0722	1
4.	Sand grains	7.41	6.90	51.1290	0.6751	2
	Total	100.00	100.00	7573.1245	100.0000	

TABLE 14

RELATIVE IMPORTANCE OF FOOD ITEMS IN THE STOMACH CONTENTS OF ***DUSSUMIERIA ACUTA*** FROM THE GULF OF MANNAR

Location: Gulf of Mannar. December 1969. Total No.of Fish: 79.

Sl. No.	Stomach contents	Percentage volume (V)	Percentage occurrence (O)	VO	$\frac{VO}{\Sigma VO} \times 100$	Rank
1.	*Lucifer*	21.28	22.00	468.1600	12.3917	2
2.	*Alima*	0.29	2.00	0.5800	0.0153	5
3.	Mysids	0.06	2.00	0.1200	0.0032	7
4.	Copepods	0.06	2.00	0.1200	0.0032	7
5.	Mysis larvae	0.14	2.00	0.2800	0.0074	6
6.	'Fishes'	5.43	6.00	32.5800	0.8624	4
7.	Crustacean remains	6.76	16.00	108.1600	2.8629	3
8.	Digested matter	66.00	48.00	3168.0000	83.8539	
	Total:	100.02	100.00	3778.0000	100.0000	

TABLE 15

RELATIVE IMPORTANCE OF FOOD ITEMS IN THE STOMACH CONTENTS OF *DUSSUMIERIA ACUTA* FROM THE GULF OF MANNAR

Location: Gulf of Mannar. January 1970. Total No. of Fish: 59.

Sl. No.	Stomach contents	Percentage volume (V)	Percentage occurrence (O)	VO	$\frac{VO}{\Sigma VO} \times 100$	Rank
1.	*Spiratella* (gastropod)	1.44	2.00	2.8800	0.0311	3
2.	Digested matter	96.52	96.00	9265.9200	99.9249	1
3.	Sand grains	2.04	2.00	4.0800	0.0440	2
	Total	100.00	100.00	9294.0000	100.0000	

TABLE 16

RELATIVE IMPORTANCE OF FOOD ITEMS IN THE STOMACH CONTENTS OF *DUSSUMIERIA ACUTA* FROM THE GULF OF MANNAR

Location: Gulf of Mannar. February 1970. Total No. of Fish: 74

Sl. No.	Stomach contents	Percentage volume (V)	Percentage occurrence (O)	VO	$\frac{VO}{\Sigma VO} \times 100$	Rank
1.	Digested matter	99.10	97.62	9674.1420	99.9779	1
2.	Sand grains	0.90	2.38	2.1420	0.0221	2
	Total	100.00	100.00	9676.2840	100.0000	

TABLE 17

RELATIVE IMPORTANCE OF FOOD ITEMS IN THE STOMACHCONTENTS OF *DUSSUMIERIA ACUTA* FROM THE GULF OF MANNAR

Location: Gulf of Mannar. March 1970. Total No.of Fish: 35.

Sl. No.	Stomach contents	Percentage volume (V)	Percentage occurrence (O)	VO	$\frac{VO}{\Sigma VO}$x100	Rank
1.	'Fishes'	2.67	2.17	5.7939	0.1510	6
2.	*Lucifer*	5.43	8.70	47.2410	1.2313	4
3.	Alima	7.33	8.70	63.7710	1.6622	3
4.	*Porcellana* larva	0.37	4.35	1.6095	0.0420	7
5.	Amphipod	0.07	2.17	0.1519	0.0040	9
6.	Young prawns	0.17	2.17	0.3689	0.0096	8
7.	Crustacean remains	9.13	17.39	158.7707	4.1383	2
8.	Digested matter	70.83	50.00	3541.5000	92.3081	1
9.	Sand grains	4.00	4.35	17.4000	0.4535	5
	Total	100.00	100.00	3836.6069	100.0000	

Other items which were observed in the stomach in small quantities with limited occurrence were euphausid in October with 3.57 percent occurrence, amphipod in March with 2.17 percent occurrence, isopod in June with 0.47 percent occurrence, and _Mysis_ of Mysidacea in October and December with 2.38 percent and 2.00 percent occurrence respectively. _Acetes_ was noticed only in October, when it had an occurrence of 3.57 percent. These food items were not noticed in months other than those mentioned above.

Copepod occurred from May to July and in December and the maximum occurrence of 3.32 percent was noticed in June when it attained an index of 0.0135. Similarly _Porcellana_ was found to occur in the stomach in June (0.47%), October (3.57%) and March (4.35%).

Young prawns were observed in the stomach of _D. acuta_ in May, June, October and March with a maximum occurrence of 3.99 percent in May. They attained the minimum index of 0.0017 in October.

Crustacean remains were found to occur in considerable quantities in the stomach during the months from April to June in September, October, December and in March and ranked second (next to _Lucifer_) in May. They occurred maximum in June (22.28%) and attained a highest index in May (24.0518). A minimum occurrence of 4.50% was noticed in April, while they were absent during the months of July, August, November, January and February.

'__Molluscs__' Among the molluscs, bivalve larvae showed 0.29% of occurrence in May and were not observed in any other months. Similarly a single specimen of the gastroped __Spiratella__ was found to occur once (2.00%) in January.

'__Fishes__': Next to crustaceans, 'fishes' as an important item of food, occurred frequently in certain months in large quantities. They were noticed in the stomach of __D. acuta__ from April to June, in September, December and March, with maximum (7.3973) and minimum (0.0410) indices in May and June respectively. A maximum occurrence of 14.49% was noticed in September.

Fish eggs were found to occur in the month of June in very small quantity and was absent in the stomach in all other months.

'__Plant materials__': During May 1969 and from October 1969 to March 1970, plant materials' were totally absent in the stomach. In all other months their occurrence ranged from a minimum of 0.47% in June to a maximum of 3.37% in April.

Fish scales and sand grains were frequently found in the stomach of __D. acuta__. Except in August 1969 and from December 1969 to March 1970, fish scales were absent in the stomachs. A maximum occurrence of 4.76% and a minimum of 0.95% were noticed in October and June respectively. Sand grains were noticed in all the months other than June, August, September and December 1969. The frequency of occurrence ranged from a minimum of 2.00% in January 1970 to a maximum of 12.36 in April 1969.

The percentage occurrence of digested matter and the index it attained in each month was noticed to be very high. It had a maximum occurrence of 98.11% in August 1969 and a minimum of 19.94% in May. The digested matter had the maximum and minimum indices in February 1970 (99.9779) and in May 1969 (31.8035) respectively.

Quantitative analysis of the stomach contents of *D. acuta* from the Palk Bay, during the period April 1969 to March 1970.

The data collected from the Palk Bay side for a period of 9 months during April and June to November 1969 and January and March 1970 were used for this study. The details are presented in Tables 18 to 26. An important feature noticed in these samples was that there were fewer stomachs in either 'little' or 'empty' conditions, as compared to the Gulf of Mannar samples. This is because the majority of the samples were collected from the day catches.

Crustaceans: *Lucifer* was present in the stomach in all the months except May, December and February, when no samples were available for observation. Lucifer ranked first in the order of abundance in July, August and November attaining indices 80.4379, 35.9860 and 37.6374 respectively. It ranked second in April, June, September and October. A maximum value of 42.30% occurrence was observed in July, while April ranked second (31.42%). The minimum occurrence of 4.49% was noticed in January 1970 when it attained a minimum index of 1.0894.

Alima was noticed in the stomach in all the months of observation except in August. The peak of the abundance was in March, when it formed the second predominant food item next to crustacean remains and attained an index of 21.2067. The occurrence percentage of alima ranged from 2.86% in April to 20.00% in October. Among the food items alima ranked third during October and November.

Zoea was present in its stomach in minor quantities in June and August 1969 and January and March 1970. A maximum occurrence of 14.93% was noticed in March, when the index was 9.3741 and a minimum of 2.25% occurrence in January giving an index of 0.1086. In June and August the percentage occurrence was 2.27% and 6.45% respectively.

Megalopa occurred during June, September, October, November and January and constituted 0.5368, 0.0048, 0.2549, 0.4182 and 2.7310 indices respectively. A maximum of 8.99%

TABLE 18

RELATIVE IMPORTANCE OF FOOD ITEMS IN THE STOMACH CONTENTS OF *DUSSUMIERIA ACUTA* FROM THE PALK BAY

Location: Palk Bay. April 1969. Total No.of Fish: 19.

Sl. No.	Stomach contents	Percentage value (V)	Percentage occurrence (O)	VO	$\frac{VO}{\Sigma VO} x100$	Rank
1.	*Lucifer*	27.89	31.42	876.3038	27.1506	2
2.	Alima	2.11	2.86	6.0346	0.1870	4
3.	Crustacean remains	40.26	37.14	1495.2564	46.3277	1
4.	Digested matter	29.74	28.58	849.9692	26.3347	3
	Total	100.00	100.00	3227.5640	100.0000	

May 1969, no samples

TABLE 19

RELATIVE IMPORTANCE OF FOOD ITEMS IN THE STOMACH CONTENTS OF DUSSUMIERIA ACUTA FROM THE PALK BAY

Location: Palk Bay. June 1969. Total No.of Fish: 18.

Sl. No.	Stomach contents	Percentage volume (V)	Percentage occurrence (O)	VO	$\frac{VO}{\Sigma VO}$ x100	Rank
1.	*Lucifer*	27.67	27.27	754.5609	29.0930	2
2.	Alima	3.06	4.55	13.9230	0.5368	4
3.	Megalopa	3.06	4.55	13.9230	0.5368	4
4.	Mysis larvae	0.61	4.55	2.7755	0.1070	6
5.	Zoea	2.22	2.27	5.0394	0.1943	5
6.	'Fishes'	0.28	2.27	0.6356	0.0245	8
7.	Fish scales	0.28	4.55	1.2740	0.0491	7
8.	Crustacean remains	14.44	18.18	262.5192	10.1217	3
9.	Digested matter	48.38	31.81	1538.9678	59.3367	1
	Total	100.00	100.00	2593.6184	99.9999	

TABLE 20

RELATIVE IMPORTANCE OF FOOD ITEMS IN THE STOMACH CONTENTS OF *DUSSUMIERIA ACUTA* FROM THE PLAK BAY

Location: Palk Bay. July 1969. Total No.of Fish: 13.

Sl. No.	Stomach contents	Percentage volume (V)	Percentage occurrence (O)	VO	$\frac{VO}{\Sigma VO} x100$	Rank
1.	*Lucifer*	71.15	42.30	3009.6450	80.4379	1
2.	Alima	0.23	3.85	0.8855	0.0237	5
3.	'Fishes'	3.08	3.85	11.8580	0.3169	4
4.	Fish scales	0.08	3.85	0.3080	0.0082	6
5.	Crustacean remains	17.00	38.46	653.8200	17.4745	2
6.	Digested matter	8.46	7.69	65.0574	1.7388	3
	Total:	100.00	100.00	3741.5739	100.0000	

TABLE 21

RELATIVE IMPORTANCE OF FOOD ITEMS IN THE STOMACH CONTENTS OF *DUSSUMIERIA ACUTA* FROM THE PALK BAY

Location: Palk Bay. August 1969. Total No. of Fish: 12.

Sl. No.	Stomach contents	Percentage volume (V)	Percentage occurrence (O)	VO	$\frac{VO}{\Sigma VO} \times 100$	Rank
1.	*Lucifer*	36.25	25.80	935.2500	35.9860	1
2.	Young prawns	2.08	6.45	13.4160	0.5162	4
3.	Zoea	0.83	6.45	5.3535	0.2060	5
4.	Phyllosoma	0.42	3.23	1.3566	0.0522	6
5.	Fish scales	0.17	3.23	0.5491	0.0213	7
6.	Crustacean remains	32.92	25.80	849.3360	32.6802	2
7.	Digested matter	27.33	29.04	793.6632	30.5381	3
	Total	100.00	100.00	2598.9244	100.0000	

TABLE 22

RELATIVE IMPORTANCE OF FOOD ITEMS IN THE STOMACH CONTENTS OF *DUSSUMIERIA ACUTA* FROM THE PALK BAY

Location: Palk Bay. September 1969. Total No. of Fish: 29.

Sl. No.	Stomach contents	Percentage volume (V)	Percentage occurrence (O)	VO	$\frac{VO}{\Sigma VO} \times 100$	Rank
1.	*Lucifer*	31.28	28.33	886.1624	36.2253	2
2.	Alima	4.11	6.67	27.4137	1.1206	4
3.	*Porcellana* larva	0.04	1.67	0.0668	0.0027	9
4.	Young prawns	2.86	3.33	9.5238	0.3893	5
5.	Megalopa	0.07	1.67	0.1169	0.0048	8
6.	Fish scales	0.86	6.67	5.7362	0.2345	6
7.	Crustacean remains	32.03	31.66	1014.0698	41.4540	1
8.	Digested matter	27.32	18.33	500.7756	20.4711	3
9.	Sand grains	1.43	1.67	2.3881	0.0976	7
	Total	100.00	100.00	2446.2533	99.9999	

TABLE 23

RELATIVE IMPORTANCE OF FOOD ITEMS IN THE STOMACH CONTENTS OF <u>DUSSUMIERIA ACUTA</u> FROM THE PALK BAY

Location: Palk Bay. October 1969. Total No.of Fish: 17.

Sl. No.	Stomach contents	Percentage volume (V)	Percentage occurrence (O)	VO	$\frac{VO}{\Sigma VO}$x100	Rank
1.	*Lucifer*	20.31	20.00	406.2000	19.2901	2
2.	Alima	10.12	20.00	362.4000	17.2101	3
3.	Megalopa	0.94	5.71	5.3674	0.2549	6
4.	Euphausid	0.13	2.86	0.3718	0.0177	7
5.	'Fishes'	4.31	2.86	12.3266	0.5854	5
6.	Crustacean remains	12.13	25.71	311.8623	14.8101	4
7.	Digested matter	44.06	22.86	1007.2116	47.8317	1
	Total	100.00	100.00	2105.7397	100.0000	

TABLE 24

RELATIVE IMPORTANCE OF FOOD ITEMS IN THE STOMACH CONTENTS OF *DUSSUMIERIA ACUTA* FROM THE PALK BAY

Location: Palk Bay. November 1969. Total No.of Fish: 35.

Sl. No.	Stomach contents	Percentage volume (V)	Percentage occurrence (O)	VO	$\frac{VO}{\Sigma VO}$x100	Rank
1.	*Lucifer*	29.35	24.30	713.2050	37.6374	1
2.	Alima	20.00	13.08	261.6000	13.8052	3
3.	Copepod	0.15	0.93	0.1395	0.0074	10
4.	Megalopa	1.21	6.55	7.9255	0.4182	7
5.	Eupagurid larva	0.15	1.87	0.2805	0.0148	9
6.	*Porcellana* larva	0.03	0.93	0.0279	0.0015	11
7.	Young prawns	2.44	7.48	18.2512	0.9632	5
8.	'Plant materials'	17.94	13.08	234.6552	12.3833	4
9.	Sand grains	0.44	1.87	0.8228	0.0434	8
10.	Crustacean remains	24.62	26.17	644.3054	34.0013	2
11.	Digested matter	3.67	3.74	13.7258	0.7243	6
	Total:	100.00	100.00	1894.9388	100.0000	

December 1969, No sample.

TABLE 25

RELATIVE IMPORTANCE OF FOOD ITEMS IN THE STOMACH CONTENTS OF *DUSSUMIERIA ACUTA* FROM THE PALK BAY

Location: Palk Bay. January 1970. Total No. of Fish: 23.

Sl. No.	Stomach contents	Percentage volume (V)	Percentage occurrence (O)	VO	$\frac{VO}{\Sigma VO}$ x100	Rank
1.	*Lucifer*	3.57	4.49	16.0293	1.0894	5
2.	Alima	1.52	3.37	5.1224	0.3481	10
3.	Megalopa	4.47	8.99	40.1853	2.7310	4
4.	Mysis larva	0.43	3.37	1.4491	0.0985	15
5.	Mysids	0.26	2.25	0.5850	0.0398	16
6.	Amphipods	1.09	5.63	6.1367	0.4171	9
7.	Euphausid	2.13	4.49	9.5637	0.6500	7
8.	Eupagurid larva	0.65	3.37	2.1905	0.1489	13
9.	*Porcellana* larva	0.22	1.12	0.2464	0.0167	17
10.	Copepods	0.81	3.37	2.7297	0.1855	12
11.	Zoea	0.71	2.25	1.5975	0.1086	14
12.	Young prawns	1.96	3.37	6.6052	0.4489	8
13.	*Acetes*	6.96	2.25	15.6600	1.0643	6
14.	'Fishes'	3.48	1.12	3.8976	0.2649	11
15.	'Plant materials'	29.57	14.61	432.0177	29.3605	2
16.	Crustacean remains	36.17	23.59	853.2503	57.9880	1
17.	Digested matter	6.00	12.36	74.1600	5.0400	3
	Total	100.00	100.00	1471.4264	100.0002	

February 1970, No sample.

TABLE 26

RELATIVE IMPORTANCE OF FOOD ITEMS IN THE STOMACH CONTENTS OF *DUSSUMIERIA ACUTA* FROM THE PALK BAY

Location: Palk Bay.   March 1970.   Total No.of Fish: 34.

Sl. No.	Stomach contents	Percentage volume (V)	Percentage occurrence (O)	VO	$\frac{VO}{\sum VO} \times 100$	Rank
1.	*Lucifer*	14.10	14.93	210.5130	10.7986	4
2.	Alima	21.31	19.40	413.4140	21.2067	2
3.	Zoea	12.24	14.93	183.7432	9.3741	5
4.	Mysis larva	0.34	1.49	0.5066	0.0260	7
5.	Fish eggs	0.45	4.47	2.0115	0.1032	6
6.	Crustacean remains	24.83	29.85	741.1755	38.0198	1
7.	Digested matter	26.73	14.93	399.0789	20.4714	3
	Total:	100.00	100.00	1949.4427	99.9998	

occurrence was noticed in January. Mysis stage of prawns were found to occur in the stomach in June (4.55%), January (3.37%) and in March (1.49%). Eupagurid larvae were present in the stomach of D. acuta in very small quantities in November and January only and the respective percentages of occurrence were 1.87 and 3.37.

During certain months euphausid, amphipod, mysid and Acetes were present in the stomach in limited quantities. Euphusids occurred in October (2.86%) and January (4.49%) only. Amphipods, mysids and Acetes were present only during January and among these food items amphipods showed maximum of 5.63% occurrence, whereas the occurrence of mysids and Acetes were 2.25% each.

Copepod occurred as food only during November and January to the extent of 0.93% and 3.37%. Porcellana was present during September, November and January and the occurrence ranged from 0.93% in November to 1.67% in September with 1.12% in January.

Young prawns were observed in the stomach during August, September, November and January. The maximum occurrence of 7.48% was noticed in November and a minimum 3.33% in September. In August they ranked fourth and during September and November they came down to fifth rank among the food items.

Crustacean remains were found to occur in considerable quantities in the stomach in all the months. Its occurrence ranged from a minimum of 18.18% in June to a maximum of 38.46% in July. According to the index of preponderence it ranked first during April (46.3277), September (41.4539), January (57.9880) and March (38.0198). In July, August and November it was the second predominant item, while in June and October it ranked third and fourth respectively.

Molluscs: Molluscs were not found in the stomach of D. acuta collected from Palk Bay side during the period.

'Fishes': Juvenile fishes were observed among the food items during the months of June, July, October and January. A maximum of 3.85% of occurrence was noticed in July and the minimum occurrence of 1.12% in January. But the maximum index of 0.5854 was observed in October. Fish eggs were noticed in the stomach, only in fishes collected during March, when its index showed a value of 0.1032 with an occurrence of 4.47%.

'Plant materials': 'Plant materials' occurred in the stomachs only during November and January, when they attained 12.3833 and 29.3605 indices, respectively. They attained the second rank in January, next to crustacean remains, and fourth rank in November. In all other months, other than November and January, they were absent in the stomach.

Fish scales were observed in the stomach of D. acuta during the months from June to September with a maximum of 6.67% of occurrence in September and a minimum of 3.23% in August. Sand grains were noticed only in September and November to an extent of 0.0976 and 0.0434 indices.

Digested matter was found to occur in all the months and its percentage of occurrence ranged from a minimum of 3.74 in November to a maximum of 31.81 in June. It dominated amongst all other food items during June and October when it ranked first with indices, at 59.3367 and 47.8317 respectively and obtained third rank in all other months except in November, when it ranked sixth in the order of abundance.

Quantitative analysis of the stomach contents of D. acuta from the Gulf of Mannar during the period April 1970 to March 1971

During this period samples were available from the Gulf of Mannar throughout the year. Details of the analysis of the stomach contents are given in tables 27 to 38.

Crustaceans: Lucifer occurred as food in the stomach of D. acuta during April to June and December. Its occurrence ranged from a minimum of 9.35% in December to 31.02% in May. During May it ranked first in abundance amongst the food items. In other three months it had only the third rank. The maximum index of 66.1341 was observed in May.

Alima was found to occur in all the months other than October, January and March. Maximum and minimum occurrences

TABLE 27

RELATIVE IMPORTANCE OF FOOD ITEMS IN THE STOMACH CONTENTS OF *DUSSUMIERIA ACUTA* FROM THE GULF OF MANNER

Location: Gulf of Mannar. April 1970. Total No.of Fish: 40.

Sl. No.	Stomach contents	Percentage volume (V)	Percentage occurrence (O)	VO	$\frac{VO}{\Sigma VO} x100$	Rank
1.	*Lucifer*	8.38	12.66	106.0908	4.4545	3
2.	Alima	5.13	15.19	77.9247	3.2719	4
3.	Young prawns	0.28	3.80	1.0640	0.0447	7
4.	'Fishes'	31.56	18.99	599.3244	25.1643	2
5.	*Porcellana* larva	0.28	3.80	1.0640	0.0447	9
6.	Amphipod	0.06	2.53	0.1518	0.0064	9
7.	Squid	0.16	1.26	0.2016	0.0085	8
8.	'Plant materials'	0.69	2.53	1.7457	0.0733	6
9.	Crustacean remains	1.41	8.86	12.4926	0.5245	5
10.	Digested matter	52.06	30.38	1581.5828	66.4072	1
	Total	100.01	100.00	2381.6424	100.0000	

TABLE 28

RELATIVE IMPORTANCE OF FOOD ITEMS IN THE STOMACH CONTENTS OF <u>DUSSUMIERIA ACUTA</u> FROM THE GULF OF MANNAR

Location: Gulf of Mannar. May 1970. Total No.of Fish:100.

Sl. No.	Stomach contents	Percentage volume (V)	Percentage occurrence (O)	VO	$\frac{VO}{\Sigma VO} \times 100$	Rank
1.	*Lucifer*	49.96	31.02	1549.7592	66.1341	1
2.	Alima	4.84	5.71	27.6364	1.1793	5
3.	Megalopa	1.47	3.67	5.3949	0.2302	6
4.	Zoea	0.35	2.86	1.0010	0.0427	8
5.	Copepod	0.30	5.31	1.5930	0.0680	7
6.	Mysis larva	0.10	1.63	0.1630	0.0070	11
7.	Eupagurid larva	0.02	0.41	0.0082	0.0004	12
8.	*Acetes*	0.18	1.23	0.2214	0.0094	10
9.	Young prawns	0.27	2.04	0.5508	0.0235	9
10.	'Fishes'	10.76	6.53	70.2628	2.9984	4
11.	Crustacean remains	18.68	30.20	564.1360	24.0738	2
12.	Digested matter	13.06	9.39	122.6334	5.2332	3
	Total	99.99	100.00	2343.3601	100.000	

TABLE 29

RELATIVE IMPORTANCE OF FOOD ITEMS IN THE STOMACH CONTENTS OF *DUSSUMIERIA ACUTA* FROM THE GULF OF MANNAR

Location: Gulf of Mannar. June 1970. Total No.of Fish: 62.

Sl. No.	Stomach contents	Percentage volume (V)	Percentage occurrence (O)	VO	$\frac{VO}{\Sigma VO} x100$	Rank
1.	*Lucifer*	5.93	11.67	69.2031	2.0417	3
2.	Alima	7.03	8.33	58.5599	1.7277	4
3.	Zoea	0.47	5.00	2.3500	0.0693	6
4.	Young prawns	0.47	1.67	0.7849	0.0232	8
5.	'Plant materials'	2.97	3.33	9.8901	0.2918	5
6.	Crustacean remains	16.41	23.33	382.8453	11.2953	2
7.	Fish eggs	0.63	3.33	2.0979	0.0619	7
8.	Digested matter	66.09	43.33	2863.6797	84.4890	1
	Total:	100.00	99.99	3389.4109	99.9999	

TABLE 30

RELATIVE IMPORTANCE OF FOOD ITEMS IN THE STOMACH CONTENTS OF *DUSSUMIERIA ACUTA* FROM THE GULF OF MANNAR

Location: Gulf of Mannar. July 1970. Total No. of Fish: 70.

Sl. No.	Stomach contents	Percentage volume (V)	Percentage occurrence (O)	VO	$\frac{VO}{\sum VO} x100$	Rank
1.	Alima	1.22	2.08	2.5376	0.0340	4
2.	Zoea (Crab)	0.33	2.08	0.3564	0.0047	6
3.	Fish scales	3.56	4.17	14.8452	0.1989	3
4.	Crustacean remains	0.67	2.08	1.3936	0.0186	5
5.	Digested matter	88.89	83.34	7408.0926	99.2973	1
6.	Sand grains	5.33	6.25	33.3125	0.4465	2
	Total:	100.00	100.00	7460.5379	100.0000	

TABLE 31

RELATIVE IMPORTANCE OF FOOD ITEMS IN THE STOMACH CONTENTS OF <u>DUSSUMIERIA ACUTA</u> FROM THE GULF OF MANNAR

Location: Gulf of Mannar. August 1970. Total No. of Fish: 85.

Sl. No.	Stomach contents	Percentage volume (V)	Percentage occurrence (O)	VO	$\frac{VO}{\Sigma VO} x100$	Rank
1.	Alima	0.65	1.85	1.2025	0.0159	6
2.	Zoea (Crab)	3.16	5.36	16.9376	0.2236	2
3.	Euphausids	0.11	1.85	0.2035	0.0027	7
4.	Fish scales	0.65	3.70	2.4050	0.0317	5
5.	Crustacean remains	1.41	3.70	5.2170	0.0689	3
6.	Digested matter	92.61	81.49	7546.7889	99.6228	1
7.	Sand grains	1.41	1.85	2.6085	0.0344	4
	Total	100.00	100.00	7575.3630	100.0000	

TABLE 32

RELATIVE IMPORTANCE OF FOOD ITEMS IN THE STOMACH CONTENTS OF <u>DUSSUMIERIA ACUTA</u> FROM THE GULF OF MANNAR

Location: Gulf of Mannar. September 1970. Total No.of Fish:54.

Sl. No.	Stomach contents	Percentage volume (V)	Percentage occurrence (O)	VO	$\frac{VO}{\sum VO}$x100	Rank
1.	Alima	3.03	6.67	20.2101	0.4662	4
2.	'Fishes'	25.13	18.33	460.6329	10.6262	2
3.	Crustacean remains	4.87	6.67	32.4829	0.7493	3
4.	'Plant materials'	1.71	1.67	2.8557	0.0659	6
5.	Digested matter	63.55	60.00	3813.0000	87.9610	1
6.	Fish scales	0.53	3.33	1.7649	0.0407	7
7.	Sand grains	1.18	3.33	3.9294	0.0906	5
	Total	100.00	100.00	4334.8759	99.9999	

TABLE 33

RELATIVE IMPORTANCE OF FOOD ITEMS IN THE STOMACH CONTENTS OF <u>DUSSUMIERIA ACUTA</u> FROM THE GULF OF MANNAR

Location: Gulf of Mannar. October 1970. Total No. of Fish: 76.

Sl. No.	Stomach contents	Percentage volume (V)	Percentage occurrence (O)	VO	$\frac{VO}{\Sigma VO}$x100	Rank
1.	Fish scales	1.02	4.17	4.2534	0.0472	2
2.	Digested matter	98.30	91.66	9010.1780	99.9214	1
3.	Sand grains	0.68	4.17	2.8356	0.0314	3
	Total	100.00	100.00	9017.2670	100.0000	

TABLE 34

RELATIVE IMPORTANCE OF FOOD ITEMS IN THE STOMACH CONTENTS OF <u>DUSSUMIERIA ACUTA</u> FROM THE GULF OF MANNAR

Location: Gulf of Mannar. November 1970. Total No. of Fish: 49.

Sl. No.	Stomach contents	Percentage volume (V)	Percentage occurrence (O)	VO	$\frac{VO}{\Sigma VO}$x100	Rank
1.	Alima	0.69	2.33	1.6077	0.0308	5
2.	<u>Acetes</u>	0.69	2.33	1.6077	0.0308	5
3.	Fish scales	2.59	4.65	12.0435	0.2306	4
4.	Crustacean remains	16.03	18.60	2[illegible]8.1580	5.7095	2
5.	Digested matter	77.86	62.79	4888.8294	93.6172	1
6.	Sand grains	2.14	9.30	19.9020	0.3811	3
	Total	100.00	100.00	5222.1483	100.0000	

TABLE 35

RELATIVE IMPORTANCE OF FOOD ITEMS IN THE STOMACH CONTENTS OF *DUSSUMIERIA ACUTA* FROM THE GULF OF MANNAR

Location: Gulf of Mannar   December 1970   Total No. of Fish: 78.

Sl. No.	Stomach contents	Percentage volume (V)	Percentage occurrence (O)	VO	$\frac{VO}{\Sigma VO} x 100$	Rank
1.	*Lucifer*	8.33	9.53	79.3849	2.0174	3
2.	Alima	1.33	2.38	3.1654	0.0804	5
3.	Zoea	0.33	2.38	0.7854	0.0200	7
4.	Fish scales	0.67	2.38	1.5946	0.0405	6
5.	Crustacean remains	25.00	26.19	654.7500	16.6389	2
6.	Digested matter	60.67	52.38	3177.8946	80.7589	1
7.	Sand grains	3.67	4.76	17.4692	0.4439	4
	Total	100.00	100.00	3935.0441	100.0000	

TABLE 36

RELATIVE IMPORTANCE OF FOOD ITEMS IN THE STOMACH CONTENTS OF *DUSSUMIERIA ACUTA* FROM THE GULF OF MANNAR

Location: Gulf of Mannar. January 1971. Total No. of Fish: 83.

Sl. No.	Stomach contents	Percentage volume (V)	Percentage occurrence (O)	VO	$\frac{VO}{\Sigma VO} x 100$	Rank
1.	Crustacean remains	4.52	6.06	27.3912	0.3045	2
2.	Digested matter	95.48	93.94	8969.3912	99.6955	1
	Total	100.00	100.00	8996.7824	100.0000	

TABLE 37

RELATIVE IMPORTANCE OF FOOD ITEMS IN THE STOMACH CONTENTS OF DUSSUMIERIA ACUTA FROM THE GULF OF MANNAR

Location: Gulf of Mannar. February 1971. Total No. of Fish: 70.

Sl. No.	Stomach contents	Percentage volume (V)	Percentage occurrence (O)	VO	$\frac{VO}{\Sigma VO} \times 100$	Rank
1.	Alima	4.85	7.50	36.3750	0.7974	3
2.	Copepods	0.59	2.50	1.4750	0.0323	5
3.	Isopods	0.21	2.50	0.5250	0.0115	6
4.	Crustacean remains	21.71	22.50	488.4750	10.7078	2
5.	Digested matter	66.76	60.00	4005.6000	87.8065	1
6.	Sand grains	5.88	5.00	29.4000	0.6445	4
	Total	100.00	100.00	4561.8500	100.0000	

TABLE 38

RELATIVE IMPORTANCE OF FOOD ITEMS IN THE STOMACH CONTENTS OF DUSSUMIERIA ACUTA FROM THE GULF OF MANNAR

Location: Gulf of Mannar. March 1971. Total No. of Fish: 24.

Sl. No.	Stomach contents	Percentage volume (V)	Percentage occurrence (O)	VO	$\frac{VO}{\Sigma VO} \times 100$	Rank
1.	Digested matter	100.00	100.00	10000.0000	100.0000	

were 3.80 in April 2.04 in May and 1.67 in June. In all other months it was absent.

Crustacean remains occurred as food from April to September and November to February. Its occurrence ranged from a minimum of 2.08% in July to a maximum of 30.20% in May. It attained the maximum index of 24.0738 in May whereas December stood second when the index was 16.6389. It secured the second rank amongst the food items during May, June and November to February.

Molluscs: Molluscs were absent in the stomach of D. acuta collected from the Gulf of Mannar during the period April 1970 to March 1971 except for a small squid occurred only once (1.26%) in a fish in April.

'Fishes': Juvenile fishes occurred as food in the stomach of D. acuta during April, May and September, Its importance as food can be understood from the fact that it ranked second in importance amongst the food items during April and September. It attained the maximum index (25.1643) during April with a maximum occurrence of 18.99%. In May it showed only 6.53% of occurrence whereas in September 18.33% was noticed. Fish eggs were present in the stomach only in June with 3.33% of occurrence.

'Plant materials': Plant materials were noticed as food only in small quantities in 1970 when they showed an occurrence of

2.53% in April, 3.33% in June and 1.67% in September. In no other months plant materials were noticed in the stomachs.

Fish scales were observed in the stomach during July to December when their occurrence ranged from 2.38% in December to 4.65% in November. Sand grains were noticed from July to December 1970 and February 1971.

Digested matter dominated over all the food items in all the months of observation except on May. Its occurrence ranged from a minimum of 9.39% in May to 100% in March.

Quantitative analysis of stomach contents of *D. acuta* from the Palk Bay centres during the period April 1970 to March 1971.

Data collected for a period of 8 months during April, June, July, August, November and December 1970 and February and March 1971 were available for observation from the Palk Bay during 1970-71 period and the details of the study are presented in Table 39 to 46.

Crustaceans: *Lucifer* was found to occur in all the months and its occurrence ranged from a minimum of 2.13% in November 1970 to a maximum of 37.08% in June 1970. Based on the index it obtained in each month it can be seen that it ranked first in July, December and February when the respective indices were 52.5908, 57.3962, and 44.3880. During June (33.5454) and August (23.5781) it ranked second. It ranked third in April (9.7475) and fourth in March (16.1319) among the food items during the respective months. It obtained a minimum index of 0.0183 in November when it had only the seventh rank.

Alima occurred as food during all the months other than June and August. It ranked first in the order of abundance during November when the index was 75.5208 with a maximum of 38.30% of occurrence. In March it had third rank with the index 17.4014 and 16.17% of occurrence. The minimum occurrence was noticed in February (1.53%).

Zoea was present in the stomach of _D. acuta_ during April, June, August and November 1970 and February and March 1971. Its occurrence ranged from a minimum of 0.76% in February to a maximum of 11.88% in April, and the index for these months were 0.0036 and 4.4150 respectively. Megalopa larva of crab occurred only in four months - November, December, February and March. Its occurrence was 6.38% each in November and December, 0.76% in February and 5.88% in March. The maximum index was noticed in March (0.5653).

Phyllosoma larva of lobster was present during August and March with a maximum occurrence in the former month (5.41%). Mysis stage of prawns was present only in March

TABLE 39

RELATIVE IMPORTANCE OF FOOD ITEMS IN THE STOMACH CONTENTS OF *DUSSUMIERIA ACUTA* FROM THE PALK BAY

Location: Palk Bay. April 1970. Total No.of Fish: 50.

Sl. No.	Stomach contents	Percentage volume (V)	Percentage occurrence (O)	VO	$\frac{VO}{\Sigma VO} \times 100$	Rank
1.	*Lucifer*	10.73	17.82	191.2086	9.7475	3
2.	Alima	7.94	9.90	78.6060	4.0072	6
3.	Zoea	7.29	11.88	86.6052	4.4150	5
4.	*Porcellana* larva	0.73	1.98	1.4454	0.0737	7
5.	Fish eggs	0.15	0.99	0.1485	0.0076	8
6.	'Fishes'	9.79	8.91	87.2289	4.4468	4
7.	Fish scales	0.04	0.99	0.0396	0.0020	9
8.	Crustacean remains	25.94	22.78	590.9132	30.1240	2
9.	Digested matter	37.39	24.75	925.4025	47.1760	1
	Total	100.00	100.00	1961.5979	99.9998	

May 1970, No samples

TABLE 40

RELATIVE IMPORTANCE OF FOOD ITEMS IN THE STOMACH CONTENTS OF *DUSSUMIERIA ACUTA* FROM THE PALK BAY

Location: Palk Bay. June 1970. Total No. of Fish: 50.

Sl. No.	Stomach contents	Percentage volume (V)	Percentage occurrence (O)	VO	$\frac{VO}{\Sigma VO} \times 100$	Rank
1.	*Lucifer*	28.14	37.08	1043.4312	33.5454	2
2.	Zoea	0.30	1.12	0.3360	0.0108	6
3.	Young prawns	0.50	2.25	1.1250	0.0362	5
4.	'Fishes'	1.70	1.12	1.9040	0.0612	4
5.	Crustacean remains	26.36	26.97	710.9292	22.8557	3
6.	Digested matter	43.00	31.46	1352.7800	43.4907	1
	Total	100.00	100.00	3110.5054	100.0000	

TABLE 41

RELATIVE IMPORTANCE OF FOOD ITEMS IN THE STOMACH CONTENTS OF *DUSSUMIERIA ACUTA* FROM THE PALK BAY

Location: Palk Bay. July 1970. Total No. of Fish: 17.

Sl. No.	Stomach contents	Percentage volume (V)	Percentage Occurrence (O)	VO	$\frac{VO}{\Sigma VO} \times 100$	Rank
1.	*Lucifer*	47.35	33.33	1578.1755	52.5908	1
2.	Alima	3.24	10.00	32.4000	1.0797	4
3.	Crustacean remains	24.12	36.67	884.4804	29.4743	2
4.	Digested mater	25.29	20.00	505.8000	16.8552	3
	Total	100.00	100.00	3000.8559	100.0000	

TABLE 42

RELATIVE IMPORTANCE OF FOOD ITEMS IN THE STOMACH CONTENTS OF *DUSSUMIERIA ACUTA* FROM THE PALK BAY

Location: Palk Bay. August 1970. Total No. of Fish: 15.

Sl. No.	Stomach contents	Percentage volume (V)	Percentage occurrence (O)	VO	$\frac{VO}{\Sigma VO} x 100$	Rank
1.	*Lucifer*	29.67	21.62	641.4654	23.5781	3
2.	Zoea	0.33	2.70	0.8910	0.0328	5
3.	Young prawns	1.67	5.41	9.0347	0.3321	4
4.	Phyllosoma	1.67	5.41	9.0347	0.3321	4
5.	*Porcellana* larva	0.33	2.70	0.8910	0.0328	5
6.	Crustacean remains	34.00	29.73	1010.8200	37.1542	2
7.	Digested matter	32.33	32.43	1048.4619	38.5379	1
	Total:	100.00	100.00	2720.5987	100.0000	

September and October 1970, No samples.

TABLE 43

RELATIVE IMPORTANCE OF FOOD ITEMS IN THE STOMACH CONTENTS OF **DUSSUMIERIA ACUTA** FROM THE PALK BAY

Location: Palk Bay. November 1970. Total No. of Fish: 19

Sl. No.	Stomach contents	Percentage volume (V)	Percentage occurrence (O)	VO	$\frac{VO}{\Sigma VO} \times 100$	Rank
1.	*Lucifer*	0.27	2.13	0.5751	0.0183	7
2.	Zoea	0.05	2.13	0.1065	0.0034	8
3.	Alima	61.84	38.30	2368.4720	75.5208	1
4.	Megalopa	0.42	6.38	2.6796	0.0854	5
5.	Fish eggs	0.53	4.26	2.2578	0.0720	6
6.	'Plant materials'	1.05	6.38	6.6990	0.2136	4
7.	Crustacean remains	20.84	25.53	532.0452	16.9647	2
8.	Digested matter	15.00	14.89	223.3500	7.1217	3
	Total	100.00	100.00	3136.1852	99.9999	

TABLE 44

RELATIVE IMPORTANCE OF FOOD ITEMS IN THE STOMACH CONTENTS OF *DUSSUMIERIA ACUTA* FROM THE PALK BAY

Location: Palk Bay. December 1970. Total No. of Fish: 29.

Sl. No.	Stomach contents	Percentage volume (V)	Percentage occurrence (O)	VO	$\frac{VO}{\Sigma VO} x100$	Rank
1.	*Lucifer*	50.95	27.66	1409.2770	57.3952	1
2.	Megalopa	2.04	6.38	13.0152	0.5301	5
3.	Eupagurid larva	0.14	2.13	0.2982	0.0121	8
4.	Alima	1.14	4.25	4.8450	0.1973	6
5.	*Acetes*	0.14	2.13	0.2982	0.0121	8
6.	'Fishes'	0.23	2.13	0.4899	0.0200	7
7.	'Plant materials'	5.54	10.64	58.9456	2.4007	4
8.	Crustacean remains	7.59	19.15	145.3485	5.9197	3
9.	Digested matter	32.23	25.53	822.8319	33.5118	2
	Total	100.00	100.00	2455.3495	100.0000	

January 1971, No samples.

TABLE 45

RELATIVE IMPORTANCE OF FOOD ITEMS IN THE STOMACH CONTENTS OF *DUSSUMIERIA ACUTA* FROM THE PALK BAY

Location: Palk Bay. February 1971. Total No.of Fish: 53.

Sl. No.	Stomach contents	Percentage volume (V)	Percentage occurrence (O)	VO	$\frac{VO}{\Sigma VO}$x100	Rank
1.	*Lucifer*	35.33	26.72	944.0176	44.3880	1
2.	Copepod	0.54	5.35	2.8890	0.1358	7
3.	Megalopa	0.08	0.76	0.0608	0.0029	12
4.	Alima	1.44	1.53	2.2032	0.1036	8
5.	Zoea	0.10	0.76	0.0760	0.0036	11
6.	Young prawns	0.38	2.29	0.8702	0.0409	9
7.	Bivalves	0.69	5.35	3.6915	0.1736	6
8.	'Fishes'	12.21	7.63	93.1623	4.3805	4
9.	Crustacean remains	25.21	25.19	635.0399	29.8598	2
10.	'Plant materials'	0.58	00.76	0.4408	0.0207	10
11.	Sand grains	2.21	3.05	6.7405	0.3169	5
12.	Digested matter	21.23	20.61	437.5503	20.5737	3
	Total	100.00	100.00	2126.7421	100.0000	

TABLE 46

RELATIVE INPORTANCE OF FOOD ITEMS IN THE STOMACH CONTENTS OF DUSSUMIERIA ACUTA FROM THE PALK BAY

Location: Palk Bay. March 1971. Total No.of Fish: 56.

Sl. No.	Stomach contents	Percentage volume (V)	Percentage occurrence (O)	VO	$\frac{VO}{\Sigma VO} \times 100$	Rank
1.	*Lucifer*	14.67	20.59	302.0553	16.1319	4
2.	Alima	20.15	16.17	325.8255	17.4014	3
3.	Megalopa	1.80	5.88	10.5840	0.5653	6
4.	Zoea	0.80	4.41	3.5280	0.1884	7
5.	*Porcellana* larva	0.30	2.20	0.6600	0.0352	10
6.	Mysids	0.19	0.74	0.1406	0.0075	11
7.	Phyllosoma	1.11	0.74	0.8214	0.0439	9
8.	Mysis larva	0.09	0.74	0.0666	0.0036	12
9.	Eupagurid larva	0.09	0.74	0.0666	0.0036	12
10.	Young prawns	0.83	1.74	1.4442	0.0771	8
11.	'Plant materials'	2.31	5.15	11.8965	0.6354	5
12.	Crustacean remains	32.44	25.46	825.9224	44.1102	1
13.	Digested matter	25.22	15.44	389.3968	20.7966	2
	Total	100.00	100.00	1872.4079	100.0001	

and the percentage of occurrence was 0.74. Pagurid larva was noticed in the stomach of D. acuta only in two months, December and March. Euphausids, amphipods, and isopods were completely absent. Mysis of family mysidacea was present only in March. Acetes showed 2.13% of occurrence in December and was absent in all other months. Copepod was found to occur only in February and the percentage of occurrence was 5.35. Procellana was observed in three months, April, August and March and the respective occurrence percentages were 1.98, 2.70 and 2.20. The maximum index noticed was 0.0737 in April. Young prawns were observed as food during the months of June, August, February and March and the percentage occurrence ranged from a minimum of 1.74 in March to a maximum 5.41 in August. The maximum index (0.3321) was in August and the minimum (0.0362) in June.

Crustacean remains were found to occur in the stomach of D. acuta in all the months of observation from the Palk Bay centres during the period 1970-71. The occurrence ranged from a minimum of 19.15% in December to a maximum of 36.67% in July. It obtained first rank amongst the food items during March when the index was 44.1102 with an occurrence of 25.46%. During April, July, August, November and February its rank was second and during June and December the rank was only third.

Molluscs: Molluscs were represented only by bivalve larvae during the month of February and the occurrence percentage was 5.35 and the index 0.1736.

'Fishes': Juvenile fishes occurred in the stomach of D.acuta from the Palk Bay centres in April, June and December 1970 and February 1971, and the percentage of occurrence in these months were 8.91, 1.12, 2.13, and 7.63 respectively. The maximum index was noticed in April (4.4468) and the minimum in December (0.0200). Fish eggs were noticed only in April and November with a maximum occurrence of 4.26% in November.

'Plant materials': 'Plant materials' were observed in the stomach during November and December 1970 and February and March 1971. Maximum occurrence of 10.64% was noticed in December and minimum of 0.76% in February. It occurred 6.38% in November and 5.15% in March.

Fish scales were noticed only during April and November whereas sand grains were present only during February.

Digested matter dominated among all other food items during the months of April, June and August when it ranked first. It occurred in the stomach in all the months and the percentage of occurrence ranged from a minimum of 14.89 in November to a maximum of 32.43 in August. Maximum index was noticed in April (47.1760) and minimum in November (7.1217).

PLATE VII

Fig. 1 Month-wise average volume points of stomach contents of Dussumieria acuta in day and night samples during 1969-70.

Fig. 2 Month-wise average volume points of stomach contents of D. acuta in day and night samples during 1970-71.

Fig. 3-9 Month-wise percentage occurrence of some selected food items of D. acuta for two years.

Fig. 3 Lucifer

Fig. 4 Alima

Fig. 5 Zoea

Fig. 6 Young prawns

Fig. 7 Crustacean remains

Fig. 8 'Fishes'

Fig. 9 'Plant materials'.

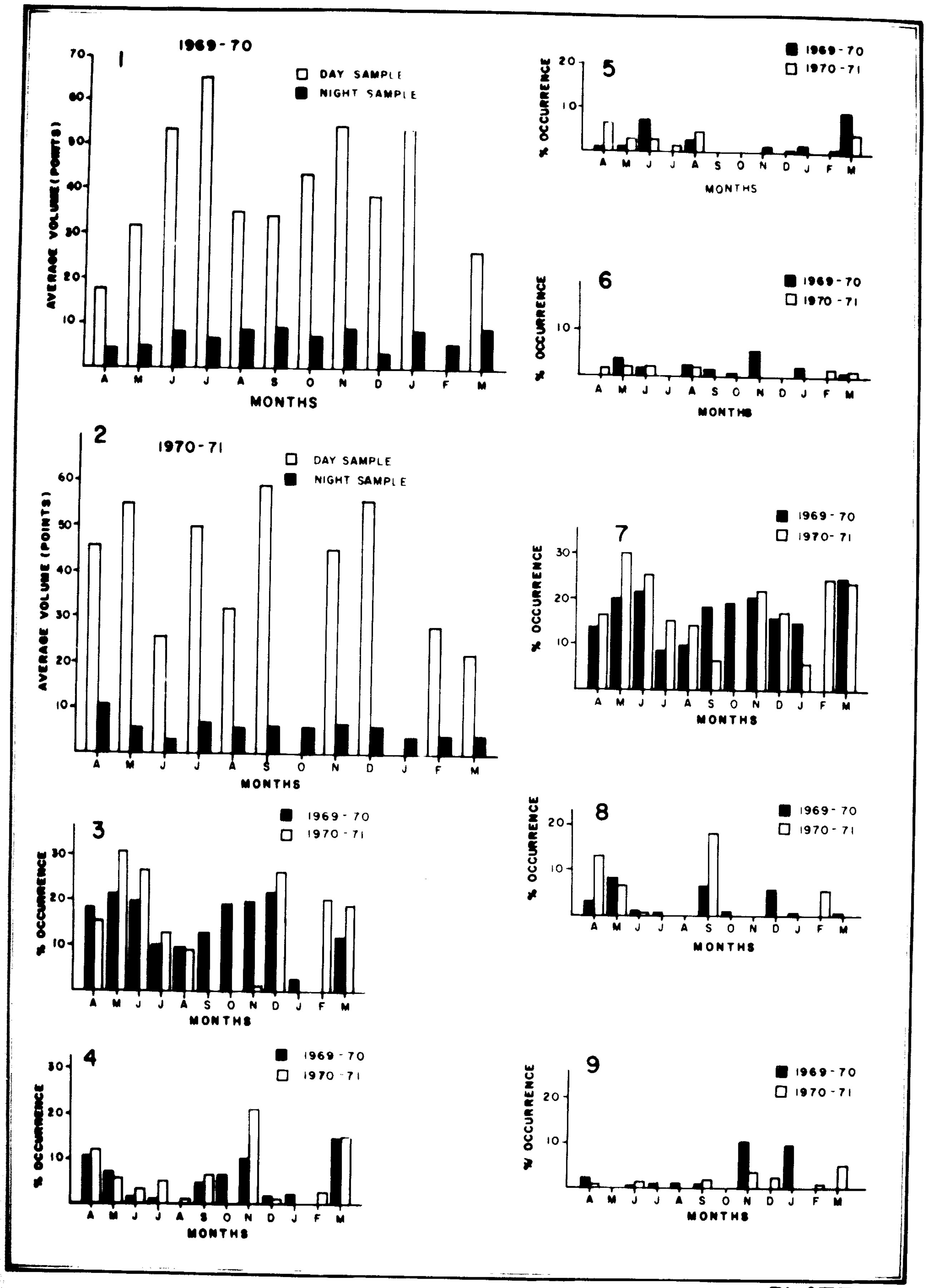

1
1969-70
DAY SAMPLE
NIGHT SAMPLE
AVERAGE VOLUME (POINTS)
MONTHS
2
1970-71
DAY SAMPLE
NIGHT SAMPLE
AVERAGE VOLUME (POINTS)
MONTHS
3
1969-70
1970-71
% OCCURRENCE
MONTHS
4
1969-70
1970-71
% OCCURRENCE
MONTHS
5
1969-70
1970-71
% OCCURRENCE
MONTHS
6
1969-70
1970-71
% OCCURRENCE
MONTHS
7
1969-70
1970-71
% OCCURRENCE
MONTHS
8
1969-70
1970-71
% OCCURRENCE
MONTHS
9
1969-70
1970-71
% OCCURRENCE
MONTHS
A M J J A S O N D J F M

PLATE. VII

4.3. DIURNAL VARIATION IN FEEDING HABITS

During the course of this investigation a significant variation in the feeding intensity of *Dussumieria acuta* between day and night was noticed. For this study samples collected from shore-seine, trawl net and gill net were used. Since the exact time of capture was not available, the samples were generally grouped into two major categories, day samples and night samples. The day sample comprised of those fishes caught during the day time between 6 a.m and 6 p.m and the night samples referred to those fishes caught in the night, mostly in the early morning before the sunrise.

A total number of 874 fish from day catch and 1373 fish from night catch were analysed for this study during the period April 1969 to March 1971. The percentage occurrence of stomachs in various degrees of fulness in day and night samples were calculated and the results are presented in Tables 47 and 48. From the volume points alloted to each stomach, according to its degree of fulness, the average volume points were calculated for each month by dividing the total volume points attained by all the fishes for the month by the total number of fish examined in that month. The fishes with the empty stomachs were also incorporated in this calculation. The average volume points thus calculated for day and night samples in different months are presented in Plate VII, Figs. 1 and 2.

TABLE 47

PERCENTAGE OCCURRENCE OF THE STOMACHS OF <u>DUSSUMIERIA ACUTA</u> IN VARIOUS DEGREE OF FULNESS IN DAY AND NIGHT SAMPLES (APRIL 1969 TO MARCH 1970)

Months (1)	Time (2)	Gorged % (3)	Full % (4)	$\frac{3}{4}$ full % (5)	$\frac{1}{2}$ full % (6)	$\frac{1}{4}$ full % (7)	'Little' % (8)	Empty % (9)	No. of fhish (10)
April	Day	—	2.56	5.13	5.13	17.95	69.23	—	39
	Night	—	—	—	—	—	41.18	58.82	51
May	Day	8.80	7.20	9.60	8.80	22.40	34.40	8.80	125
	Night	—	—	—	—	—	47.83	52.17	23
June	Day	16.36	18.18	18.18	16.36	23.64	3.64	3.64	55
	Night	—	—	—	0.93	1.87	71.03	26.17	107
July	Day	23.08	38.46	15.38	—	15.38	7.69	—	13
	Night	—	—	—	—	0.79	63.49	35.72	126
August	Day	8.33	8.33	16.67	—	33.33	33.33	—	12
	Night	—	—	—	—	3.08	76.92	20.00	65
September	Day	4.65	16.28	13.95	6.98	18.60	37.21	2.33	43
	Night	—	—	—	—	2.22	82.22	15.56	45

Continued

Table 47(Contd.....)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
October	Day	6.06	21.21	15.15	15.15	15.15	21.21	6.06	33
	Night	—	—	2.04	—	—	57.14	40.82	49
November	Day	17.14	22.86	8.57	22.86	17.14	8.57	2.86	35
	Night	—	2.38	—	—	4.76	57.14	35.71	42
December	Day	—	27.78	5.55	22.22	11.11	16.67	16.67	18
	Night	—	—	—	—	—	32.79	67.21	61
January	Day	—	39.13	21.74	8.70	26.09	4.35	—	23
	Night	—	—	—	—	—	83.05	16.95	59
February	Day			No sample					
	Night	—	—	—	—	—	55.41	44.59	74
March	Day	8.00	6.00	4.00	8.00	12.00	48.00	14.00	50
	Night	—	—	—	—	5.26	78.95	15.79	19
Total									1167

TABLE 48

PERCENTAGE OCCURRENCE OF THE STOMACHS OF DUSSUMIERIA ACUTA IN VARIOUS DEGREE OF FULNESS IN DAY AND NIGHT SAMPLES (APRIL 1970 TO MARCH 1971)

Month (1)	Time 2)	Gorged % (3)	Full % (4)	$\frac{3}{4}$ full % (5)	$\frac{1}{2}$ full % (6)	$\frac{1}{4}$ full % (7)	'Little' % (8)	Empty % (9)	No.of fish (10)
April	Day	19.70	16.67	3.03	10.61	22.73	24.24	3.03	66
	Night	4.17	—	—	—	—	62.50	33.33	24
May	Day	9.52	22.62	26.19	21.42	11.90	8.33	—	84
	Night	—	—	—	—	—	56.15	43.75	16
June	Day	1.35	6.67	8.11	16.22	12.16	51.35	4.05	74
	Night	—	—	—	—	—	28.95	71.05	38
July	Day	17.65	23.53	11.76	—	17.65	29.41	—	17
	Night	—	—	—	—	1.43	62.86	35.71	70
August	Day	6.67	6.67	13.33	6.67	26.67	40.00	—	15
	Night	—	1.18	—	—	1.18	51.76	45.87	85
Sept.	Day	13.33	40.00	13.33	6.67	6.67	20.00	—	15
	Night	—	—	—	—	2.56	56.41	41.03	39

(Continued)

Table 48 (Contd....)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
October	Day			No sample					
	Night	—	—	—	—	—	57.59	42.11	76
November	Day	5.26	21.05	15.79	15.79	31.58	10.53	—	19
	Night	—	—	—	2.04	—	57.14	40.82	49
December	Day	35.29	17.65	5.88	5.88	17.65	5.88	11.76	17
	Night	—	2.22	—	—	5.56	31.11	61.11	90
January	Day			No sample					
	Night	—	—	—	—	—	37.35	62.65	83
February	Day	4.62	4.62	12.31	9.23	23.07	41.53	4.62	65
	Night	—	—	—	—	—	41.38	58.62	58
March	Day	—	—	12.50	10.71	30.36	42.86	3.57	56
	Night	—	—	—	—	—	41.67	58.33	24
Total									1080

During the year April 1969 to March 1970 (Plate VII, Fig.1) it may be noticed that the monthly average volume points of the night samples ranged from 3.28 in December to 8.95 in March and in the night samples from 17.77 points in April to 65.38 points in July. This shows that the monthly averages were less than 'trace' condition (10 points) in night samples and above 30 points in day sample, except for April and March. No day samples were available in February. During the subsequent year, April 1970 to March 1971 (Pl. VIII Fig.2) the average volume in the night samples ranged from 2.89 in June to 10.41 in April, whereas in the day samples the points varied from 22.14 in March to 59.33 in September. In the night samples, except for April, the average volume was less than 7 and in the day samples except for June, February and March it was above 30 (no day samples in January and October). This shows that there is a clear variation in feeding intensity of D. acuta between day and night.

D. acuta caught in the night had their stomachs completely shrunken with thick walls and prominent internal folds and most of these contained no food items and were completely empty. The stomachs with a condition of feed 'little' contained trace of highly digested and macerated materials where the identity of food items had completely lost. Stomachs with higher conditions of feed were very rarely noticed. Contrary to this the fish caught in the day time had stomachs with various degrees of fullness. Only very few stomachs were empty and those designated as 'little' had their walls showing the signs of dilation by softening of the stomach walls and smoothening of the internal folds. The food items present inside were fresh and were clearly identifiable. This indicated that the fish has just commenced to feed. It may be emphasized that while the category 'little' in the night samples is the end point of the process of digestion, that of the day (morning hours) samples is the commencement of the feeding activity.

During the period, April 1969 to March 1971 samples from night catch were available in all the months. Except for February 1970, October 1970 and January 1971 day samples were available in all other months.

Throughout the period it was observed that the percentage of empty stomach was very low in day samples, whereas it was very high in night samples (Table 47). In the day samples during the first year the empty stomach ranged from a minimum of 2.33% in September 1969 to 16.67% in December 1969. In April, July and August 1969 and in January 1970 empty stomachs were completely absent in day samples. The percentage of empty stomachs in the day samples for the whole year was only 6.05% (Table 49). In the night samples, during this period, the empty stomachs ranged from a minimum of 15.56% in September 1969 to a maximum of 67.21% in December 1969 and empty stomachs were present in all the months without any exception (Table 47), and it gave a value of 35.64% for the year (Table 49). The percentage of 'little' stomachs in the day samples during this period was 29.37 (Table 49) which ranged from 3.64% in June 1969 to 69.23% in April 1969. In the night samples the percentage of 'little' stomach was 62.69 and ranged from 32.79% in December to 83.05% in January 1969.

During the subsequent year, April 1970 to March 1971, (Table 48) in the day samples the empty stomachs ranged from a minimum of 3.03% in April 1970 to a maximum of 11.76% in December 1970, with a value of 2.57% for the year (Table 49). Empty stomachs were completely absent in May, July, August, September and November 1970. In the night samples during this period the empty stomachs ranged from a minimum of 33.33% in April 1970 to a maximum of 71.05% in June 1970 (Table 48), with a value of 50.61% for the whole year (Table 49). Empty stomachs were observed in all the months in night samples during this period. The percentage value of 'little' stomachs in day sample was 30.14 which ranged from 5.88% in December to 51.35% in June. In the night samples for the year 47.55% stomachs were in

TABLE 49

PERCENTAGE OCCURRENCE OF STOMACHS IN THREE MAIN CATEGORIES OF FULNESS SHOWING THE DIURNAL VARIATION IN FEEDING ACTIVITY IN DUSSUMIERIA ACUTA FOR THE PERIOD APRIL 1969 TO MARCH 1971

Years	Degree of fullness	Day		Night	
		No. of fish	Percentage	No. of fish	Percentage
1969-70	Empty	27	6.05	257	35.64
	'Little'	131	29.37	452	62.69
	1/4 full and above	288	64.58	12	1.67
1970-71	Empty	12	2.57	330	50.61
	'Little'	129	30.14	310	47.55
	1/4 full and above	287	67.29	12	1.84

the category of 'little' (Table 49) which ranged from 28.95% in June 1970 to 62.86% in July 1970 (Table 48).

In general, in the day sample only 6.05% stomachs during the first year and 2.57% stomachs in the second year were empty, whereas the rest contained fresh food items in various degrees of fullness (Table 49). In the night sample (Table 49), 98.33% stomachs during the first year and 98.16% during the second year were either 'empty' or 'little'. Since the 'little' stomachs of the night samples contained no fresh food components other than some pulpy digested matter, it was inferred that, in effect, in the night samples, the fishes with both these categories of stomachs ('little' and 'empty') were not feeding in the night. It was observed in the night samples that, only 1.67% fishes during the first year and 1.84% fishes during the second year had stomachs with various degrees of fulness. These low values revealed that the feeding activity of _D. acuta_ was negligibly low in the night and even if any occurred, could only be accidental.

The occurrence of such a diurnal variation in the feeding intensity of _D. acuta_ suggests the possibility of the illumination being linked with the feeding habit of this fish. From the qualitative analysis of the stomach contents, it was evident that the fish fed mainly on crustaceans, especially *Lucifer*, alima, zoea, megalopa, etc., and other than crustaceans they fed mainly on 'fishes' of which *Stolephorus* sp. was the dominant one. They also ingested some 'plant materials' but no diatoms were observed in the stomach. Such a composition of the diet suggests that the fish prefer some food items to others and in order to pick up these favourite items from among the myriads of planktonic items around them, *D. acuta*, make use of the day light illumination and has adopted a habit of day feeding.

4.4. COMPARISON OF THE STOMACH CONTENTS OF *DUSSUMIERIA ACUTA* FROM THE GULF OF MANNAR AND THE PALK BAY.

For a comparison between the stomach contents of *D. acuta* from the Gulf of Mannar and the Palk Bay, data were available for most of the months, during the two year period from April 1969 to March 1971. From the Gulf of Mannar area, though samples were available in all the months, only empty stomachs or stomachs with some digested matter and accidental inclusions were available during August 1969; January, February and October 1970; and January and February 1971. This can be attributed to the day feeding habit of the fish and the non-availability of the day samples during these months. So in effect, these months were not taken into account in this comparative study of the food of fishes from these two different localities. Also, during the other months, fewer day samples were available from the Gulf of Mannar. Hence the varieties of food items and their relative abundance were much less during certain months and for the same reason almost in all the months the digested matter ranked first in order of abundance. From the Palk Bay, except in May and October 1970 and in January 1971, in all other months samples were available for comparison and since majority of them were from day catches their stomachs invariably contained varieties of fresh and identifiable food items. In short, data for actual comparison of food of D. acuta from the Gulf of Mannar and the Palk Bay was available only in April, June, July, September, October and November 1969 and in March 1970 during the first year (April 1969 to March 1970) and in April, June, July, August, November and December 1970 and in February 1971 during the second year (April 1970 to March 1971). In this comparison since the general categories like digested matter and crustacean remains were only unidentifiable remnants of food items, and others like fish scales and sand grains were only accidental inclusions they were omitted and only identifiable food items were taken into consideration.

A comparative account of the percentage of occurrence of various food items observed in the stomachs of D. acuta from the Gulf of Mannar and the Palk Bay in different months from April 1969 to March 1971 is presented in Tables 50 and 51. The following comparison is made in terms of abundance based on the index of preponderence.

During the first year, (Table 50) in April 1969, alima was the dominant food item in the diet of D. acuta from the Gulf of Mannar and Lucifer ranked second in abundance. In the stomachs of fish from the Palk Bay, during this month, the same two items, Lucifer and alima were observed, but the former dominated.

In the stomach of fish from both the Gulf of Mannar and the Palk Bay Lucifer was the predominant item during June 1969 which was followed by zoea in those from the Gulf of Mannar and by alima and megalopa in those from the Palk Bay. In these months the varieties of food items were greater in the Gulf of Mannar samples than those from the Palk Bay.

During July 1969 the number of actively fed fish was very low in the Gulf of Mannar samples. The number of food items and their abundance were poor and amongst these, copepod was dominant. In the diet of the fish from Palk Bay, though the varieties were few, Lucifer dominated in this month, juvenile fishes ranking second.

TABLE 50

A COMPARISON OF THE PERCENTAGE OCCURRENCE OF VARIOUS FOOD ITEMS OF DUSSUMIERIA ACUTA FROM THE GULF OF MANNAR AND THE PALK BAY IN DIFFERENT MONTHS FOR THE PERIOD APRIL 1969 TO MARCH 1970

Sl. No.	Food items	Months/Locality											
		April		May		June		July		August		September	
		G.M.	P.B.	G.M.	P.B.	G.M.	P.B.	G.M.	P.B.	G.M.	P.B.	G.M.	P.B.
1.	*Lucifer*	13.48	31.42	21.65	—	18.48	27.27	1.11	42.30	—	25.80	—	28.33
2.	Alima	13.48	2.86	7.12	—	0.95	4.55	—	3.85	—	—	2.90	6.67
3.	Zoea	1.12	—	0.86	—	8.06	2.27	—	—	—	6.45	—	—
4.	Megalopa	—	—	4.27	—	0.47	4.55	1.11	—	—	—	—	1.67
5.	Phyllosoma	—	—	—	—	—	—	—	—	—	3.23	—	—
6.	Mysis	—	—	0.29	—	0.47	4.55	—	—	—	—	1.45	—
7.	Euphausid	—	—	—	—	—	—	—	—	—	—	—	—
8.	Eupagurid larva	—	—	—	—	2.37	—	—	—	—	—	—	—
9.	Amphipods	—	—	—	—	—	—	—	—	—	—	—	—
10.	Isopod	—	—	—	—	0.47	—	—	—	—	—	—	—
11.	Copepod	—	—	1.99	—	3.32	—	1.11	—	—	—	—	—
12.	Mysid	—	—	—	—	—	—	—	—	—	—	—	—

Continued

Table 50 (Contd.....)

Sl. No.	Food items	Months/Locality											
		October		November		December		January		February		March	
		G.M.	P.B.	G.M.	P.B.	G.M.	P.B	G.M.	P.B.	G.M.	P.B.	G.M.	P.B
1.	*Lucifer*	19.05	20.00	3.45	24.30	22.00	—	—	4.49	—	—	8.70	14.93
2.	Alima	1.19	20.00	—	13.08	2.00	—	—	3.37	—	—	8.70	14.40
3.	Zoea	—	—	—	—	—	—	—	2.25	—	—	—	14.93
4.	Megalopa	—	5.71	—	6.55	—	—	—	8.99	—	—	—	—
5.	Phyllosoma	—	—	—	—	—	—	—	—	—	—	—	—
6.	Mysis	—	—	—	—	2.00	—	—	3.37	—	—	—	1.49
7.	Euphausid	3.57	2.86	—	—	—	—	—	4.49	—	—	—	—
8.	Eupagurid larva	—	—	—	1.87	—	—	—	3.37	—	—	—	—
9.	Amphipods	—	—	—	—	—	—	—	5.63	—	—	2.17	—
10.	Isopod	—	—	—	—	—	—	—	—	—	—	—	—
11.	Copepod	—	—	—	0.93	2.00	—	—	3.37	—	—	—	—
12.	Mysid	2.38	—	—	—	2.00	—	—	2.25	—	—	—	—

Continued

Table 30 (Contd.....)

Sl. No.	Food items	April G.M.	April P.B	May G.M.	May P.B.	June G.M.	June P.B.	July G.M.	July P.B.	August G.M.	August P.B.	September G.M.	September P.B.
13.	*Acetes*	—	—	—	—	—	—	—	—	—	—	—	—
14.	*Porcellana* larva	—	—	—	—	0.47	—	—	—	—	—	—	1.67
15.	Young prawns	-	—	3.99	—	2.37	—	—	—	—	6.45	—	3.33
16.	Crustacean remains	4.50	37.14	20.23	—	22.28	18.18	—	38.46	—	25.80	7.25	31.66
17.	Bivalve larva	—	—	0.29	—	—	—	—	—	—	—	—	—
18.	Gastropod larva	—	—	—	—	—	—	—	—	—	—	—	—
19.	'Plant materials'	3.37	—	—	—	0.47	—	1.11	—	1.89	—	1.45	—
20.	Digested matter	44.94	28.58	19.94	—	36.74	31.81	90.00	7.69	98.11	29.04	71.01	18.33
21.	'Fishes'	4.50	—	8.26	—	0.95	2. 27	—	3.85	—	—	14.49	—
22.	Fish eggs	—	—	—	—	0.95	—	—	—	—	—	—	—
23.	Fish scale	2.25	—	3.70	—	0.95	4.55	2.22	3.85	—	3.23	1.45	6.67
24.	Sand grains	12.36	—	7.41	—	—	—	3.34	—	—	—	—	1.67

Continued

Table 90 (Contd....)

Sl. No.	Food items	Months/Locality											
		October		November		December		January		February		March	
		G.M.	P.B.	G.M.	P.B.	G.M.	P.B.	G.M.	P.B.	G.M.	P.B.	G.M.	P.B.
13.	*Acets*	3.57	—	—	—	—	—	—	2.25	—	—	—	—
14.	*Porcellana* larva	3.57	—	—	0.93	—	—	—	1.12	—	—	4.53	—
15.	Young prawns	1.19	—	—	7.48	—	—	—	3.37	—	—	2.17	—
16.	Crustacean remains	16.67	25.71	—	26.17	16.00	—	—	23.59	—	—	17.39	29.85
17.	Bivalve larva	—	—	—	—	—	—	—	—	—	—	—	—
18.	Castroped larva	—	—	—	—	—	—	2.00	—	—	—	—	—
19.	'Plant material'	—	—	—	13.08	—	—	—	14.61	—	—	—	—
20.	Digested matter	35.72	22.86	86.20	3.74	48.00	—	96.00	12.36	97.92	—	50.00	14.93
21.	'Fishes'	—	2.86	—	—	6.00	—	—	1.12	—	—	2.17	—
22.	Fish eggs	—	—	—	—	—	—	—	—	—	—	—	4.47
23.	Fish scale	4.76	—	3.45	—	—	—	—	—	—	—	—	—
24.	Sand grains	8.33	6.90	1.87	—	—	—	2.00	—	2.38	—	4.35	—

G.M: Gulf of Mannar: P.B = Palk Bay

The stomach contents of fish from the Gulf of Mannar revealed juvenile fishes as the most dominant item of food in September 1969, whereas in this month it was Lucifer that dominated over all other items in the diet of the fish from the Palk Bay. In both these localities alima ranked second in the order of abundance.

During October 1969 in the fish from both the Gulf of Mannar and the Palk Bay Lucifer was the predominant item of food, which was followed by alima in the latter locality.

Lucifer was the only food item noticed in the diet of fishes from the Gulf of Mannar during November 1969, while there was a great variety of items in the stomach contents of fish from the Palk Bay, of which Lucifer was the most predominant item, followed by alima and 'plant materials' in the order of abundance.

In the diet of fish from both the Gulf of Mannar and the Palk Bay, during March 1970, alima was the dominant item and was followed by Lucifer in both these localities. Zoea had a third rank in the Palk Bay samples and this place was occupied by juvenile fishes, in the Gulf of Mannar samples.

In the subsequent year (April 1970 to March 1971) (Table 51) during April the stomach of fish from the Gulf of Mannar contained 'fishes', and fish from the Palk Bay had

Lucifer as the dominant food items . In the former locality 'fishes' were followed by Lucifer and alima, while in the latter case it was 'fishes', zoea and alima that followed Lucifer in order of abundance.

In the diet of fish from both the Gulf of Mannar and the Palk Bay Lucifer was the most dominant item during June 1970. Alima ranked second, next to Lucifer in the food of the Gulf of Mannar samples and this place was occupied by 'juvenile fishes' in the Palk Bay samples.

There were fewer food items during July 1970 in both the localities. In the Gulf of Mannar samples alima and zoea were the only items of which the former slightly dominated over the latter and in fish from the Palk Bay the items noticed were Lucifer and alima of which Lucifer was the predominant one.

During August 1970, zoea was the dominant item in the food of the fish from the Gulf of Mannar while Lucifer dominated in the diet in fish from the Palk Bay followed by young prawns and phyllosoma.

In the stomach of fish from the Gulf of Mannar alima and Acetes were the only items observed during November 1970 and they were equally ranked. In the Palk Bay samples during this month the items were more and amongst them alima was the most predominant one.

Lucifer dominated as the important food item in the diet of the fish from both these localities during December 1970. In the Gulf of Mannar samples alima was second in abundance next to *Lucifer* and this place was occupied by 'plant materials' in the Palk Bay samples. During this month there was a greater variety of food items in the stomach of fish from the Palk Bay as compared to the fish from the Gulf of Mannar.

During February 1971 too, a greater variety of items was noticed in the Palk Bay samples than in those of the Gulf of Mannar. In the latter case, alima, copepod and isopod, in order of abundance, were the only items. In the diet of fish from the Palk Bay in this month, *Lucifer* was the most predominant item. Juvenile fishes ranked next to *Lucifer*.

The particulars given above on the diet of *D. acuta* from the Gulf of Mannar and the Palk Bay at the same period indicate that the major food constituents were essentially same in both these localities. The relative importance of any given item at one place was probably due to the abundance of that item in the environment there.

TABLE 51

A COMPARISON OF THE PERCENTAGE OCCURRENCE OF VARIOUS FOOD ITEMS OF <u>DUSSUMIERIA ACUTA</u> FROM THE GULF OF MANNAR AND THE PALK BAY IN DIFFERENT MONTHS FOR THE PERIOD APRIL 1970 TO MARCH 1971

Sl. No.	Food items	Months/Locality											
		April		May		June		July		August		September	
		G.M.	P.B.	G.M.	P.B.	G.M.	P.B.	G.M.	P.B.	G.M.	P.B.	G.M.	P.B.
1.	*Lucifer*	12.66	17.82	31.02	—	11.67	37.08	—	33.33	—	21.62	—	—
2.	Alima	15.91	9.90	5.71	—	8.33	—	2.08	10.00	1.85	—	6.67	—
3.	Zoea	—	11.88	2.86	—	5.00	1.12	2.08	—	5.36	2.70	—	—
4.	Megalopa	—	—	3.67	—	—	—	—	—	—	—	—	—
5.	Phyllosoma	—	—	—	—	—	—	—	—	—	5.41	—	—
6.	Mysis	—	—	1.63	—	—	—	—	—	—	—	—	—
7.	Euphausid	—	—	—	—	—	—	—	—	1.85	—	—	—
8.	Eupagurid larva	—	—	0.41	—	—	—	—	—	—	—	—	—
9.	Amphipod	2.53	—	—	—	—	—	—	—	—	—	—	—
10.	Isopod	—	—	—	—	—	—	—	—	—	—	—	—
11.	Copepod	—	—	5.31	—	—	—	—	—	—	—	—	—
12.	Mysid	—	—	—	—	—	—	—	—	—	—	—	—

Continued

Table 51 (Contd......)

Sl. No.	Food items	Months/Locality											
		October		November		December		January		February		March	
		G.M.	P.B.	G.M.	P.B.	G.M.	P.B.	G.M.	P.B.	G.M.	P.B.	G.M.	P.B.
1.	<u>Lucifer</u>	—	—	—	2.13	9.53	27.66	—	—	—	26.72	—	20.59
2.	Alima	—	—	2.33	38.30	2.38	4.25	—	—	7.50	1.53	—	16.17
3.	Zoea	—	—	—	2.13	2.38	—	—	—	—	0.76	—	4.41
4.	Megalopa	—	—	—	6.38	—	6.38	—	—	—	0.76	—	5.88
5.	Phyllosoma	—	—	—	—	—	—	—	—	—	—	—	0.74
6.	Mysis	—	—	—	—	—	—	—	—	—	—	—	0.74
7.	Euphausid	—	—	—	—	—	—	—	—	—	—	—	—
8.	Eupagurid larva	—	—	—	—	—	2.13	—	—	—	—	—	0.74
9.	Amphipod	—	—	—	—	—	—	—	—	—	—	—	—
10.	Isopod	—	—	—	—	—	—	—	—	2.50	—	—	—
11.	Copepod	—	—	—	—	—	—	—	—	2.50	5.35	—	—
12.	Mysid	—	—	—	—	—	—	—	—	—	—	—	0.74

Continued

Table 51 (Contd....)

Sl. No.	Food items	Months/Locality											
		April		May		June		July		August		September	
		G.M.	P.B.	G.M.	P.B.	G.M.	P.B.	G.M.	P.B.	G.M.	P.B.	G.M.	P.B.
13.	*Acetes*	—	—	1.23	—	—	—	—	—	—	—	—	—
14.	*Porcellana* larva	3.80	1.98	—	—	—	—	—	—	—	2.70	—	—
15.	Young prawns	3.80	—	2.04	—	1.67	2.25	—	—	—	5.41	—	—
16.	Crustacean remains	8.80	22.78	30.20	—	23.33	26.97	2.08	36.67	3.70	29.73	6.67	—
17.	Bivalve larva	—	—	—	—	—	—	—	—	—	—	—	—
18.	Squid	1.26	—	—	—	—	—	—	—	—	—	—	—
19.	'Plant materials'	2.53	—	—	—	3.33	—	—	—	—	—	1.67	—
20.	Digested matter	30.38	24.75	9.39	—	43.33	31.46	83.34	20.00	81.44	32.43	60.00	—
21.	'Fishes'	18.99	8.91	6.53	—	—	1.12	—	—	—	—	18.33	—
22.	Fish eggs	—	0.99	—	—	—	—	—	—	—	—	—	—
23.	Fish scale	—	0.99	—	—	—	—	4.17	—	3.70	—	3.33	—
24.	Sand grains	—	—	—	—	—	—	6.25	—	1.85	—	3.33	—

Continued

Table 51 (Contd....)

Sl. No.	Food items	October		November		December		January		February		March	
		G.M.	P.B.	G.M.	P.B.	G.M.	P.B.	G.M.	P.B.	G.M.	P.B.	G.M.	P.B.
13.	*Acetes*	—	—	2.33	—	—	2.13	—	—	—	—	—	—
14.	*Porcellana* larva	—	—	—	—	—	—	—	—	—	—	—	2.20
15.	Young prawns	—	—	—	—	—	—	—	—	—	2.29	—	1.74
16.	Crustacean remains	—	—	18.60	25.53	26.19	19.15	6.06	—	22.50	25.19	—	25.46
17.	Bivalve larva	—	—	—	—	—	—	—	—	—	5.35	—	—
18.	Squid	—	—	—	—	—	—	—	—	—	—	—	—
19.	'Plant materials'	—	—	—	6.38	—	10.64	—	—	—	0.76	—	5.15
20.	Digested matter	91.66	—	62.79	14.53	52.38	25.53	93.94	—	60.61	20.00	100.00	15.44
21.	'Fishes'	—	—	—	—	—	2.13	—	—	—	7.63	—	—
22.	Fish eggs	—	—	—	4.26	—	—	—	—	—	—	—	—
23.	Fish scale	4.17	—	4.65	14.89	2.38	—	—	—	—	—	—	—
24.	Sand grains	4.17	—	9.30	—	4.76	—	—	—	5.00	3.05	—	—

G.M = Gulf of Mannar; P.B = Palk Bay

4.5. YEAR TO YEAR VARIATION IN THE FOOD OF *DUSSUMIERIA ACUTA* FROM APRIL 1969 TO MARCH 1971.

A comparison of the analysis of stomach contents of *Dussumieria acuta* for two consecutive years, April 1969 to March 1970 and April 1970 to March 1971 was made during this study. For this purpose the samples from the Gulf of Mannar and the Palk Bay were pooled together month-wise, since there was no qualitative difference observed in the diet between samples of *D. acuta* from these two localities. The percentage occurrence, the percentage volume points and the index of preponderence obtained by each food item were calculated separately for the years mentioned above. The results are presented in Tables 52, 53 and 54 respectively.

In both the years crustaceans were the group that constituted the main food of this fish. During the first year *Lucifer* was present in all the months except in February 1970 whereas during the second year it was absent in three months in September and October 1970 and January 1971 (Pl. VII, Fig. 3). During the first year maximum occurrence was noticed in December 1969 with May 1969 ranking second, whereas during the second year these places were secured by May 1970 and December 1970 (Table 52).

Alima, like *Lucifer*, was found to occur in almost all the months of both the years except August 1969, February and

October 1970 and January 1971 (Pl. VII, Fig.4). In March during both the years the occurrence was almost same (15.64% and 15.07% respectively). During the first year maximum occurrence was in March 1970, whereas the maximum during the second year was in November 1970 (Table 52). This seems to indicate that alima is an equally important food item of D. acuta, as Lucifer, and was consumed in large quantities whenever available.

Zoea was observed in smaller quantities in April to June, August, January and March during the first year and in all the months other than September, October 1970 and January 1971 during the second year (Pl. VII, Fig.5).

Megalopa, compared to zoea, was observed in 7 months during the first year with the absence in the months of April, August and December 1969 and February and March 1970. But during the second year only in 5 months, in May, November, December 1970 and February and March 1971, it was observed among the food of D. acuta. In both the years it was absent during April (Table 52).

Mysis stage of prawns occurred in May, June, September, December, January and March during the year 1969-70 while it was present only in two months - May and March - during the subsequent year 1970-71.

Eupagurid larvae were present only in November 1969, January, March and December 1970 during the first year and only in March 1971. It occurred only in very few numbers.

During the first year euphausids were present in three months - June, October and January; but in the next year it was present only in August. Amphipods were observed in January and March during the first year, whereas they occurred in March only during the second year. Isopods were present only in one month of each year i.e. June 1969 and February 1971.

Mysid was present in October, December and January during the year 1969-70 while it was observed only in March of the year 1970-71. Acetes occurred in two months - October and January - during first year and in three months - May, November and December - during second year.

Copepod was noticed in May to July and November to January in 1969-70, while it occurred only in May and February in 1970-71. Porcellana showed a higher occurrence during the first year than in the second year by appearing for five months in the first and three months in the second year.

Young prawn was represented in 8 months during first year and 6 months during second year. The percentage occurrence was also higher in first year than in the second year (Pl. VII, Fig. 6). Maximum occurrence was noticed in May 1969.

Crustacean remains were observed in high percentages in the stomach of D. acuta in all the months except February 1970 during first year and October 1970 during second year. The maximum occurrence in the first year was noticed in June, but this had only second rank in the second year. May, in second year, had the maximum occurrence of crustacean remains which was second in rank during the first year. On an average, the percentage occurrence of crustacean remains was little higher during second year than the first year (Pl. VII, Fig. 7).

Among molluscs, bivalve larva was represented in both the year, in May 1969 and February 1971 with a high percentage of occurrence in second year. The occurrence of one Spiratella in January 1970 and one squid in April 1970 were considered only as accidental.

'Fishes' occurred in April to July, September, October and December 1969, in January and March 1970 in the year 1969-70, and in April to June, September and December 1970 and February 1971 in the year 1970-71. Though the juvenile fishes occurred in more months of the first year than the second year, the percentage of occurrence was comparatively higher during the second year (Pl. VII, Fig. 8). The maximum occurrence was observed in May during the first year, while the maximum during the second year was in September. It appeared that this item was preferred by the fish and was consumed in large quantities whenever available. The fish eggs were noticed in the stomach of D. acuta in June 1969 and March 1970 during the first year, whereas in the second year they were present in April, June and November.

The 'plant materials' were present for seven months in each year. During May and October of both the years it was not represented. In 1969-70 it was absent in December, February and March also, while it was present in these months during the second year. Similarly, during the year 1970-71 it was absent in May and October and additionally in July, August and January, while it was present in these months in the first year. The maximum occurrence was noticed in November 1969 and March 1971 for the first and second years respectively (Pl. VII, Fig. 9).

Digested matter occurred in all the months from April 1969 to March 1971 in very high percentages in both the years. Fish scales and sand grains were present during both the years in majority of the months. Their occurrence was considered as accidental intrusions.

TABLE 52

A COMPARISON OF THE PERCENTAGE OCCURRENCE OF VARIOUS FOOD ITEMS OF <u>DUSSUMIERIA ACUTA</u> IN DIFFERENT YEARS FROM APRIL 1969 TO MARCH 1971 (POOLED DATA FOR THE GULF OF MANNAR AND THE PALK BAY)

Sl. No.	Food items	Years	MONTHS April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March
1.	*Lucifer*	1969-70	18.55	21.65	20.00	10.34	9.52	13.17	19.33	19.85	22.00	2.87	—	12.39
		1970-71	15.55	31.02	26.85	12.82	8.79	—	—	1.11	26.37	—	20.47	19.18
2.	Mysid	1969-70	—	—	—	—	—	—	1.68	—	2.00	1.44	—	—
		1970-71	—	—	—	—	—	—	—	—	—	—	—	0.68
3.	Amphipod	1969-70	—	—	—	—	—	—	—	—	—	3.60	—	0.89
		1970-71	1.11	—	—	—	—	—	—	—	—	—	—	—
4.	Euphausid	1969-70	—	—	1.96	—	—	—	3.36	—	—	2.87	—	—
		1970-71	—	—	—	—	1.10	—	—	—	—	—	—	—
5.	Isopod	1969-70	—	—	0.39	—	—	—	—	—	—	—	—	—
		1970-71	—	—	—	—	—	—	—	—	—	—	0.58	—
6.	Copepod	1969-70	—	1.99	2.74	0.86	—	—	—	0.74	2.00	2.16	—	—
		1970-71	—	5.31	—	—	—	—	—	—	—	—	4.68	—
7.	*Porcellana* larva	1969-70	—	—	0.39	—	—	0.78	2.52	0.74	—	0.72	—	1.77
		1970-71	2.78	—	—	—	1.10	—	—	—	—	—	—	2.06

Continued

Sl. No.	Food items	Years	Months											
			April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March
8.	*Acetes*	1969–70	—	—	—	—	—	—	2.52	—	—	1.44	—	—
		1970–71	—	1.23	—	—	—	—	—	1.11	0.06	—	—	—
9.	Young prawns	1969–70	—	3.99	1.96	—	2.38	1.55	0.84	5.88	—	2.16	—	0.89
		1970–71	1.67	2.04	2.01	—	2.20	—	—	—	—	—	1.75	1.37
10.	Alima	1969–70	10.48	7.18	1.57	0.86	—	4.65	6.72	10.29	2.00	2.16	—	15.04
		1970–71	12.22	5.71	3.36	5.13	1.10	6.67	—	21.11	1.25	—	2.92	15.07
11.	Megalopa	1969–70	—	4.27	1.18	0.86	—	0.78	1.68	5.15	—	5.76	—	—
		1970–71	—	3.67	—	—	—	—	—	3.33	0.87	—	0.58	5.48
12.	Phyllosoma	1969–70	—	—	—	—	1.19	—	—	—	—	—	—	—
		1970–71	—	—	—	—	2.20	—	—	—	—	—	—	0.68
13.	Zoea	1969–70	0.81	0.86	7.08	—	2.38	—	—	—	—	1.44	—	8.85
		1970–71	6.67	2.86	2.69	1.28	4.40	—	—	1.11	0.19	—	0.58	4.11
14.	Mysis	1969–70	—	0.29	1.18	—	—	0.78	—	—	2.00	2.16	—	0.89
		1970–71	—	1.63	—	—	—	—	—	—	—	—	—	0.68
15.	Eupagurid larva	1969–70	—	—	—	—	—	—	—	1.47	—	2.16	—	—
		1970–71	—	0.41	—	—	—	—	—	—	0.06	—	—	0.68
16.	Crustacean remains	1969–70	13.71	20.23	21.57	8.62	9.53	18.60	19.33	20.59	16.00	15.00	—	24.78
		1970–71	16.67	30.20	25.50	15.38	14.29	6.67	—	22.22	17.63	6.67	24.56	23.97

Continued

Table 52(Contd...)

Sl. No.	Food items	Year	Months											
			April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March
17.	Bivalve larva	1969-70	—	0.29	—	—	—	—	—	—	—	—	—	—
		1970-71	—	—	—	—	—	—	—	—	—	—	4.09	—
18.	Gastropod (Spiratella)	1969-70	—	—	—	—	—	—	—	—	—	0.72	—	-
		1970-71	—	—	—	—	—	—	—	—	—	—	—	—
19.	Squid	1969-70	—	—	—	—	—	—	—	—	—	—	—	—
		1970-71	0.56	—	—	—	—	—	—	—	—	—	—	—
20.	'Plant material'	1969-70	2.42	—	0.39	0.86	1.19	0.78	—	10.29	—	9.35	—	—
		1970-71	1.11	—	1.34	—	—	1.67	—	3.33	2.35	—	0.58	4.80
21.	Digested matter	1969-70	40.32	19.94	36.07	71.55	72.61	46.50	31.93	21.32	48.00	42.44	97.62	29.20
		1970-71	27.22	9.39	36.24	58.97	61.53	60.00	91.66	37.78	48.63	93.94	29.85	21.33
22.	Fish eggs	1969-70	—	—	0.78	—	—	—	—	—	—	—	—	2.65
		1970-71	0.56	—	1.34	—	—	—	—	22.22	—	—	—	—
23.	'Fishes'	1969-70	3.23	8.26	1.18	0.86	—	7.75	0.84	—	6.00	0.72	—	0.89
		1970-71	13.33	6.53	0.67	—	—	18.33	—	—	0.10	—	5.85	—
24.	Fish scale	1969-70	1.61	3.70	1.57	2.59	1.19	3.88	3.36	0.74	—	—	—	—
		1970-71	0.56	—	—	2.56	2.20	3.33	4.17	2.22	0.38	—	—	—
22.	Sand grains	1969-70	8.87	7.41	—	2.59	—	0.78	5.88	2.94	—	0.72	2.38	1.77
		1970-71	—	—	—	3.85	1.10	3.33	4.17	4.45	2.12	—	3.51	—

TABLE 53

A COMPARISON OF THE PERCENTAGE VOLUME POINTS GAINED BY EACH FOOD ITEM OF <u>DUSSUMIERIA ACUTA</u> IN DIFFERENT YEARS FROM APRIL 1969 TO MARCH 1971 (POOLED DATA FOR THE GULF OF MANNAR AND THE PALK BAY)

Sl. No.	Food items		MONTHS											
			April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March
1.	<u>Lucifer</u>	1969-70	13.45	24.42	23.08	9.89	6.80	10.95	21.10	17.51	21.28	1.14	--	6.69
		1970-71	9.79	49.96	19.48	12.98	7.29	--	--	0.10	26.37	--	21.36	12.38
2.	Mysids	1969-70	--	--	--	--	--	--	--	--	0.20	--	0.06	0.08
		1970-71	--	--	--	--	--	--	--	--	--	--	--	0.16
3.	Amphipod	1969-70	--	--	--	--	--	--	--	--	--	--	--	0.35
		1970-71	--	0.03	0.02	--	--	--	--	--	--	--	--	--
4.	Euphausid	1969-70	--	--	0.11	--	--	--	0.66	--	--	0.68	--	--
		1970-71	--	--	--	--	0.08	--	--	--	--	--	--	--
5.	Isopod	1969-70	--	--	0.04	--	--	--	--	--	--	--	--	--
		1970-71	--	--	--	--	--	--	--	--	--	--	0.08	--
6.	Copepod	1969-70	--	0.07	0.11	0.53	--	--	--	0.08	0.06	0.28	--	--
		1970-71	--	0.30	--	--	--	--	--	--	--	--	0.56	--
7.	<u>Porcellana</u> larva	1969-70	--	--	0.04	--	--	0.01	0.57	0.02	--	0.07	--	0.19
		1970-71	0.55	--	--	--	0.08	--	--	--	--	--	--	0.25

Continued

Table 53 (Contd....)

Sl. No.	Food items		MONTHS											
			April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March
8.	<u>Acetes</u>	1969-70	—	—	—	—	—	—	1.77	—	—	2.22	—	—
		1970-71	—	0.18	—	—	—	—	—	0.42	0.06	—	—	—
9.	Young prawns	1969-70	—	0.56	0.24	—	0.39	1.00	0.03	1.36	—	0.63	—	0.08
		1970-71	0.11	0.27	0.49	—	0.41	—	—	—	—	—	0.23	0.70
10.	Alima	1969-70	12.35	5.72	1.40	0.03	—	2.54	5.41	11.15	0.29	0.49	—	14.40
		1970-71	6.81	4.84	2.74	1.77	0.49	3.03	—	24.90	1.25	—	2.79	17.00
11.	Megalopa	1969-70	—	1.78	0.57	0.05	—	0.02	0.25	0.67	—	1.51	—	—
		1970-71	—	1.47	—	—	—	—	—	0.17	0.87	—	0.05	1.52
12.	Phyllosoma	1969-70	—	—	—	—	0.08	—	—	—	—	—	—	—
		1970-71	—	—	—	—	0.41	—	—	—	—	—	—	0.94
13.	Zoea	1969-70	0.08	0.22	0.67	—	0.16	—	—	—	—	0.06	—	6.02
		1970-71	4.38	0.35	0.37	0.24	2.46	—	—	0.02	0.19	—	0.06	0.67
14.	Mysis	1969-70	—	0.02	0.11	—	—	0.02	—	—	0.14	0.14	—	0.17
		1970-71	—	0.10	—	—	—	—	—	—	—	—	—	0.08
15.	Eupagurid larva	1969-70	—	—	—	—	—	—	—	0.08	—	0.21	—	—
		1970-71	—	0.02	—	—	—	—	—	—	0.06	—	—	0.08
16.	Crustacean remains	1969-70	13.35	19.94	13.77	2.35	6.17	12.09	9.21	13.72	6.7[illegible]	11.56	—	16.85
		1970-71	16.13	18.68	22.48	7.10	9.43	4.87	—	17.94	17.63	4.52	23.83	27.38

Continued

Table 53 (Contd....)

Sl. No.	Food items	Year	MONTHS											
			April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March
17.	Bivalve larva	1969-70	—	0.04	—	—	—	—	—	—	—	—	—	—
		1970-71	—	—	—	—	—	—	—	—	—	—	0.42	—
18.	Gastropod (<u>Spiratella</u>)	1969-70	—	—	—	—	—	—	—	—	—	0.83	—	—
		1970-71	—	—	—	—	—	—	—	—	—	—	—	—
19.	Squid	1969-70	—	—	—	—	—	—	—	—	—	—	—	—
		1970-71	0.06	—	—	—	—	—	—	—	—	—	—	—
20.	Plant material	1969-70	0.72	—	0.04	0.27	0.25	0.02	—	10.00	—	9.51	—	—
		1970-71	0.28	—	1.16	—	—	1.71	—	0.42	2.35	—	0.35	1.95
21.	Digested matter	1969-70	55.18	26.75	58.37	84.36	85.13	60.81	57.13	40.57	66.00	67.75	99.10	49.15
		1970-71	43.26	13.06	52.01	71.45	77.79	65.55	98.30	52.98	48.63	95.48	39.23	36.90
22.	Fish eggs	1969-70	—	—	0.08	—	—	—	—	—	—	—	—	0.22
		1970-71	0.09	—	0.24	—	—	—	—	0.21	—	—	—	—
23.	'Fishes'	1969-70	2.70	15.02	1.14	0.43	—	11.63	1.13	—	5.43	1.11	—	1.36
		1970-71	18.50	10.76	1.04	—	—	25.13	—	—	0.10	—	7.38	—
24.	Fish scale	1969-70	0.05	1.01	0.23	0.72	0.03	0.40	1.66	1.31	—	—	—	—
		1970-71	0.02	—	—	2.58	0.49	0.53	1.02	1.56	0.38	—	—	—
25.	Sand grains	1969-70	2.02	4.45	—	1.38	—	0.50	0.89	3.52	—	1.39	0.90	2.03
		1970-71	—	—	—	3.87	1.07	1.18	0.68	1.29	2.12	—	3.66	—

TABLE 54

A COMPARISON OF THE INDEX OF PREPONDERENCE OF VARIOUS FOOD ITEMS OF DUSSUMIERIA ACUTA IN DIFFERENT YEARS FROM APRIL 1969 TO MARCH 1971 (POOLED DATA FOR THE GULF OF MANNAR AND THE PALK BAY)

Sl. No.	Food items	Years	MONTHS					
			April	May	June	July	Aug.	Sept.
1.	*Lucifer*	1969-70	8.8578	31.5231	16.0580	1.6587	1.0274	4.3670
		1970-71	7.7677	66.1341	17.4644	3.6816	1.2814	--
2.	Mysids	1969-70	--	--	--	--	--	--
		1970-71	--	--	--	--	--	--
3.	Amphipod	1969-70	--	--	--	--	--	--
		1970-71	0.0011	--	--	--	--	--
4.	Euphausid	1969-70	--	--	00.0073	--	--	--
		1970-71	--	--	--	--	0.0018	--
5.	Isopod	1969-70	--	--	0.0005	--	--	--
		1970-71	--	--	--	--	--	--
6.	Copepod	1969-70	--	0.0083	0.0105	0.0074	--	--
		1970-71	--	0.0630	--	--	--	--
7.	*Porcellana* larva	1969-70	--	--	0.0005	--	--	0.0002
		1970-71	0.0780	--	--	--	--	0.0018
8.	*Acetes*	1969-70	--	--	--	--	--	--
		1970-71	--	0.0094	--	--	--	--
9.	Young Prawns	1969-70	--	0.1332	0.0164	--	0.0147	0.0469
		1970-71	0.0094	0.0235	0.0329	--	0.0180	--
10.	Alima	1969-70	4.5950	2.4283	0.0765	0.0004	--	0.3577
		1970-71	4.2462	1.1793	0.3074	0.2009	0.0108	0.4662
11.	Megalopa	1969-70	--	0.4532	0.0234	0.0007	--	0.0005
		1970-71	--	0.2302	--	--	--	--

Continued

Table 54 (Contd....)

Sl. No.	Food items	Years	MONTHS Oct.	Nov.	Dec.	Jan.	Feb.	March
1.	Lucifer	1969-70	16.5323	20.0260	12.3917	0.1034	—	5.3464
		1970-71	—	0.0038	18.0948	—	19.3234	12.1389
2.	Mysids	1969-70	0.0136	—	0.0032	0.0036	—	—
		1970-71	—	—	—	—	—	0.0056
3.	Amphipod	1969-70	—	—	—	0.0398	—	0.0012
		1970-71	—	—	—	—	—	—
4.	Euphausid	1969-70	0.0899	—	—	0.0617	—	—
		1970-71	—	—	—	—	—	—
5.	Isopod	1969-70	—	—	—	—	—	—
		1970-71	—	—	—	—	0.0021	—
6.	Copepod	1969-70	—	0.0034	0.0032	0.0191	—	—
		1970-71	—	—	—	—	0.1158	—
7.	Porcellana larva	1969-70	0.0582	0.0009	—	0.0016	—	0.0150
		1970-71	—	—	—	—	—	0.0263
8.	Acetes	1969-70	0.1808	—	—	0.1010	—	—
		1970-71	—	0.0159	0.0024	—	—	—
9.	Young Prawns	1969-70	0.0010	0.4607	—	0.0430	—	0.0032
		1970-71	—	—	—	—	0.0178	0.0490
10.	Alima	1969-70	1.4736	6.6106	0.0153	0.0335	—	9.5105
		1970-71	—	17.8904	0.1513	—	0.3600	13.0970
11.	Megalopa	1969-70	0.0170	0.1988	—	0.2749	—	—
		1970-71	—	0.0193	0.1053	—	0.0013	0.4258

Continued

Table 54 (Contd....)

Sl. No.	Food items	Years	April	May	June	July	Aug.	Sept.
			MONTHS					
12.	Phyllosoma	1969-70	—	—	—	—	0.0015	—
		1970-71	—	—	—	—	0.0180	—
13.	Zoea	1969-70	0.0023	0.0113	0.1650	—	0.0060	—
		1970-71	1.4907	0.0427	0.0332	0.0068	0.2164	—
14.	Mysis	1969-70	—	0.0003	0.0045	—	—	0.0005
		1970-71	—	0.0070	—	—	—	—
15.	Eupagurid larva	1969-70	—	—	—	—	—	—
		1970-71	—	0.0004	—	—	—	—
16.	Crustacean remains	1969-70	6.5466	24.0518	10.3326	0.3286	0.9322	6.8098
		1970-71	13.7199	24.0738	19.1407	2.4159	2.6946	0.7493
17.	Bivalve larva	1969-70	—	0.0007	—	—	—	—
		1970-71	—	—	—	—	—	—
18.	Gastropod (*Spiratella*)	1969-70	—	—	—	—	—	—
		1970-71	—	—	—	—	—	—
19.	Squid	1969-70	—	—	—	—	—	—
		1970-71	0.0017	—	—	—	—	—
20.	Plant Materials	1969-70	0.0619	—	0.0005	0.0038	0.0236	0.0005
		1970-71	0.0159	—	0.0519	—	—	0.0659
21.	Digested matter	1969-70	78.9870	31.8035	73.2424	97.9062	97.9940	85.6287
		1970-71	60.0834	5.2332	62.9355	93.2190	95.7121	87.6910
22.	Fish eggs	1969-70	—	—	0.0022	—	—	—
		1970-71	0.0026	—	0.0107	—	—	—
23.	'Fishes'	1969-70	0.3103	7.3973	0.0468	0.0060	—	2.7494
		1970-71	12.5829	2.9984	0.0233	—	—	10.6262
24.	Fish scales	1969-70	0.0029	0.2228	0.0126	0.0302	0.0007	0.0470
		1970-71	0.0006	—	—	0.1461	0.0216	0.0407
25.	Sand grains	1969-70	0.6361	1.9661	—	0.0580	—	0.0118
		1970-71	—	—	—	0.3296	0.0235	0.0906

Continued

Table 54 (Contd....)

Sl. No.	Food items	Years	MONTHS					
			Oct.	Nov.	Dec.	Jan.	Feb.	March
12.	Phyllo-soma	1969-70	—	—	—	—	—	—
		1970-71	—	—	—	—	—	0.0327
13.	Zoea	1969-70	—	—	—	0.0027	—	2.3725
		1970-71	—	0.0008	0.0076	—	0.0015	0.1408
14.	Mysis	1969-70	—	—	0.0074	0.0096	—	0.0067
		1970-71	—	—	—	—	—	0.0028
15.	Eupagurid larva	1969-70	—	0.0068	—	0.0143	—	—
		1970-71	—	—	0.0024	—	—	0.0028
16.	Crustacean remains	1969-70	7.2162	16.2763	2.8629	5.5211	—	18.5938
		1970-71	—	13.5676	14.2320	0.3045	25.8653	33.5514
17.	Bivalve larva	1969-70	—	—	—	—	—	—
		1970-71	—	—	—	—	0.0759	—
18.	Gastropod (Spiratella)	1969-70	—	—	—	0.0189	—	—
		1970-71	—	—	—	—	—	—
19.	Squid	1969-70	—	—	—	—	—	—
		1970-71	—	—	—	—	—	—
20.	Plant Materials	1969-70	—	5.9287	—	2.8106	—	—
		1970-71	—	0.0476	0.4745	—	0.0090	0.4785
21.	Digested matter	1969-70	73.9406	49.8356	83.8539	90.8842	99.9779	63.9103
		1970-71	99.9214	68.1255	66.7388	99.6955	51.7521	40.0485
22.	Fish eggs	1969-70	—	—	—	—	—	0.0260
		1970-71	—	0.0159	—	—	—	—
23.	'Fishes'	1969-70	0.0385	—	0.8624	0.0253	—	0.0539
		1970-71	—	—	0.0040	—	1.9080	—
24.	Fish scales	1969-70	0.2261	0.0559	—	—	—	—
		1970-71	0.0472	0.1179	0.0153	—	—	—
25.	Sand grains	1969-70	0.2121	0.5963	—	0.0316	0.0221	0.1600
		1970-71	0.0314	0.1954	0.1714	—	0.5677	—

Thus it may be observed that the major food items, such as Lucifer, alima, megalopa, crustacean remains, 'fishes' and 'plant materials' did not show any major variations in their occurrence between the years and remained as the major food items during these consecutive years. Other items which occurred as food in minor quantities did not show any regularity or correlation in respect of time and their presence or absence as food in these years. So, it could be assumed that these items get into the stomach of D. acuta incidentally along with the major food items.

4.6. OCCURRENCE OF FOOD ITEMS IN VARIOUS SIZE GROUPS OF DUSSUMIERIA ACUTA

Size-wise analysis of D. acuta and the food items consumed by different size groups was made to understand whether there is any specificity or selection for different food items by fishes belonging to different size groups. For this purpose the fishes were grouped into 5 mm. size groups and the percentage occurrences of various food items in the stomach contents of fishes belonging to these size groups were calculated for two consecutive years from April 1969 to March 1970 and April 1970 to March 1971. The details of the data are presented in Tables 55 and 56. The size range during the first year was from 46 to 165 mm. and during the second year 66 to 165 mm. Empty stomachs were not included in this study.

It may be observed from the Table 55 and 56 that Lucifer was the most important food item of D. acuta preferred by all the sizes of fish from 51 to 160 mm. (Pl. VIII, Fig.1). Alima was found in the stomachs of fish ranging from 106 to 165 mm. (Pl. VIII, Fig. 2) and it occurred almost uniformly in all the size groups within this range.

Zoea (Pl. VIII, Fig.3) was noticed in size groups belonging to size range from 56 to 90 mm. and 111 to 155 mm. It was not observed in a size range from 91 to 110 mm. The percentage occurrence was higher in smaller size groups than in the bigger size groups. Megalopa was found to occur in ranges from 76 to 90 mm. and 106 to 155 mm. only (Pl.VIII, Fig. 4). It could be noticed that like zoea, megalopa also occurred in increasing percentages in smaller size groups. Phyllosoma, mysids, amphipods, euphausids, isopods, Procellana, Acetes and fish eggs were noticed only in fishes above 101 mm. size. These items occurred in very low percentages. Mysis stage of prawns was noticed in a size range from 66 to 80 mm. and 101 to 140 mm. with high percentages in the former group. Copepods were predominant in a size range of 56 to 100 mm. (Pl. VIII, Fig. 5). They were also noticed in minor percentages in the size range from 131 to 155 mm. Young prawns were seen in the stomach of fish belonging to a size range from 66 to 150 mm. and they were found in increasing percentages in fishes having the length between 66 to 115 mm. (Pl. VIII, Fig.6).

Another food item found in the stomach of fish of all the size groups in higher percentages was crustacean remains (Pl. VIII, Fig. 7) and this item was almost equally dominant in all the size groups.

Bivalve larvae were seen in the stomachs of fishes of restricted size range between 86 and 100 mm. They were also noticed in the size group 56 - 60 mm.

'Fishes' were noticed in the diet of fish ranging from 66 to 165 mm. and they occurred almost uniformly in all size groups of this size range (Pl. VIII, Fig.8).

'Plant materials' were found in the stomach of fish of a size range from 81 to 165 mm. (Pl. VIII, Fig.9) and were dominant in the 81 to 110 mm. size range. Digested matter was present in the stomach of fishes of all the size groups from 46 to 165 mm.

From the above data it could be noticed that Lucifer and crustacean remains were the items which were consumed by fish of all the size groups. Other food items consumed by fishes belonging to a wide range of size groups were zoea, young prawns, 'fishes' and 'plant materials'. Alima, megalopa, phyllosoma, mysids, amphipods, isopd, Porcellana, Acetes and fish eggs were dominant in fishes above 100 mm. whereas others like copepods, and bivalve larvae were restricted to fishes

TABLE 55

PERCENTAGE OCCURRENCE OF VARIOUS FOOD ITEMS IN DIFFERENT SIZE GROUPS OF DUSSUMIERIA ACUTA FOR THE YEAR 1969 - 70

Size groups (mm)	No. of fish	Alima	Megalopa	Phyllosoma	Zoea	Mysis	Eupagurid larva	Lucifer	Mysid	Amphipod	Euphausid	Isopod	Copepod
46-50	4	—	—	—	—	—	—	—	—	—	—	—	—
51-55	5	—	—	—	—	—	—	80.00	—	—	—	—	—
56-60	8	—	—	—	25.00	—	—	100.00	—	—	—	-	62.50
61-65	4	—	—	—	—	—	—	100.00	—	—	—	—	—
66-70	13	—	—	—	46.15	7.69	23.08	100.00	—	—	—	-	23.08
71-75	14	—	—	—	21.43	—	7.14	50.00	—	—	—	-	14.29
76-80	7	14.29	14.29	—	—	—	14.29	57.14	—	—	—	-	14.29
81-85	20	—	10.00	—	25.00	—	5.00	95.00	—	—	—	-	10.00
86-90	16	—	31.25	—	6.25	—	6.25	75.00	—	—	—	-	6.25
91-95	6	—	—	—	—	—	—	50.00	—	—	—	-	—
96-100	5	—	—	—	—	—	—	40.00	—	—	—	-	—
101-105	12	—	—	—	—	8.33	—	25.00	—	8.33	16.67	—	—

-----Continued-----

Table 55 (Contd......)

Size groups (mm)	No. of fish	Alima	Megalopa	Phyllosoma	zoea	Mysis	Eupagurid larva	Lucifer	Mysid	Amphipod	Euphausid	Isopod	Copepod
106–110	15	—	20.00	—	—	6.67	—	40.00	—	6.67	6.67	—	—
111–115	27	11.11	—	3.70	4.71	—	—	25.93	—	—	—	—	—
116–120	33	9.09	3.03	—	—	3.03	—	27.27	—	—	—	—	—
121–125	59	11.86	1.69	—	3.39	—	—	22.03	—	—	—	—	—
126–130	115	6.96	0.87	—	2.61	0.87	—	23.48	0.87	—	0.87	0.87	—
131–135	188	13.30	3.72	—	2.13	1.06	0.53	28.72	1.60	—	1.06	—	0.53
136–140	149	12.08	4.70	—	4.03	1.34	1.34	25.50	2.01	1.34	—	—	0.67
141–145	109	11.01	4.59	—	1.83	—	—	17.43	—	—	0.92	—	1.83
146–150	64	17.19	4.69	—	—	—	—	17.19	—	1.56	—	—	1.56
151–155	21	14.29	4.76	—	—	—	—	14.29	—	4.76	—	4.76	—
156–160	3	—	—	—	—	—	—	—	—	—	—	—	—
161–165	2	—	—	—	—	—	—	—	—	—	—	—	—

Continued

Table 55 (Contd.....)

Size groups (mm)	No. of fish	*Porcellana* larva	*Acetes*	Young prawns	Crustacean remains	Bivalve larva	Gastropod (*Spiratella*)	Fish eggs	'Fishes'	'Plant materials'	Digested matter	Fish scale	Sand grains
46-50	4	—	—	—	25.00	—	—	—	—	—	100.00	—	50.00
51-55	5	—	—	—	40.00	—	—	—	—	—	20.00	—	20.00
56-60	8	—	—	—	87.50	12.50	—	—	—	—	—	—	—
61-65	4	25.00	—	—	100.00	—	—	—	—	—	—	—	—
66-70	13	—	—	15.38	100.00	—	—	—	—	—	—	—	—
71-75	14	—	—	7.14	71.43	—	—	—	—	—	35.71	7.14	28.57
76-80	7	—	—	14.29	71.43	—	—	—	14.29	—	28.57	—	—
81-85	20	—	—	35.00	90.00	—	—	—	10.00	15.00	15.00	—	—
86-90	16	—	—	12.50	75.00	—	—	—	6.25	12.50	25.00	6.25	12.50
91-95	6	—	—	—	33.33	—	—	—	—	—	50.00	16.67	16.67
96-100	5	—	—	—	40.00	—	—	—	—	20.00	40.00	—	—
101-105	12	—	—	16.67	50.00	—	—	—	—	41.67	58.33	16.67	—

Continued

Table 55 (Contd.....)

Size groups (mm)	No. of fish	*Porcellana* larva	*Acetes*	Young prawns	Crustacean remains	Bivalve larva	Gastropod (*Spiratella*)	Fish eggs	'Fishes'	'Plant materials'	Digested matter	Fish scale	Sand grains
106-110	15	—	—	6.67	6.67	—	—	—	—	40.00	60.00	—	—
111-115	27	—	—	7.41	25.93	—	—	—	7.41	3.70	70.37	3.70	7.41
116-120	33	3.03	—	3.03	39.39	—	—	—	6.06	—	72.73	3.03	3.03
121-125	59	—	—	1.69	32.20	—	—	—	6.78	1.69	72.88	1.69	—
126-130	115	—	0.87	1.74	27.82	—	—	0.87	6.96	1.74	67.82	1.74	3.48
131-135	188	1.06	1.60	2.66	25.53	—	—	1.60	5.85	2.13	71.81	4.79	10.11
136-140	149	2.68	0.67	2.01	27.52	—	0.67	—	9.40	2.68	85.90	4.70	6.71
141-145	109	—	—	5.50	22.94	—	—	0.92	1.83	4.59	88.07	3.67	3.67
146-150	64	—	1.56	4.69	17.19	—	—	—	6.25	3.13	82.81	4.69	6.25
151-155	21	4.76	—	—	28.57	—	—	—	—	—	76.19	—	—
156-160	3	—	—	—	—	—	—	—	—	—	100.00	—	—
161-165	2	—	—	—	—	—	—	—	—	—	100.00	—	—

TABLE 56

PERCENTAGE OCCURRENCE OF VARIOUS FOOD ITEMS IN DIFFERENT SIZE GROUPS OF <u>DUSSUMIERIA ACUTA</u> FOR THE YEAR 1970-71

Size groups (mm)	No. of fish	Alima	Megalopa	Phyllosoma	Zoea	Mysis	Eupagurid larva	<u>Lucifer</u>	Mysid	Amphipod	Isopod	Copepod	<u>Porcellana</u> larva
66- 70	9	—	—	—	—	11.11	—	100.00	—	—	—	11.11	—
71-75	22	—	—	—	4.55	4.55	4.55	100.00	—	—	—	22.73	—
76- 80	23	—	—	—	4.35	8.70	—	100.00	—	—	—	39.13	—
81- 85	11	—	—	—	—	—	—	72.73	—	—	—	9.09	—
86- 90	13	—	7.69	—	—	—	—	69.23	—	—	—	15.38	—
91- 95	7	—	—	—	—	—	—	71.43	—	—	—	14.29	—
96-100	4	—	—	—	—	—	—	50.00	—	—	—	25.00	—
101-405	2	—	—	—	—	—	—	100.00	—	—	—	—	—
106-110	10	20.00	—	—	—	—	—	70.00	—	—	—	—	—
111-115	20	15.00	—	5.00	15.00	—	—	35.00	—	—	—	—	5.00

Continued

Table 56 (Contd......)

Size groups (mm)	No. of fish	Alima	Megalops	Phyllosoma	Zoea	Mysis	Eupagurid larva	Lucifer	Mysid	Amphipod	Isopod	Copepod	Porcellana larva
116-120	48	10.42	4.17	—	2.08	—	—	20.83	—	—	—	—	—
121-125	70	7.14	—	1.43	—	—	—	14.29	—	—	—	—	—
126-130	118	6.78	4.24	—	3.39	0.85	—	33.90	—	—	—	—	—
131-135	139	12.95	4.32	—	6.47	—	1.44	24.46	0.72	—	—	—	2.16
136-140	119	24.37	4.20	0.84	8.40	—	—	28.57	—	—	—	—	1.68
141-145	70	18.57	5.71	—	10.00	—	—	24.28	—	—	—	—	1.43
146-150	41	24.39	—	—	4.88	—	—	12;20	—	2.44	—	—	2.44
151-155	12	16.67	8.33	—	16.67	—	—	16.67	—	—	8.33	8.33	—
156-160	4	—	—	—	—	—	—	—	—	—	—	—	—
161-165	1	100.00	—	—	—	—	—	—	—	100.00	—	—	100.00

Continued

Table 56 (Contd....)

Size groups (mm)	No. of fish	Acetes	Young prawns	Crustacean remains	Bivalve larva	Squid	'Fishes'	Digested matter	'Plant materials'	Fish scales	Sand grains
66- 70	9	—	—	77.78	—	—	33.33	22.22	—	—	—
71- 75	22	—	—	95.45	—	—	4.55	9.09	—	—	—
76-80	23	—	8.70	82.61	—	—	8.70	21.74	—	—	—
81-85	11	—	—	54.55	—	—	27.27	45.45	—	—	—
86- 90	13	—	15.38	84.62	30.77	—	15.38	46.15	—	—	—
91- 95	7	—	—	71.43	28.57	—	14.29	42.86	14.20	—	—
96-100	4	—	—	25.00	25.00	—	—	75.00	—	—	—
101-105	2	—	—	100.00	—	—	—	—	—	—	—
106-110	10	—	—	60.00	—	—	10.00	30.00	—	—	10.00
111-115	20	—	5.00	50.00	—	—	10.00	90.00	—	—	—

Continued

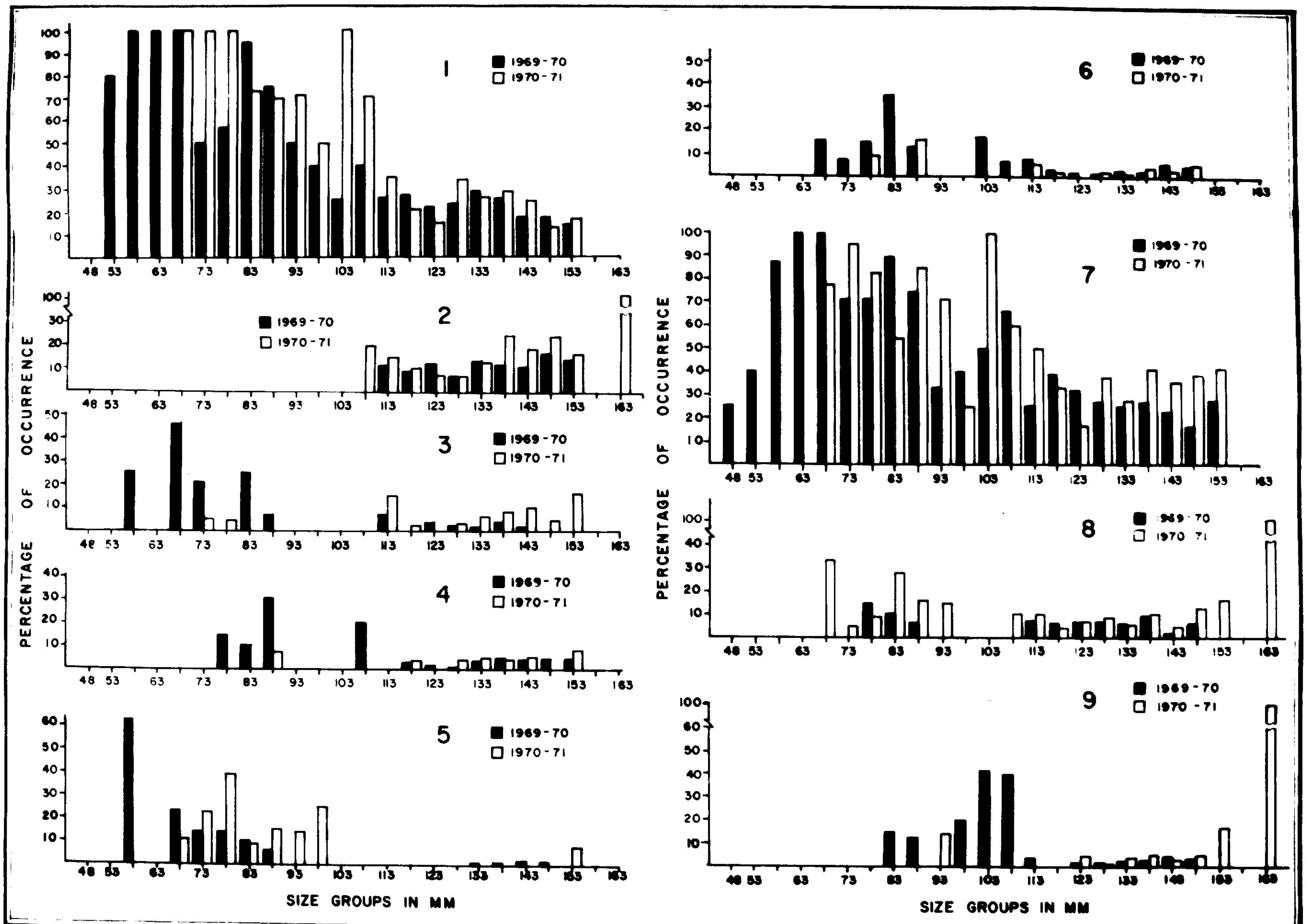
Table 56 (Contd......)

Size groups (mm)	No. of fish	Acetes	Young prawns	Crustacean remains	Bivalve larve	Squid	'Fishes'	Digested matter	'Plant materials'	Fish scales	Sand grains
116-120	48	2.08	2.08	33.33	—	—	4.17	75.00	—	—	2.08
121-125	70	1.43	—	17.14	—	—	7.14	81.42	4.17	4.29	5.71
126-130	118	—	1.69	37.29	—	0.85	8.47	66.94	0.85	0.85	2.54
131-135	139	—	1.44	28.06	—	—	5.76	74.82	3.60	1.44	1.44
136-140	119	0.84	3.36	41.17	—	—	10.08	71.42	5.04	0.84	1.68
141-145	70	—	2.86	35.71	—	—	4.29	75.71	2.86	4.29	2.86
146-150	41	4.88	4.88	39.02	—	—	12.20	60.98	4.88	—	2.44
151-155	12	—	—	41.67	—	—	16.67	58.33	16.67	8.33	—
156-160	4	—	—	—	—	—	—	100.00	—	—	—
161-165	1	—	—	—	—	—	100.00	100.00	100.00	—	—

PLATE VIII

Percentage occurrence of some selected food items in different size-groups of *D. acuta* for two years.

Fig. 1 *Lucifer*
Fig. 2 Alima
Fig. 3 Zoea
Fig. 4 Megalopa
Fig. 5 Copepods
Fig. 6 Young prawns
Fig. 7 Crustacean remains
Fig. 8 'Fishes'
Fig. 9 'Plant materials'.



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■ 1969-70
□ 1970-71
PERCENTAGE OF OCCURRENCE
SIZE GROUPS IN MM

PLATE. VIII

measuring below 100 mm. Zoea, megalopa, mysis stage of prawns and copepods were observed in higher percentages in fish belonging to smaller size groups than in the larger size groups.

In general, it may be assumed from the data presented above that there were no striking changes in the diet of D. acuta from smaller size to bigger size. The diet apparently depended more on the availability of particular organisms than on any other factors. The only change that could be noticed was that, as the fish grows bigger the number of items added to the diet increased. It was also noticed that the smaller fishes generally consumed the smaller organisms from among their favourite food items.

4.7. CONDITION OF FEED

Since D. acuta was observed to feed only at day time, samples collected from day catches alone were considered for this study. During the two-year period, day samples were not available in February and October 1970 and January 1971. Fishes with stomachs classified as 'gorged', 'full', '3/4 full' and '1/2 full' were considered to have actively fed. The percentage occurrence of these categories in different months is presented in Tables 57 and 58.

TABLE 57

PERCENTAGE OCCURRENCE OF THE STOMACH FROM THE DAY SAMPLES OF <u>DUSSUMIERIA ACUTA</u> IN VARIOUS DEGREES OF FULLNESS (APRIL 1969 - MARCH 1970)

Condition of feed	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March
'Gorged'	—	8.80	16.36	23.08	8.33	4.65	6.06	17.14	—	—	—	8.00
'Full'	2.56	7.20	18.18	38.46	8.33	16.28	21.21	22.86	27.78	39.13	—	6.00
'3/4 full'	5.13	9.60	18.18	15.38	16.67	13.95	15.15	8.57	5.55	21.74	—	4.00
'1/2 full'	5.13	8.80	16.36	—	—	6.98	15.15	22.86	22.22	8.70	—	8.00
'1/4 full'	17.95	22.40	23.64	15.38	33.33	18.60	15.15	17.14	11.11	26.09	—	12.00
'Little'	69.23	34.40	3.64	7.69	33.33	37.21	21.21	8.57	16.67	4.35	—	48.00
Empty	—	8.80	3.64	—	—	2.33	6.06	2.86	16.67	—	—	14.00
No. of fish	39	125	55	13	12	43	33	35	18	23	Nil	50

TABLE 58

PERCENTAGE OCCURRENCE OF THE STOMACHS FROM THE DAY SAMPLES OF DUSSUMIERIA ACUTA IN VARIOUS DEGREES OF FULLNESS (APRIL 1970 - MARCH 1971)

Condition of feed	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March
'Gorged'	19.70	9.52	1.35	17.65	6.67	13.33	—	5.26	35.29	—	4.62	—
'Full'	16.67	22.62	6.76	23.53	6.67	40.00	—	21.05	17.65	—	4.62	—
'$\frac{3}{4}$ full'	3.03	26.19	8.11	11.76	13.33	13.33	—	15.79	5.88	—	12.31	12.50
'1/2 full'	10.61	21.42	16.22	—	6.67	6.67	—	15.79	5.88	—	9.23	10.71
'1/4 full'	22.73	11.90	12.16	17.65	26.67	6.67	—	31.58	17.65	—	23.07	30.36
'Little'	24.24	8.33	51.35	29.41	40.00	20.00	—	10.53	5.88	—	41.53	42.86
Empty	3.03	—	4.05	—	—	—	—	—	11.76	—	4.62	3.57
No. of fish	66	84	74	17	15	15	Nil	19	17	Nil	65	56

From Fig. 2 (Plate IX) it may be noticed that during April and May 1969 the majority of the fish were poorly fed, whereas in June the percentage of the actively fed fish showed an increase and it reached the maximum in July. In August there was a sudden fall in the percentage of the actively fed fish. A slight rise was observed in September. Again in October the majority of the fish fed actively and this trend continued till January 1970 with a peak in November 1969. In February day samples were not available and in March 1970 the percentage of well fed fish showed a fall and the majority were in poorly fed condition. During the second year period, in April 1970, unlike that of the previous year, the percentage of the actively fed and poorly fed fishes were almost fifty-fifty. But in May there was a steep rise in the percentage of actively fed fish which was followed by a fall in June. Again, in July the majority fed actively, whereas in August the condition was just the reverse. Most of the fish were actively fed from September to December resulting in a second peak in September. In October 1970 and January 1971 day samples were not available. In February and March 1971 the majority were in poorly fed condition, as was noticed in March 1970 in the previous year period.

The variations in the feeding intensity were further studied based on the maturation of the fish and the volume points attained by each stomach. Since 50% of the fish mature at 132 mm total length (see pages on size of first maturity), they were grouped into immature (below 132 mm) and mature (132 mm and above) fish. The fish caught in day time only were examined for this study. The average volume points of stomach contents in each month for the two groups were obtained by dividing the total volume points gained by all stomachs by the total number of stomachs that contributed to this volume. Empty stomachs were excluded from this calculation. Their incidence has been indicated in connection with diurnal variation in feeding habits. The details are presented in Tables 59 and 60.

During the period April 1969 to March 1970, for immature fish, the average volume point of stomach contents was higher than the average for the whole year in June, July, August, October, November and January. For mature fish it was higher in October to January. During the subsequent year, from April 1970 to March 1971, the average volume points for immature fish was higher than that for the whole year in May, July, September and December; for mature fish it was higher than annual average during April, May, September and November.

The average volume points for the pooled data of both the categories, namely immature and mature fish, were estimated month-wise for the two years from April 1969 to March 1971 and the results are presented in Plate IX, Fig. 1.

TABLE 59

AVERAGE VOLUME POINTS OF STOMACH CONTENTS OF DUSSUMIERIA ACUTA
(APRIL 1969 - MARCH 1970)

Months	IMMATURE FISH			MATURE FISH			Average for both immature and mature fish
	Total No. of fish	Total volume points of all the stomachs	Average volume points	Total No. of fish	Total volume points of all the stomachs	Average volume points	
April	14	190	13.57	25	500	20.00	17.69
May	53	2000	37.74	66	1930	29.24	33.03
June	48	2790	58.13	10	250	25.00	52.41
July	12	850	70.83	1	20	20.00	66.92
August	7	340	48.57	5	80	16.00	35.00
September	37	1480	40.00	5	80	16.00	37.14
October	14	700	50.00	18	810	45.00	47.19
November	20	1310	65.50	14	580	41.45	55.59
December	7	320	45.71	8	370	46.25	46.00
January	13	800	61.54	10	430	43.00	53.48
February	NO SAMPLE						
March	17	540	31.76	26	740	28.46	29.77
Grand total and average	242	11320	46.78	188	5790	30.80	39.79

Empty stomach not included.

TABLE 60

AVERAGE VOLUME POINTS OF STOMACH CONTENTS OF DUSSUMIERIA ACUTA (APRIL 1970 - MARCH 1971)

Months	IMMATURE FISH			MATURE FISH			Average for both immature and mature fish
	Total No. of fish	Total volume points of all the stomachs	Average volume points	Total No. of fish	Total volume points of all the stomachs	Average volume points	
April	24	930	38.75	40	2110	52.75	47.50
May	65	3670	56.46	19	960	50.53	55.12
June	41	1100	26.83	30	800	26.67	26.76
July	14	800	57.14	3	50	16.67	50.00
August	9	390	43.33	6	90	15.00	32.00
September	14	810	57.86	1	80	80.00	59.33
October	NO SAMPLE						
November	11	480	43.64	8	380	47.50	45.26
December	13	970	74.62	9	210	23.33	53.64
January	NO SAMPLE						
February	41	1510	36.83	21	320	15.24	29.52
March	14	220	15.71	40	1020	25.50	22.96
Grand Total and average	246	10880	44.23	177	6020	34.01	39.95

Empty stomachs not included.

PLATE IX

Fig. 1 Month-wise average volume (points) of stomach contents of immature and mature fishes (pooled) of D. acuta for two years.

Fig. 2 Month-wise percentage occurrence of actively fed fish of D. acuta for two years.

Fig. 3 Ova diameter frequency polygon of the anterior, middle and posterior regions of the right lobe of a mature ovary (stage V) of D. acuta.

Fig. 4 Combined ova diameter frequency polygon of three regions of the right lobe of the ovary of D. acuta.

Fig. 5 Ova diameter frequency polygon of the anterior, middle and posterior regions of the left lobe of the same ovary of D. acuta.

Fig. 6 Combined ova diameter frequency polygon of the three regions of the left lobe.

Fig. 7-15 Percentage frequency polygon of the ova diameter measurements (in micrometer divisions) of D. acuta in different stages of maturity.

Fig. 7	Stage I	-	Immature
Fig. 8	Stage II	-	Developing immature
Fig. 9	Stage III	-	Maturing
Fig. 10	Stage IV	-	Mature
Fig. 11	Stage V	-	Advanced mature
Fig. 12	Stage VI	-	Ripe
Fig. 13	Stage VII A	-	Partially spent
Fig. 14	Stage VII B	-	Fully spent
Fig. 15	Stage II B	-	Recovering spent.

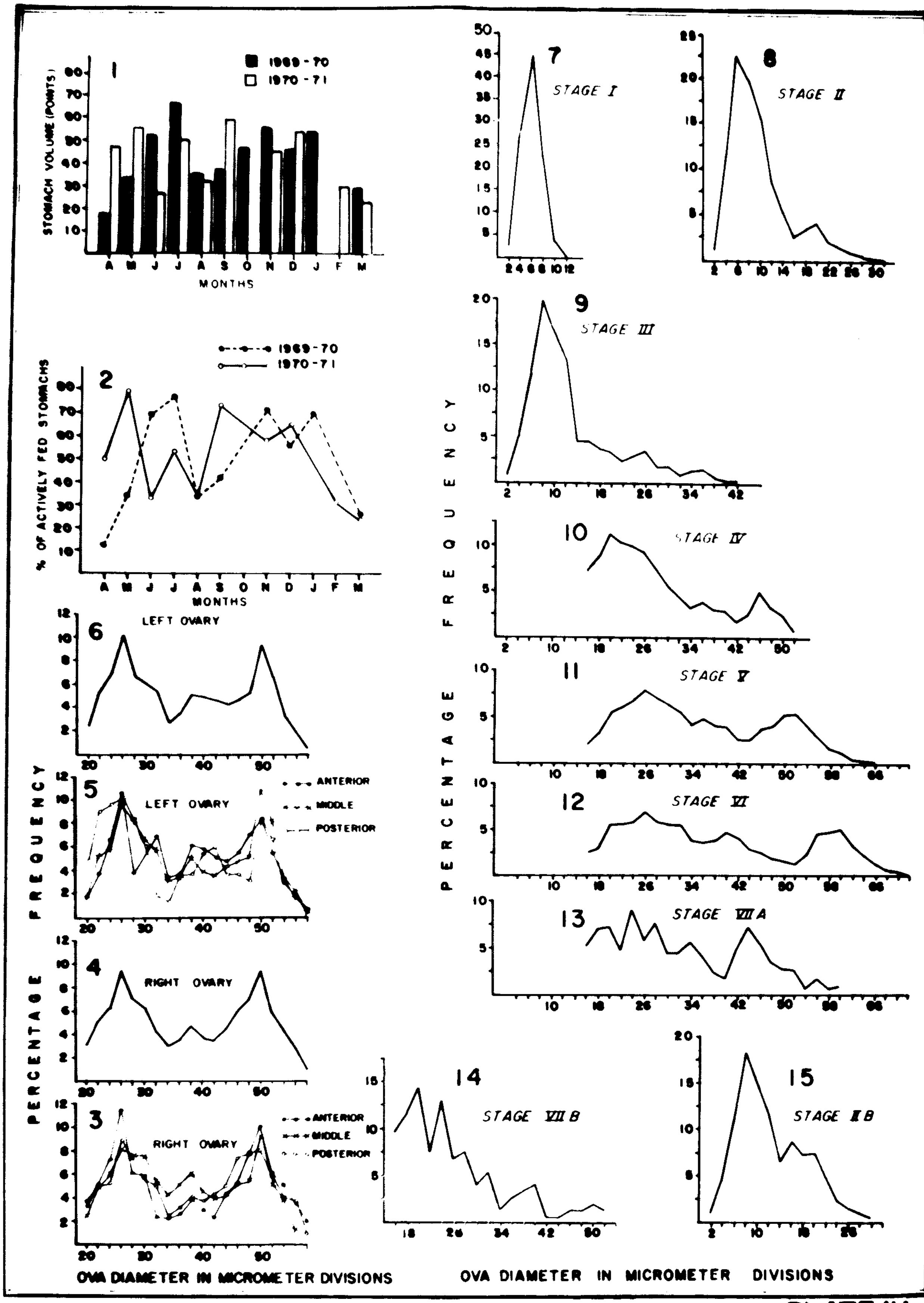

1
1969-70
1970-71
STOMACH VOLUME (POINTS)
MONTHS
2
1969-70
1970-71
% OF ACTIVELY FED STOMACHS
MONTHS
6
LEFT OVARY
5
LEFT OVARY
ANTERIOR
MIDDLE
POSTERIOR
4
RIGHT OVARY
3
RIGHT OVARY
ANTERIOR
MIDDLE
POSTERIOR
PERCENTAGE FREQUENCY
OVA DIAMETER IN MICROMETER DIVISIONS
7
STAGE I
8
STAGE II
9
STAGE III
10
STAGE IV
11
STAGE V
12
STAGE VI
13
STAGE VII A
14
STAGE VII B
15
STAGE II B
PERCENTAGE FREQUENCY
OVA DIAMETER IN MICROMETER DIVISIONS

PLATE IX

The annual average for 1969-70 and 1970-71 were 39.79 points and 39.95 points respectively. During the first year the monthly average of the volume points reached above the annual average in June, July, October, November, December and January and in the second year in April, May, July, September, November and December.

From the above data it would appear that, in general, the feeding intensity was higher in immature fish than in the mature fish, in both the years. In certain months the feeding intensity was high and was above the annual average both in immature as well as in mature fish and in other months it was low showing that the variations in feeding activity are not related to maturation.

4.8. FEEDING HABITS AND SELECTIVITY

During the course of the examination of stomach contents and study of food of D. acuta certain interesting observations were made on the feeding habits.

D. acuta has got a small and terminal mouth and consequently is prevented from consuming larger food particles. It has been observed that D. acuta is mainly a zooplankton feeder. The preferred food items were, in general, elongate and slender forms like Lucifer, alima, euphausids, Acetes, young ones of Stolephorus spp., etc.

Some exceptions, of course, occurred but they were invariably small, like zoea larvae, *Porcellana* etc., or were soft and thin like megalopa and phyllosoma larvae. All the food items were swallowed whole and in the freshly fed stomachs they were found in the full form and shape and were closely packed. The elongated food items like *Lucifer* and alima were folded in a zig-zag manner and the broader items like phyllosoma were folded longitudinally and were closely packed without any loss of space. These features were clearly visible in the case of gorged and fully fed stomachs. The elongate and rather stiff organisms like juvenile fishes were packed longitudinally inside the stomach without any specific orientation of the head of the prey, indicating that *D. acuta* catches the prey both from front and from rear. In some instances headless fish were also noticed inside t he stomach which reveals that some sort of biting also takes place, when necessary, especially, while preying on the fast moving, slightly larger young *Stolephorus*. The presence of maxillary teeth in *D. acuta* also supports this inference.

The stomach of *D. acuta* sometimes contained exclusively certain food items like *Lucifer*, alima or juvenile fishes and in rare cases zoea larvae, indicating the abundant availability and the preference shown for such items. In almost all cases of the well fed stomachs it was noticed that one of the items clearly dominated over all other items, indicating that the fish fed mainly on the preferred items first and if any space left in the stomach was filled by other supplementary items. The percentage occurrence of three dominant food items namely Lucifer, alima and fish in the well fed stomachs of D. acuta in various months, along with their volumetric and numerical assessments, are presented in Tables 61 and 62. In this analysis the well fed stomach includes gorged, full and $\frac{3}{4}$ full stomachs only. From the Tables it may be noticed that in December 1970 a fish measuring 122 mm total length consumed 370 numbers of Lucifer at a stretch. The maximum number of alima noticed was 36 in November 1970 in a specimen measuring 151 mm. Similarly in the stomach of a fish measuring 130 mm total length in May 1969 and another fish measuring 129 mm in May 1970 contained 102 numbers of juvenile fishes each. On occasions, when the stomach of a specimen was mainly occupied by one food item and the rest were digested matter, the latter was nothing else other than the digested parts of the major item. This was clearly evident when the stomach was filled with Lucifer or alima and crustacean remains, where the crustacean remains were only broken parts of Lucifer or alima. All these observations indicate that D. acuta has some preference for Lucifer, alima and juvenile fishes, especially species of Stolephorus etc., and fed voraciously on these organisms, if they were available in the suroundings.

TABLE 61

THE VOLUMETRIC AND NUMERICAL DATA OF THREE MAJOR FOOD ITEMS IN THE WELL FED STOMACHS OF DUSSUMIERIA ACUTA IN VARIOUS MONTHS FOR THE YEAR 1969 - 1970

Months	No. of fish	Food items	Percentage occurrence of food items	Average volume points of stomachs	Volume of food items in percentage of stomach volume		Number of each food organisms in the stomach	
					Range	Average	Range	Average
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
April 1969	4	*Lucifer*	Nil					
		Alima	50.00	60.0	43-95	62.0	5- 6	5.5
		Fish	50.0	70.0	73-80	76.5	1- 4	2.5
May	16	*Lucifer*	12.5	70.0	20-24	22.0	21- 28	24.5
		Alima	Nil					
		Fish	87.5	84.3	40-95	75.1	1-102	26.4
June	1	*Lucifer*	100.0	100.0	95	95.0	100	100.0
		Alima	Nil					
		Fish	Nil					
July	10	*Lucifer*	100.0	82.0	70-98	87.3	21-295	166.0
		Alima	Nil					
		Fish	Nil					
Aug.	4	*Lucifer*	100.0	75.0	65-98	78.3	23- 42	28.8
		Alima	Nil					
		Fish	Nil					
Sept.	11	*Lucifer*	36.4	70.0	69-90	81.0	39- 70	51.0
		Alima	Nil					
		Fish	63.6	80.0	92-100	95.4	2- 7	4.1

Continued

Table 61 (Contd.....)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Oct.	15	*Lucifer*	73.3	78.2	50-98	74.8	23-205	90.5
		Alima	20.0	73.3	50-80	72.7	2- 13	6.0
		Fish	6.7	60.0	69	69.0	1	1.0
Nov.	10	*Lucifer*	30.0	80.0	40-70	60.0	43- 48	46.3
		Alima	70.0	82.9	35-80	60.0	2- 10	6.0
		Fish	Nil					
Dec.	5	*Lucifer*	60.0	73.3	50-95	68.3	26-250	105.3
		Alima	Nil					
		Fish	40.0	80.0	70-80	75.0	6- 9	7.5
Jan.	1	*Lucifer*	Nil					
1970		Alima	Nil					
		Fish	100.0	80.0	80	80.0	1	1.0
Feb.		No sample						
March	7	*Lucifer*	28.6	80.0	75-95	85.0	55-218	136.5
		Alima	71.4	88.0	40-95	78.0	3- 22	10.8
		Fish	Nil					

TABLE 62

THE VOLUMETRIC AND NUMERICAL DATA OF THREE MAJOR FOOD ITEMS IN THE WELL FED STOMACHS OF DUSSUMIERIA ACUTA IN VARIOUS MONTHS FOR THE YEAR 1970 - 1971

Months	No. of fish	Food items	Percentage occurrence of food items	Average volume points of stomachs	Volume of food items in percentage of stomach volume		Number of each food organisms in the stomach	
					Range	Average	Range	Average
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
April	25	Lucifer	16.0	80.0	35-100	58.8	55- 85	60.8
		Alima	12.0	93.3	40- 55	45.0	12- 20	15.7
		Fish	72.0	93.3	40- 95	78.7	1- 13	6.0
May	11	Lucifer	18.2	90.0	35- 75	55.0	70-120	95.0
		Alima	18.2	90.0	35- 60	57.5	8- 10	9.0
		Fish	63.6	80.0	40- 96	71.6	1-102	32.9
June	8	Lucifer	75.0	73.3	60- 90	78.3	29- 85	53.2
		Alima	12.5	100.0	60	60.0	6	6.0
		Fish	12.5	60.0	85	85.0	2	2.0
July	9	Lucifer	100.0	82.2	70-100	91.7	21-295	166.7
		Alima	Nil					
		Fish	Nil					
August	4	Lucifer	100.0	75.0	65- 80	73.8	23- 42	28.8
		Alima	Nil					
		Fish	Nil					
Sept.	10	Lucifer	Nil					
		Alima	Nil					
		Fish	100.0	80.0	80-100	87.7	3- 11	6.2

Continued

Table 62 (Contd.....)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Oct.	No Sample							
Nov.	8	*Lucifer*	Nil					
		Alima	100.0	75.0	65- 90	80.6	3- 36	18.5
		Fish	Nil					
Dec.	12	*Lucifer*	100.0	90.0	65-100	90.1	55-370	199.8
		Alima	Nil					
		Fish	Nil					
January 1971	1	*Lucifer*	100.0	60.0	40	40.0	42	42.0
		Alima	Nil					
		Fish	Nil					
Feb.	5	*Lucifer*	60.0	73.3	40- 45	45.0	35- 35	35.0
		Alima	Nil					
		Fish	40.0	80.0	50- 90	70.0	4- 7	5.5
March	7	*Lucifer*	42.9	60.0	70- 80	75.0	45- 55	50.0
		Alima	57.1	60.0	40- 80	63.8	6- 9	7.5
		Fish	Nil					

From the nature of the stomach contents it may be inferred that D. acuta feeds on the surface and is a plankton feeder, preying on zooplankton like smaller and larval crustaceans, juvenile and larval fishes and occasionally plant materials which are bits of seaweeds. The diurnal variation in the feeding habits has been described earlier.

No cannibalism has ever been noticed in the case of D. acuta in the course of this study.

4.9. FOOD OF DUSSUMIERIA HASSELTII

To make a comparison of the food of Dussumieria acuta, the food of Dussumieria hasseltii from Indian waters was also examined during this period. Sufficient number of specimens of this species was not available from Mandapam area to carry out a detailed study. So, a quantitative analysis of the stomach contents of a few specimens of D. hasseltii from Cuddalore, Mandapam, Titicorin, Kanyakumari and Vizhinjam was also made during the two years in 1969 and 1970.

Nine specimens of size range 185-205 mm total length were collected from Cuddalore in April 1970. Out of this 3 had actively fed on Stolephorus sp., alima, megalopa, young prawns and crustacean remains. The rest had poorly fed stomachs. From Mandapam area, 15 specimens were collected in March 1969 from shore-seine catch at Pudumadam, and these ranged in size between 104 and 175 mm. The food items were

Acetes sp. fish, young prawns, Alima, and crustacean remains. The average feeding index showed that these specimens fed actively. In April 1969, 3 specimens of size range of 170-178 mm collected from shore-seine at Rameswaram Road (Rameswaram Island) had fed on fish, alima, young prawns, *Porcellana* sp. and crustacean remains. General feeding intensity was poor. In February 1970, 7 specimens ranging between 157 and 167 mm, collected from Kundugal point (Rameswaram Island) were all with empty stomachs. 20 specimens collected from Dhanushkodi (Rameswaram Island) caught in shore-seine in August 1970 ranged between 122 and 134 mm total length and their stomachs were full and the food items were *Acetes* sp., alima, fish, megalopa, copepods, *Porcellana* sp., zoea, *Lucifer* and crustacean remains. Further, 3 specimens collected in October, 1970 from the shore-seine catch at Panaikulam (Palk Bay) ranged between 147 and 164 mm and all had empty stomachs.

In August, 1969, 3 specimens of *D. hasseltii* ranging in size between 125 and 143 mm were collected from Tuticorin and all the three had empty stomachs.

From Kanyakumari 8 specimens were available in April, 1969 in the size range of 114 - 185 mm. On the average they had a poorly fed stomach. The food items noticed were fish, *Acetes* sp. alima and crustacean remains.

From Vizhinjam (Arabian Sea) samples were available for observation for two months in May and November, 1969.

23 specimens collected in May, 1969 were poorly fed and the food items were Lucifer sp., young prawns, copepods, Acetes sp. fish and crustacean remains. The size of the specimens ranged between 152 and 175 mm. In November, 1969 another sample of 20 specimens, ranging between 154 and 178 mm, were available from Vizhinjam which had fed actively on megalopa, alima, fish, young prawns and crustacean remains.

Since adequate number of specimens of D. hasseltii was was not available locally, throughout the year, neither a detailed study of the feeding habits nor the diurnal variation in feeding could be studied in this species. However, from the above observations, it may be said that this species also is a zooplankton feeder, like D. acuta, feeding mainly on smaller and larval crustaceans and young and larval fishes.

The food and feeding habits of two species of the Genus Dussumieria, namely Dussumieria acuta and D. hasseltii, have been studied by several earlier workers. Devanesan and Chidambaram (1948) observed Dussumieria spp. as surface feeders, feeding mainly on plankton and occasionally on white-bait. Vijayaraghavan (1950) studied the food of both these species along with a few other fishes from Madras coast and found that the food of Dussumieria spp. belonged to the groups of teleosteans, copepods, Macrura, Brachyura, Anomura, Mysis, other Entomostraca, Stomatopoda, crustacean remains, Mollusca, vegetable matter, Chaetognatha and animal matter. This is only a very broad categorization.

Sekharan (1949), in his studies on feeding and maturity of D. acuta in relation to fat in the muscles, had pointed out that the main food items were crustacean and teleosts. Vijayaraghavan (1951 b) analysed the food of D. acuta in detail based on the specimens from Madras coast and found that Penaeus larvae, Lucifer sp., Mysidacea, Paguridae, zoea and megalopa of crab, copepoda, Ostracoda, Amphipoda, Squilla larvae, Acetes, crabs, Cumacea, phyllosoma, crustacean remains, Ophiuroidea, Sagitta, Polycheata, bivalve larvae, teleosts and teleostean eggs, medusae, algae, green matter and sand particles occured in the stomachs. Kuthalingam (1961) examined the food of larval and adult D. acuta from Madras coast and found that the fish fed on a variety of planktonic animals such as copepod nauplii and adults, decapod larvae, molluscan larvae, echinoderm larvae, cirripede larvae, Lucifer, Noctiluca, zoea and megalopa stages of crab, Acetes, squilla larvae, Penaeus larvae, anomura larvae, pagurids, amphipods, ostracods, polycheate larvae, Sagitta, diatoms, fish eggs and larvae, etc. Larval forms of Caranx and Leiognathus spp. were also found in its food. The copepods he noticed as food of D. acuta, belonged to eight species namely Oithona spinulosa, O. rigida, Temora sp., Paracalanus parvus, Pontella sp., Eucalanus sp., Pseudodiaptomus sp. and Labidocera sp. He also noticed that D. acuta fed on different species of diatoms like Thalassiothrix sp., Pleurosigma sp., Coscinodiscus sp., Planktonella sp., Asterionella sp., Nitzchia, Chaetoceros sp. Rhizosolenia sp., Podosira sp., Melosira sp., Sceletonema sp., Cyclotella sp. and Thalassiosira sp.

The food of D. hasseltii from the Gulf of Mannar and the Palk Bay had been studied by Devanesan and Chacko (1944) and listed the food items under two main heads as zooplankton and phytoplankton. The zooplanktons were copepods, Rhopalophthalmus egregius, Lucifer hanseni, crab zoea and megalopa larvae, larvae of squilla, Acetes sp, Cresis acicula, Spiratella sp., larval bivalves and Sagitta sp. The phytoplankton consisted of Coscinodiscus spp., Rhizosolenia, Thalassiothrix, Trichodesmium and algal filaments. Chacko (1949) examined 1500 specimens of D. hasseltii ranging in size between 9 and 20 cm from the Gulf of Mannar and found that this fish fed mainly on crustaceans, molluscs, worms and different species of phytoplankton. No fish items were noticed as food. The food organisms were Coscinodiscus, Rhizosolenia, Thalassiothrix, Trichodesmium, copepods, Rhopalophthalmus, Lucifer, crab zoea, megalopa, Cresis acicula, Spiratella, larval bivalves, and Sagitta species. Tham Ah Kow (1950) recorded ostracods, copepods, amphipods, mysids, Squilla larvae, penaeid larvae, Acetes, Lucifer, Leptochela, Porcellana larvae, brachyuran larvae, decapod larvae and Stolephorus larvae as food items of D.hasseltii from Singapore Strait and stated that this species feeds mainly on copepods, ostracods, decapod larvae, small decapods and fish larvae; and amphipods, mysids and *Squilla* larvae form its subsidiary food. The food and feeding habits of *D. hasseltii* from Malabar coast were studied by Venkataraman (1960) and reported that *Lucifer*, prawns, copepods, decapod larvae, teleosts and other crustaceans formed the food of this fish and of these the sergestid *Lucifer* formed the favourite food. Basheeruddin and Nagappan Nayar (1961) also noticed that crustaceans like zoea larvae, amphipods and copepods formed the main food of *D. hasseltii* of Madras coast. The food and feeding habits of *D. hasseltii* of the Gulf of Mannar had also been studied by Mahadevan and Chacko (1962). They observed that diatoms, stomatopod and prawn larvae and copepods formed the main food of this fish. Other items noticed were Algae, *Sagitta* and *Lucifer*, zoea larvae, bivalve and gastropod larvae, fish eggs, *Acetes*, megalopa larvae, pteropods, and digested and unidentifiable matter. Srinivasa Rao (1964) observed crustaceans like *Lucifer*, alima, megalopa, amphipod, zoea, *Cypris*, *Eucalanus*, prawn remains and teleosts like *Anchoviella* and *Sphyraena* as food of *D. hasseltii* of Waltair coast and pointed out that this fish prefers *Anchoviella* and alima larvae. All these earlier reports on the food and feeding habits of these two species of rainbow sardines show that the food items are almost the same and these authors positively agree that these fishes are plankton feeders feeding mainly on larval and adult, but smaller, crustaceans and larval and juvenile teleostean fishes.

The present observations on the food of D. acuta and D. hasseltii also agree with the observations of these earlier workers but with certain differences as to the wide range of food organisms recorded from place to place and the absence or presence of certain food items, all of which could be attributed to the environmental differences, determining the relative abundance of certain food items in different localities wherefrom the samples were procured for study. It may be stated that D. acuta is mainly a crustacean feeder, also feeding on larval and juvenile fishes whenever available. The accounts of all the earlier authors and the observations of the present author reveal that the rainbow sardine although feeding on a variety of organisms, consume more of some particular items, while the rest forms its supplementary food.

Some authors like Devanesan and Chacko (1944), Chacko (1949), Mahadevan and Chacko (1962) noticed that D. hasseltii feeds on different species of phytoplankton (diatoms) also. Mahadevan and Chacko (1962) observed that the rate of feeding was low and poor from April to August when diatoms constituted the chief item of food. They noticed a seasonal phytoplanktonic abundance in the plankton during the period. Kuthalingam (1961) observed that D. acuta also feeds on different species of diatoms and stated that the larvae of this fish from 72 hours to 12th day after hatching were strictly vegetarian and fed only on diatoms when assorted plankton was supplied to it. Among the adult fish he examined the youngest fish measuring 60-80 mm did not include diatoms in their diet, whereas the old and larger ones showed high percentage of diatoms in the stomach. This he attributed to the reason that the gill rakers in the young fish were so poorly formed whereas in the older fish these had developed twigs pinnately so as to form a more efficient strainer. Therefore, the absence of diatoms in the diet of the young fish and the inclusion in the diet of the older fish are merely a mechanical result and not due to a deliberate choice or a change over to a mixed diet. In the present study no diatoms or phytoplanktons were noticed as food in the stomach of D. acuta and D. hasseltii except for some plant materials in the stomach of the former which were only bits of seaweeds and seagrasses. This is in agreement with many of the earlier work except for the few mentioned above. Similarly, some of the items like Sagitta sp. Noctiluca sp., Cumacea, echinoderms, medusae, Rhopalophthalmus sp. Cresia, polycheats, Trichodesmium etc., which were noticed as food of rainbow sardine by one or other of the earlier workers, were not observed in the present study. It was also observed that D. acuta is a visual feeder and it exhibits some sort of selectivity, prefering the crustacean and juvenile teleostean fishes. The presence of slightly larger swimming forms like young prawns and juvenile fishes in the stomach suggest that these zooplankton feeders at times resort to particulate feeding though their general feeding habit is by filteration enabled by gill rakers.

Venkataraman (1960) observed a high percentage (53%) of empty stomachs in D. hasseltii of Calicut area. Tham Ah Kow (1950) also noticed the same feature in the specimens of the species caught from Singapore Strait. But these authors had not mentioned any specific reason for it. On the other hand Mahadevan and Chacko (1962) had observed comparatively low percentage (15.75%) of empty stomachs in D. hasseltii. They also opined that the percentage of empty stomach was low from September to April and high in the subsequent months thus showing two stages of feeding. The maximum feeding they observed was in March and in November-December. The trend of feeding had been interpreted by them as seasonal rather than in accordance with the size of the fish and they also assumed that active feeding periods may be the after effect of spawning. In the present study on D. acuta also high percentage of empty stomachs were noticed. But a detailed analysis showed that this fish exhibited a diurnal variation in feeding habit, feeding during day time and starving during night. Since the majority of the commercial catch, from which specimens were collected, came from night fishing the percentage of the empty stomach was more. When the day catch was analysed it was seen that the percentage of empty stomach was very low. In the present study, as against the observations of Mahadevan and Chacko (1962), no specific seasonal variation in feeding or any correlation with spawning was noticed. But the variation was in the feeding intensity between day and night and was not due to any other aspects.

While feeding on zooplankton and larval and juvenile fishes, the rainbow sardines themselves form very delicious food for still other bigger, voraceous, piscivorous fishes. A perusal on the literature on the food of various piscivorous fishes showed that rainbow sardines become prey for Chirocentrus dorab, seer fishes (Scomberomorus spp.), ribbon fishes (family Trichiuridae), fishes of the family Sciaenidae and the tunas. Vijayaraghavan (1951a) had observed that Dussumieria formed the common food of Trichiurus haumela (Forsk) of the size range 10 to 20 inches. Tham Ah Kow (1950) had noticed in Singapore Straits the fishermen using D. hasseltii as bait for fishing Chirocentrus dorab.

CHAPTER 5

REPRODUCTION

A thorough knowledge on some of the basic biological factors, such as maturation cycle, size at first maturity, sex-ratio, spawning, fecundity and ponderal index, of the fish species is essential for the successful management of their fisheries.

Clark (1934) studied by means of ova diameter measurements, the maturity and spawning of California sardine, *Sardina caerulea*. Later, in a similar manner, Hickling and Rutenberg (1936) studied the spawning periods in hake, haddock, pilchard and other fishes. de Jong (1940) determined the spawning periods of a number of tropical fishes by ova diameter studies. Other important work on the fecundity studies of fishes includes those of Hickling (1940) on the herring of the Southern North Sea, Mac Gregor (1957) on the Pacific sardine, *Sardinops caerulea* and Bagenel (1957 and 1963) on the long rough dab, *Hippoglossoides plastessoides* and the plaice.

In recent years, in India, many accounts have been published on the maturity, spawning behaviour and fecundity of commercially important fishes. Although Hornell (1910) made a few observations on the spawning habits of Indian oil sardine, _Sardinella longiceps_, the first concerted attempt to understand its maturity and spwning habits was by Hornell and Nayudu (1923). Karnadikar and Palekar (1950) studied the spawning habits of _Polynemus tetradactylus_. Similarly, the maturity and spawning habits of _Thrissocles purava_, _Harpodon nehereus_ and _Coilia dussumierii_ have been worked out in detail by Palekar and Karandikar (1952 a, 1952 b and 1953). The spawning periodicity in some of the marine teleosts along the east coast of India was studied by Prabhu (1956). Dharmamba (1959) studied the maturation and spawning of six common species of clupeids of Lawson's Bay (Waltair). Qasim and Qayyum (1961) made observations on the spawning frequency and breeding season of some fresh water fishes in the plains of Northern India.

Studies on fecundity and spawning of _Dussumieria hasseltii_ were carried out by Devanesan and Chacko (1944), Chacko (1950) and Mahadevan and Chacko (1962). All these earlier works were restricted to the general bionomics of the species. Dharmamba (1959) studied the maturation and spawning habits of _D. hasseltii_ of Lawson's Bay (Waltair) by means of ova diameter measurements.

5.1. STRUCTURE OF GONAD:

Sexes in *Dussumieria acuta* are separate but the fish does not show any sexual dimorphism. When the fish is fully mature the males and females can be differentiated by applying gentle pressure on either side of the abdomen when the milt or the ova, as the case may be, will ooze out.

The gonads are bilobed structures located in the body cavity on either side of the intestine. The ovaries are long and slender in the early stages, but increase in breadth and thickness with the advancement of maturity. As the ovaries mature, they get distended due to the changes in the intra-ovarian eggs and attain yellow colour as a result of yolk formation in the eggs. A distinct asymmetry could be noticed in the structure of the ovary. The two lobes of the ovary are not alike in shape as well as in the relative position they occupy in the body cavity. In early stages of maturity the right lobe occupies the full length of the body cavity, the anterior tip lying on the right side of the mass of the intestinal caecae, and is thin and slender, gradually increasing in width towards the anterior tip. As the maturity advances this lobe becomes long and pear-shaped, filling the right side of the body cavity, and contains the greater number of ova. The left lobe of the ovary is posteriorly placed and reaches only $\frac{3}{4}$ of the length of the right ovary. In early stages it is spindle-shaped and as the maturity advances the shape is retained though there is increase of breadth and thickness. It contains comparatively smaller number of ova. A mature ovary when viewed from the ventral side, in situ, will be completely masking the alimentary tract except for the posterior end of the intestine. The ovary is of the cystovarian type and the internal structures are of the pattern found in the ovaries of most teleostean fishes.

The testes are small, thin, flat, pinky-whitish structures with long and slender vasa deferentia in the earlier stages, but with advancement of maturity, they get enlarged and attain whitish colour. Fully developed testes are flat, thick and milk-white in colour with long, slender but conspicuous vasa deferentia. The asymmetry between the right and the left lobes of the testes is quite distinct in the shape and the relative positions they occupy in the body cavity. In early stages the right lobe is very small, thin, translucent, pinky-white and slightly oval placed anteriorly in the body cavity on the right side of the mass of the intestinal caecae with long and slender vas deferens. As maturity advances the lobe increases in size, completely masking the intestinal caecae. The left lobe, in early stages, is small, slender, elongated and spindle-shaped and is posteriorly placed reaching $\frac{3}{4}$ of the length of the right lobe. In late stages of maturity the shape remains the same; but the size increases. In mature males the testes are milky white in colour.

In *D. acuta* the sexes could not be determined accurately, in specimens measuring below 100 mm total length since the gonads are too minute, slender and thread-like, to be differentiated by the naked eye and such fishes are here treated as indeterminate ones.

5.2. CLASSIFICATION OF MATURITY STAGES:

The maturity stages of *D. acuta* have been classified based on the macroscopic appearence and microscopic structure of ova in the ovary and the following stages of maturity were recognized for the species. The description relates to fresh as well as preserved specimen. In the frequency polygons the diameter measurements were classified into size groups of 2 m.d. intervals as 1-2, 3-4, 5-6 etc. and the modes were represented by the second number in the size groups viz., 2, 4, 6, etc., or the corresponding millimeter conversions. The maturity stages for the males were classified depending only on macroscopic examination of the testes.

Stage I - Immature: Ovaries long, slender and rounded, tapering posteriorly, and occupying the full length of the body cavity. The left lobe is very small and spindle-shaped being placed posteriorly. The ovary is slightly fleshy in colour and translucent. Ova are not visible to naked eye. Under microscope small and transparent ova, each with a transparent nucleus, are visible. Majority of the ova range in size between 0.047 and 0.12 mm (3 and 8 m.d.) with a mode at 0.09 mm (6 m.d.). The maximum size of the ova was observed as 0.19 mm (12.m.d.).

The testes are small, translucent, pinky white, thin, slightly elongated and oval shaped structures with a long and slender vas deferens. The right lobe is placed at the anteriormost region of the body cavity, whereas the left lobe is posteriorly placed and is more elongate and spindle-shaped. This asymmetry in shape and position exists in all stages.

Stage IIa - Developing immature: The ovaries slightly enlarged, long, translucent and amber coloured. Ova visible to the naked eye as small granule. Ova small, and transparent with large transparent nucleus. Yolk formation has started in a few ova of the larger size groups which are mostly semi-opaque. Majority of the ova are in between 0.05 and 0.16 mm (3 to 10 m.d.) diameter. Some eggs have grown still bigger with a mode at 0.31 mm (20 m.d). Maximum size reached upto 0.50 mm (32 m.d.).

The testes of this stage has increased in size and is opaque and whitish. The vas deferens is long and thread-like.

State II b - Recovering spent: Ovaries of this category were observed in fishes above the size at first maturity (132 mm total length). The ovaries have a collapsed and flattened appearance and are slightly opaque and flesh coloured. Majority of the ova are transparent, with a mode at 0.12 mm (8 m.d.). The advancing mode is at 0.25 mm (16 m.d.). The maximum size of the ova was 0.47 mm (30.m.d.). A portion of the ovary when viewed under microscope shows small empty spaces between groups of oocytes, whereas in developing immatures, the oocytes overlap each other, being compactly arranged in the lamellae with spaces in between.

The testes are pinkish-white in colour and have a slightly wrinkled appearance. It is different from the previous stage in having a slightly longer right lobe and a wider vas deferens.

Stage III - Maturing: The ovaries are greatly enlarged and occupy $\frac{3}{4}$ of the space in the body cavity. The right ovary long and pear-shaped, while the left one short and spindle-shaped. The ovaries are turgid, opaque and yellow-coloured. The ovarian membrane is transparent and the eggs are visible externally through the cyst. The advancing group of ova have a mode at 0.56 mm (36 m.d.). The maximum size observed was 0.66 mm (42 m.d.). A second mode of maturing ova may be noticed at 0.41 mm (26 m.d.). Both these sets of ova are opaque, thickly yolked and yellowish in colour.

Testes increased in size. The right lobe is wider and reaches $\frac{3}{4}$ towards the ventral side of the body cavity, on the right side, masking the intestinal caecae. With the long and slender vas deferens, it will have the shape of the letter 'P'. The left lobe is spindle-shaped. The lobes are thicker and whitish in colour. The vasa deferentia are white, long and thread like.

<u>State IV - Mature</u>: The ovaries are further enlarged; compact and pear-shaped, almost filling the body cavity, orange-yellow in colour. The ovarian cyst thin and transparent. The largest ova may measure about 0.78 mm (80 m.d.). These groups of maturing yolked eggs may be noticed in the ova diameter frequency polygon. The most advancing group had the mode at 0.72 mm (46 m.d.). The other two modes may be around 0.56 mm (36 m.d.) and 0.31 mm (20 m.d.). The yolked ova are completely opaque with a thick transparent egg membrane.

The testes greatly enlarged in width and fully reaches the ventral side of the body cavity. Milky-white in colour.

<u>Stage V - Advanced mature</u>: The ovaries completely fill the body cavity and mask the alimentary tract when viewed from the ventral side. Light reddish in colour. The ovarian cyst, very thin, transparent and the individual eggs visible externally. A few fully mature transparent ova may be noticed externally through the cyst in fresh condition, as colourless dots. The maximum diameter of ova observed was 1.03 mm (66 m.d.). The advancing group of ova had a mode at 0.81 mm (52 m.d.). In

addition to this, two more groups of yolked ova may also be noticed. Among the mature ova some are completely opaque, some with transparent periphery, some partly transparent and a few fully transparent. The partly transparent ova are light yellow in colour. The completely transparent ova have a frothy appearance and have a single oil globule or in some cases two or three small droplets.

The width of the testes is greatly enlarged and the lobes occupy the entire depth of the body cavity, or even more, with the result their outer margins fold round to the opposite sides through the ventral side of the alimentary tract, close to the ventral wall of the body cavity. When viewed from the ventral side the alimentary canal will be completely masked by the testes which is milky-white in colour.

Stage VI - Ripe: The ovaries are turgid and light reddish in colour. With an increased number of colourless dots looking like boiled sago sprinkled throughout. In fresh condition, if slight pressure is exerted on either side of the abdomen, a gelatinous mass of transparent ova will be exuded. The largest ova are transparent and jelly-like reaching a maximum diameter of 1.12 mm (72 m.d.). The mode of the ripe eggs is around 0.94 mm (60 m.d.). The transparent ova have single oil globule in fresh condition.

The testes milky-white in colour and greatly enlarged. Exude milt on application of slight pressure.

<u>Stage VII a - Partially spent</u>: They are slightly shrunk in volume and reduced in size and will be almost of the size of stage IV, but are a bit flaccid and collapsed with slight wrinkles on the surface especially towards the posterior end where the eggs will be loosely packed indicating that some of the mature eggs have been shed. The turgidity of the ovary will be lost. The maximum diameter of the ova is about 0.94 mm (60 m.d.) and the frequency distribution shows only two categories of yolked ova. The advanced group has its mode at 0.69 mm (44 m.d.). These ova are completely yolked and opaque. In these ovaries the tissue will be more. A few degenerating ova, undergoing resorption may also be noticed.

The testes in this stage will be shrunk and wrinkled. The margins will be transparent or translucent with white patches here and there. The central part will be milky-white in colour.

<u>Stage VII b - Fully spent</u>: The ovaries are shrunk and elongated, flabby with wrinkles on surface due to collapsed condition. In preserved condition it has a greyish colour. Still a group of yolked eggs may be observed along with some remnants of mature ova measuring upto 0.81 mm (52.m.d.). These eggs may not be healthy in appearance. The lumen of the ovary is filled with ruptured tissues, yolk fragments, scattered oil droplets, etc., which indicate the degeneration of the ova. The ova undergoing resorption are sometimes translucent in appearance, with the yolk in the form of small spherules, light grey or

brownish in colour surrounded by wide transparent space. It is assumed that all the remaining yolked ova in this stage may undergo degeneration and be resorbed resulting in stage II b.

The testes of this stage is loose and white in colour and shrunk, and greatly reduced, with translucent patchy regions.

5.3. DISTRIBUTION OF OVA IN THE OVARY:

Inorder to find out the distribution of ova in different regions of the ovary of D. acuta, samples from anterior, middle and posterior regions of the right lobe of a mature ovary (stage V) from a specimen measuring 145 mm in total length were cut out and teased on a plankton counting chamber and the ova diameter measurements in each portion were noted separately. The frequencies plotted (Plate IX, Fig.3) showed a similar pattern in the distribution of the maturing and mature ova and hence the diameter frequency polygons of three regions were combined (Plate IX, Fig.4). Similarly the distributional pattern of ova in the left lobe of the same ovary was also found to be uniform (Pl. IX, Figs. 5 & 6). In this study the small ova measuring below 0.31 mm (20 m.d.) were not measured since they were of the immature stock. In all the further studies, since the right ovary was considerably bigger and contained a large number of ova than the left the diameter measurements of ova were taken from the eggs of the middle region of the right ovary.

Ovaries in all the stages of maturity contained immature ova measuring up to 0.22 mm (14 m.d.) through the year. Hence, in stages other than immature (stage I), only developing immature (stage II) and maturing (Stage III) ova above 0.22 mm (14 m.d.) were measured. Several other earlier workers like Clark (1934) and de Jong (1940) have followed the same method and found that it gave satisfactory results.

5.4. DEVELOPMENT OF OVA TO MATURITY.

Ova diameter measurements of as many as 93 ovaries in different stages of maturity were taken for this study. Based on the characteristic macroscopic appearance of the ovary correlated with microscopic study of the ova, nine maturity stages have been given earlier. In the tabulated data and in the figures representing the ova diameter frequency polygons, measurements are given in class intervals of two micrometer divisions.

Ovaries typical of the nine stages described earlier have been selected and their ova diameter frequencies are presented in Table 63 and the corresponding frequency polygons were drawn (Pl. IX, Figs. 7-15). In stage I, majority of the ova were in size range 0.02 - 0.12 mm (3 - 8 m.d.) with the

TABLE 63

PERCENTAGE FREQUENCIES OF OVA DIAMETER IN MICROMETER DIVISIONS IN DIFFERENT MATURITY STAGES

[illegible]	Maturity stages								
	I Immature	II Developing immature	III Maturing	IV Mature	V Advanced mature	VI Ripe	VII A Partially spent	VII B Fully spent	II B Recovering II
	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
[illegible]	2.69	1.11	0.80	—	—	—	—	—	1.01
[illegible]	28.13	10.67	5.11	—	—	—	—	—	4.47
[illegible]	44.73	22.78	11.82	—	—	—	—	—	10.97
[illegible]	20.73	20.00	19.63	—	—	—	—	—	18.18
[illegible]	3.59	15.67	16.57	—	—	—	—	—	14.57
[illegible]	0.13	8.44	13.36	—	—	—	—	—	11.40
[illegible]		5.22	4.45	—	—	—	—	—	6.35
		2.67	4.45	7.08	1.97	2.50	5.17	9.66	8.66
		3.47	3.58	8.59	3.25	2.83	6.90	11.72	7.22
		4.11	3.28	11.15	5.41	5.46	7.24	14.48	7.36
		2.22	2.37	10.10	6.05	5.53	4.83	7.59	4.62
		1.56	2.92	9.64	6.73	5.72	8.97	13.10	2.31
		0.89	3.50	9.05	7.81	6.78	5.86	6.90	1.44
		0.67	1.75	7.28	7.09	5.29	7.59	7.59	1.01
		0.33	1.75	5.44	6.31	5.66	4.48	4.14	0.43
		0.22	0.88	4.33	5.46	5.33	4.48	5.52	
			1.24	3.15	4.13	3.75	5.52	1.38	
			1.39	3.74	4.69	3.62	4.14	2.76	

(Continued)

Table 63 (Contd.....)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
37-38			0.58	2.89	3.99	3.75	2.41	3.45	
39-40			0.20	2.75	3.87	4.67	1.72	4.14	
41-42			0.29	1.64	2.48	4.08	4.83	0.69	
43-44				2.43	2.46	2.83	7.24	0.69	
45-46				4.85	3.63	2.50	5.52	1.38	
47-48				3.02	3.94	1.84	3.45	1.38	
49-50				2.23	5.17	1.64	2.76	2.07	
51-52				0.66	5.25	1.32	2.76	1.38	
53-54					4.01	2.30	0.69		
55-56					2.78	4.55	1.72		
57-58					1.60	4.67	0.69		
59-60					1.11	4.94	1.03		
61-62					0.38	3.22			
63-64					0.26	2.17			
65-66					0.17	1.25			
67-68						0.59			
69-70						0.39			
71-72						0.13			

mode at 0.09 mm (6 m.d.) and a few of eggs measured upto 0.19 mm (12 m.d.). In stage II the maturing of the ova was noticed and the first batch of developing ova was found withdrawn from the general stock with a mode at 0.31 mm (20 m.d.) and a maximum size at 0.50 mm (32 m.d.). As the maturity of the ovary passed on from stage II to III, a second group of ova got separated from the original, immature stock, while the first group progressed further to give a mode at 0.56 mm (36 m.d.). The second group had the mode at 0.41 mm (26 m.d.). Indications of more eggs being drawn from the immature stock and getting added to the second group of maturing ova could be noticed in this stage. The maximum size of the ova observed in stage III was 0.66 mm (42 m.d.). In the next stage (stage IV) the development of ova advanced further and in addition to the immature stock three modes were visible. The modes observed at 0.56 mm (36 m.d.) and 0.41 mm (26.m.d.) in the previous stage advanced to 0.72 mm (46 m.d.) and 0.56 mm (36 m.d.) respectively in stage IV. A fresh group of maturing ova had separated from the immature stock and advanced to a mode at 0.31 mm (20 m.d.). The maximum size of the ova measured in stage IV was 0. 83 mm (53 m.d.). The mode at 0.56 mm (36 m.d.) observed in stage IV remained stationary in stage V indicating that there was no growth to this group, whereas the mode at 0.72 mm (46 m.d.) of stage IV progressed further to show a peak at 0.81 mm (52 m.d.) in stage V. This mode was constituted by the mature group of ova, to be spawned in the ensuing spawning season, and was distinctly separated from other maturing group as evident from the frequency curve of this stage. The third mode observed at 0.31 mm (20 m.d.) in stage IV had progressed further in stage V, forming a mode at 0.41 mm (26 m.d.). The maximum size of ova measured in stage V was 1.03 mm (66 m.d.). In stage VI the mature group of ova advanced further forming a mode at 0.94 mm (60 m.d.) and showed a faster growth rate than the other two modes. The maximum size of the egg was 1.12 mm (72 m.d.). These were ripe eggs to be spawned. As the first group of ova matured enough to be spawned, the mode of the second batch of ova, which was remaining stationary at 0.56 mm (36.m.d.) in stage IV and V, started developing and progressed to give a small peak at 0.62 mm (40.m.d.). The third mode remained stationary at 0.41 mm (26 m.d.). The ova diameter frequency curve of stage VI showed that the first group of ova was distinctly separated from the second group. Stage VII A showed an ovary in a partially spent condition where the first batch of ova was extruded. From the diameter frequency polygon of this stage it may be seen that a few residual ova still remained in the ovary, while the second group of ova started developing to maturity and became a prominent mode at 0.69 mm (44 m.d.). It may be assumed that this group of eggs in due course may develop to take up the place of the first group which was already eliminated and may result in a second spawning in the same season. Fluctuations within the curve representing the third group of ova resulting in many modes may be noticed in stage VIIA, a major mode being at 0.37 mm (24 m.d.). This stage VIIA almost resembles stage IV except for the presence of a few residual ova which provide evidence that spawning had occured recently. A few degenerating ova were also noticed in stage VIIA. In stage VIIB may be observed that the advancing batch of ova met with in stage VIIA has also been eliminated. The frequency polygon of this stage presented several minor modes within the third group of eggs. The size of the major mode was 0.31 mm (20 m.d.). Two small modes, one at 0.62 mm (40 m.d.) and another at 0.78 mm (50 m.d.) were also noticed in stage VIIB, of which the latter may be residual eggs left over in the second spawning and the former one be the result of the progression of the 0.53 mm (34 m.d.) mode observed in stage VIIA (Pl. VIII, Fig. 13). The number of the degenerating eggs was more in stage VIIB. In addition to the stages described above, some ovaries with the ova diameter frequencies resembling almost stage II (Pl. IX, Fig. 15), were also met with in the course of this study, in which two groups of ova were present. The first group ranging in size from 0.20 to 0.47 mm (13 to 30 m.d.), with a peak at 0.25 mm (16 m.d.), was formed by fresh and healthy ova. The second group, measuring less than 0.20 mm (13 m.d.) with a mode at 0.12 mm (8 m.d.) was the immature stock. Such an ovary described as stage IIB is noticed only in mature fish above 132 mm in total length (size at first maturity). The frequency distribution of these ovaries may resemble stage II but they were different in morphological characters. It may be assumed that the maturing yolked eggs left over by the second spawning degenerated and were resorbed, resulting in an ovary as described in stage IIB. This may pass through a resting phase before further maturation starts for the next spawning season.

5.5. SPAWNING:

A total of 1587 fish was examined during April 1969 to March 1970 and 1973 fish during April 1970 to March 1971 to study the percentage occurrence of gonads in different stages of maturity. The details of the observations are presented in Tables 64 and 65. In this study the maturity stages as defined by the International Council for the Exploration of the Sea (ICES) (Wood, 1930), as reproduced by Lovern and Wood (1937) was followed. Hence, stage II in this study includes both virgin II and recovering II and stage VII includes only spent fishes.

The percentage occurrence of the ovary in different stages of maturity is presented in Plate X, Figs. 1 and 2 respectively. In April 1969 stages II to V and VII were present, stage IV being the most dominant. In May all the

TABLE 64

PERCENTAGE OCCURRENCE OF GONADS OF DUSSUMIERIA ACUTA IN DIFFERENT STAGES OF MATURITY

April 1969 to March 1970

Months	No. of fish	Sex	Stages of maturity						
			I	II	III	IV	V	VI	VII
April	60	F	—	1.66	15.00	45.00	26.67	-	11.67
	37	M	2.70	—	27.03	35.14	21.62	-	13.51
May	87	F	—	1.15	2.30	29.88	26.44	31.01	9.20
	90	M	2.22	2.22	—	22.22	27.78	25.56	20.00
June	58	F	20.69	18.96	27.59	13.79	—	3.45	15.52
	58	M	15.52	25.86	27.58	12.07	6.90	6.90	5.17
July	92	F	21.74	19.57	34.78	20.65	3.26	—	—
	89	M	20.23	23.60	29.21	16.85	1.12	6.74	2.25
August	50	F	12.00	32.00	2.00	32.00	2.00	—	—
	73	M	12.33	39.72	28.77	17.81	1.37	—	—
September	77	F	22.08	62.34	5.19	9.09	1.30	—	—
	72	M	20.83	54.19	11.11	11.11	2.78	—	—
October	104	F	10.58	89.42					
	63	M	6.35	93.65					
November	51	F	9.24	90.76					
	38	M	13.16	86.84					
December	62	F	12.90	87.10					
	50	M	24.00	76.00					
January	98	F	19.39	67.35	13.26				
	68	M	35.30	60.29	4.41				
February	44	F	11.36	54.55	34.09	-			
	31	M	3.22	45.26	41.94	9.68			
March	76	F	2.63	3.95	40.79	44.74	7.89	—	
	59	M	—	11.86	52.54	16.95	8.48	10.17	

TABLE 65

PERCENTAGE OCCURRENCE OF GONADS OF <u>DUSSUMIERIA ACUTA</u> IN DIFFERENT STAGES OF MATURITY

April 1970 to March, 1971

Months	No.of fish	Sex	Stages of maturity						
			I	II	III	IV	V	VI	VII
April	90	F	1.11	—	20.00	42.22	30.00	4.45	2.22
	30	M	6.67	—	28.00	26.67	32.00	3.33	3.33
May	48	F	4.17	—	10.42	29.17	16.66	39.58	—
	53	M	1.59	—	18.87	24.53	9.43	24.53	20.75
June	68	F	10.29	26.47	29.42	19.12	4.41	—	10.29
	89	M	10.11	31.46	25.84	10.11	4.50	4.50	13.48
July	52	F	15.38	9.62	32.69	38.46	3.85		
	75	M	5.33	30.67	32.00	25.33	6.67		
August	61	F	11.48	32.79	45.90	9.83	—	—	—
	71	M	15.49	54.93	15.49	7.04	2.82	—	4.23
September	46	F	28.26	65.22	6.52				
	68	M	36.76	60.29	2.95				
October	68	F	38.24	61.76					
	61	M	42.62	57.38					
November	47	F	21.28	78.72					
	49	M	20.41	79.04					
December	121	F	16.53	83.47					
	82	M	25.61	74.39					
January	73	F	26.03	50.68	15.07	8.22			
	48	M	29.17	54.17	16.66	—			
February	92	F	22.83	42.39	33.70	1.08			
	58	M	24.14	39.66	32.76	3.44			
March	78	F	—	8.97	53.85	25.64	7.69	—	3.85
	45	M	2.22	8.89	71.11	17.78	—	—	—

tages, except stage I, were observed and stage VI which was not seen in April was found dominating in May. During June stages I to IV, VI and VII were observed. Stage I was not seen in the previous two months and stage V observed in the previous month was absent in June. An increase in the percentage of stages II, III & VII and a decrease in the percentage of stage IV and VI could be noticed in this month. In July and August almost the same pattern was noticed with the presence of stages I to V. All these five stages were observed in September also, but the percentage of stage III, IV and V were much less and the majority were in stage II. During October, November and December only stages I and II were noticed, stage II being predominant. An increase in the percentage of stage II was noticed in June onwards, and it reached its maximum in November and thereafter its percentage began to decrease. Maturing of the ovary (stage III) started in January 1970 and the percentage of stage II increased in the subsequent months. In January and February stages I to III were noticed and in March stages IV and V also started to appear in good percentages, especially stage IV. Stages I and II were represented only in small percentages.

During the subsequent year, April 1970 to March 1971 (Pl. X, Fig.2) the percentage occurrence of ovary in different stages of maturity presented almost a similar picture as that in the previous year. In April, except stages II all the other stages were recorded simultaneously. Stage IV ranked first in this month and stage V stood next. Stage I and III to VI were present during May, stage VI being predominant. Fishes of all other stages, except stage VI, were observed in June and an increase in percentage of stage VII could be noticed in this month. In July stages I to V were represented with a dominance of stage IV while stages VI and VII were not noticed. During August the percentages of stages II and III showed an increase, along with the disappearance of fishes in stages V, VI and VII and a lowering in the percentage of stages I and IV. Stages I, II and III were recorded in September. In October, November and December, as in the previous year, only stages I and II were noticed in the catch. An increase in the percentage of stage II started in August, reached its maximum during December. In the subsequent three months the number of fishes in stage II began to decrease considerably with the onset of maturation. In addition to stages I and II fishes with maturing ovary of stages III and IV were observed during January and February. In March, fishes in stage I were absent and in addition to stages II, III and IV, fishes in V and VII were also noticed.

A comparison of the data of these two successive years indicates some salient features in the species' spawning periodicity. Stage I was present in all the months of the year. During October, November and December only stages I and II were found to occur in the commercial catch. In all other months fish in various stages of maturity were present. The process of maturation was found to start by January with the appearance of fishes in stage III which occurred in all other months from January to September. Though stage IV ovaries could be noticed in January 1971, in both the years under study, they occurred in high percentage only from March onwards. Fish with ovaries in advanced stages of maturity (stages V and VI) were observed in March to September. Spent fishes (stage VII) were recorded in March to June. The absence of fish in stage III and above during October, November, and December in both the years, indicates that maturation process is not continuous throughout the year and there is possibly a resting period after the spawning season.

Studies on the percentage occurrence of male gonads in different stages of maturity for the same period indicated a similar pattern as of the females in the corresponding years. The details of these observations are presented in Tabless 64 and 65 and in Plate X, Figs. 3 and 4. The start of the maturation process was indicated by the appearance of fishes in stage III from January onwards and this stage was present in all the subsequent months till September. Testes belonging to stage IV appeared in February and lasted till September. Stage V was present in March, April, May, June, July, August and September and stage VI was observed in March, April, May,

PLATE X

Fig. 1 Month-wise percentage occurrence of different maturity stages of female gonad of *D. acuta* during 1969-70.

Fig. 2 Month-wise percentage occurrence of different maturity stages of female gonad of *D. acuta* during 1970-71.

Fig. 3. Month-wise percentage occurrence of different maturity stages of male gonad of *D. acuta* during 1969-70.

Fig. 4 Month-wise percentage occurrence of different maturity stages of male gonad of *D. acuta* during 1970-71.

Fig. 5 Month-wise percentage occurrence of mature and spent females of *D. acuta* from April 1969 to March 1971.

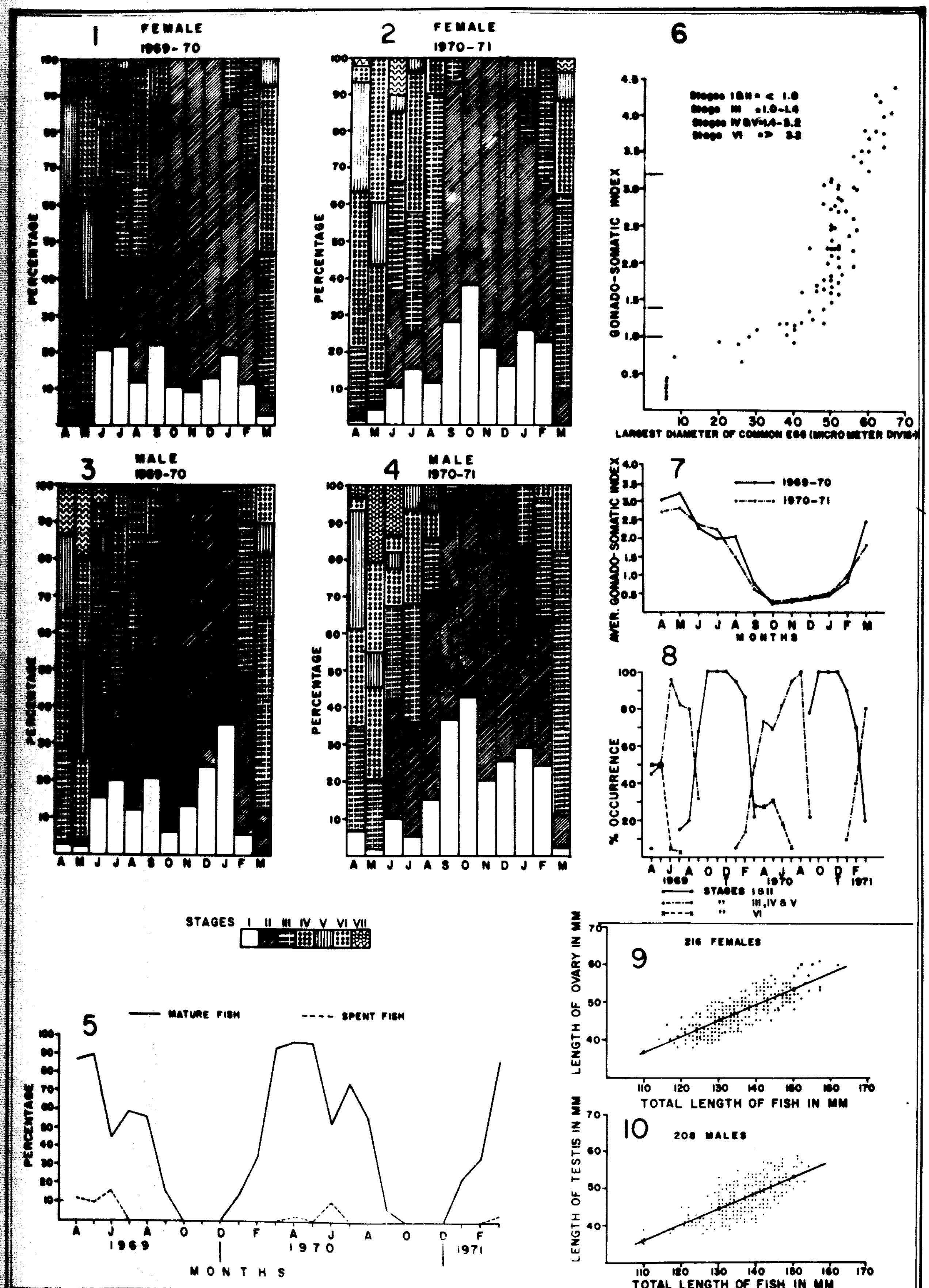
Fig. 6 Gonado-somatic index of individual fish of *D. acuta* plotted against the largest mode of the egg diameter.

Fig. 7 Month-wise average gonado-somatic index of *D. acuta* during 1969-70 and 1970-71.

Fig. 8 Month-wise percentage occurrence of three groups of gonads namely immature (stages I & II), maturing (stages III, IV & V) and ripe (stage VI) of *D. acuta* from April 1969 to March 1971.

Fig. 9 Scatter diagram fitted with regression line showing the length of ovary of *D. acuta* plotted against the total length of the fish.

Fig. 10 Scatter diagram fitted with regression line showing the length of testis of *D. acuta* plotted against the total length of the fish.



1 FEMALE 1969-70
2 FEMALE 1970-71
PERCENTAGE
3 MALE 1969-70
4 MALE 1970-71
STAGES I II III IV V VI VII
5
MATURE FISH
SPENT FISH
1969
1970
1971
MONTHS
6
GONADO-SOMATIC INDEX
LARGEST DIAMETER OF COMMON EGG (MICROMETER DIVIS.)
7
1969-70
1970-71
AVER. GONADO-SOMATIC INDEX
MONTHS
8
% OCCURRENCE
STAGES I & II
III, IV & V
VI
9
216 FEMALES
LENGTH OF OVARY IN MM
TOTAL LENGTH OF FISH IN MM
10
208 MALES
LENGTH OF TESTIS IN MM
TOTAL LENGTH OF FISH IN MM

PLATE. X

June and July. Stage VII was noticed in the months of April, May, June, July and August and stage I was found to occur in all the months. During October, November and December only stages I and II were noticed, stage II being dominent.

The percentage occurrence of mature (stages III, IV, V and VI) and spent (stage VII) female fishes is given in Tables 66 and 67. As may be seen from these Tables mature fish does not occur throughout the year but is absent in October, November and December. It occurred in all other months, with peaks in May and July 1969, April and July 1970 and March 1971 (Pl. X, Fig. 5). The mature fish occurred in high percentages (above 50%) during April, May, July and August 1969; during March to August 1970 and during March 1971. The above Tables also show that the spent fish was found to occur in April, May and June 1969; in April and June 1970 and in March 1971. (Pl. X, Fig. 5). From all these it may be assumed that D. acuta has a definite, but prolonged, spawning season once in a year extending from March to September with a peak period from March to July or August.

TABLE 66

...TAGE OCCURRENCE OF MATURE AND SPENT FISH (April 1969 to March 1970) OF DUSSUMIERIA ACUTA

...hs	Total No. of fish in all stages	Mature fish Stages III, IV, V & VI	Spent fish Stage VII
...l	60	86.67	11.67
	87	89.65	9.20
	58	44.83	15.52
...y	92	59.08	--
...st	50	56.00	--
...mber	77	15.58	--
...ber	104	--	--
...ber	51	--	--
...ber	62	--	--
...ary	98	13.26	--
...uary	44	34.09	--
...h	76	93.42	--

TABLE 67

PERCENTAGE OCCURRENCE OF MATURE AND SPENT FISH (April 1970 to March 1971) OF DUSSUMIERIA ACUTA

Months	Total No. of fish in all stages	Mature fish Stages III, IV, V & VI	Spent fish Stage VII
April	90	96.67	2.22
May	48	95.83	--
June	68	52.95	10.29
July	52	75.00	--
August	61	55.73	--
September	46	6.52	--
October	68	--	--
November	47	--	--
December	121	--	--
January	73	23.29	--
February	92	34.78	--
March	78	87.18	3.85

5.6. FREQUENCY OF SPAWNING:

According to Clark (1934), Hickling and Rutenburg (1936) and de Jong (1940) the multiplicity of modes in the frequency curve of ova diameters from mature female indicates that it spawns more than once in a season. In the case of *Dussumieria acuta* the same condition was observed. It is understood that when the mature group of ova is spawned its place is soon taken up by the advancing group of eggs which has been following the first group and has already undergone half the maturation process. According to de Jong (1940), the second group which has undergone half the maturation takes about half the time taken by an immature group to attain maturity, and hence, the subsequent spawning should take place soon after, provided this group did not degenerate and get resorbed. In a ripe ovary of *D. acuta* (Pl. IX, Fig. 12) three groups of ova could be noticed in addition to the immature stock. The first group (fully mature) ranges in size from 0.80 to 1.12 mm (51 to 72 m.d.) with a mode at 0.94 mm (60 m.d.). This group is to be spawned soon and is clearly separated from the second group of ova (mature) which ranges in size from 0.55 to 0.80 mm (35 to 51 m.d.) with a mode at 0.62 mm (40 m.d.). A third group (maturing) ranging in size from 0.23 to 0.55 mm (15 to 35 m.d.) with a mode at 0.41 (26 m.d.), is also noticed following the second group. Below 0.23 (15 m.d.) it is the immature stock. As already explained, two types of spent ovaries were also recorded in D. acuta. In the first type called "partially spent" (stage VIIA; Pl. IX, Fig. 13) the mature batch of ova has just been released. This may be evident from the remains of residual ova in such ovaries. In this ovary the second batch of mature ova, to be spawned in due course, has already started to advance and forms a mode at 0.69 mm (44 m.d.). In the second type which is "fully spent" (stage VIIB; Pl.IX, Fig. 14) the second batch has also been presumably spawned out, as evident from the presence of residual ova. The third group of ova is yolked and has advanced only a quarter of the maturation process. The chances may be rather remote for this group to complete its maturation process and spawn in the same spawning season itself. Moreover, the presence of ovaries described as IIB (Pl. IX, Fig. 15) which was observed only in fishes above 132 mm total length (size at first maturity), completely deny the possibility of this third group of maturing ova remaining as such and being carried to the next spawning season. It may be noticed that in stage VIIB a few bigger, residual ova still remain in the ovary. The mode at 0.31 mm (20 m.d.) in stage VIIB represents fresh and healthy ova similar to those observed at 0.31 mm (20 m.d.) in stage II which has a range up to 0.50 mm (32 m.d.). It may be assumed that all the other maturing and residual ova observed in stage VIIB completely degenerate and are resorbed, resulting in the stage as observed in stage IIB which is quite similar to stage II. On other hand, it is also rather doubtful whether the fish will be having enough energy to recover all the remaining ova for a third spawning within the same season. The presence of ovaries as described in stage IIB and the absence of fish with ovaries having ova larger than characteristic of stage II during October, November and December months (Tables 64 and 65) rule out the possibility of all these ova remaining in the ovary to be carried over to the next spawning season and adds support to the view of degeneration and resorption of the residual ova. Moreover, it may be noticed that the curve representing the third batch of ova is almost smooth upto stage VI (Pl. IX, Fig. 12) but thereafter fluctuation starts within this mode, resulting in several minor modes as seen from stages VIIA and VIIB. It may be more logical to view this along with the gradual decrease in the main modal values within this batch of ova as due to degeneration and resorption taking place in the maturing group of ova within this batch. In addition to this, the morphological characters of the ovary such as the presence of loose connective tissue; scattered yolk fragments and broken oil globule throughout the ovary; the presence of crumpled ova, empty and collapsed egg shell and small but thickly opaque eggs within the ovaries of stage VIIB, which are characteristics of ovaries undergoing degeneration and resorption, also seem to support the view that the left-over, yolked ova after the second spawning are not spawned later in the same season but undergo degeneration and resorption.

In an early stage of maturation (stage III) the ova diameter frequency polygon does not show a distinct separation among different batches of ova, especially between the first and the second batches. But in a more advanced stage (stage VI) the mature group of ova appear to be clearly separated from the maturing group. From this it may be assumed that the species exhibits a definite periodicity in spawning which at a time may be of short duration. It may be noticed from the polygons of stages IV and V that the second batch of mature ova remained practically stationary, while the first batch advanced in maturation. This second batch started its progression only when the first batch is ready to be extruded as seen from the polygon of stage VI. Once the first batch is eliminated, its place is taken by the second batch, as shown by the polygon of the partially spent fish. Since two batches of ova are to be shed one after another with an interval in between, the spawning by the individual fish may be of long duration. In short it may be concluded that D. acuta exhibits a definite periodicity in spawning and the spawning period is rather prolonged with the individual fish spawning twice during a season.

5.7. GONADO-SOMATIC INDEX:

In addition to the method of ova-diameter measurement, the state of maturity of a fish may also be assessed from the size of ovaries, provided there exists a measurable relation between the weight of the ovary and the stage of maturity and weight of the fish. Based on this, June (1953) calculated relative ovary weight $\left(\frac{\text{ovary weight} \times 10^3}{\text{fish weight}}\right)$ of Hawaiian yellowfin tuna (*Neothunnus macropterus*) and found this to be a more suitable method to find out the state of maturity of this fish. This method was adopted by Yuen (1955) to determine the different stages of maturity in Central Pacific big-eye (*Parathunnus sibi*). This relative ovary weight, otherwise known as gonado-somatic index, of *Dussumieria acuta* was calculated inorder to study the relationship between the gonad index and maturity. This study was confined to females since the testes of this fish was small and slender and the difference in weight between stages was very little. The index was calculated for individual fish in different months using the formula, gonado-somatic index = $\frac{\text{Ovary weight} \times 100}{\text{fish weight}}$.

The gonado-somatic index of individual fish thus obtained was plotted against the largest mode of the egg diameter (Pl. X, Fig. 6). Based on the regression of modal diameter on gonad index, the gonad indices were classified into 4 categories of maturity. (1) The mature ovaries of stages I and II having an index below 1.00; (2) Stage III (maturing) ovary having an index between 1.00 and 1.4; (3) Mature ovaries of stages IV and V having the index between 1.4 and 3.2 and (4) The ripe ovaries of stage VI with index above 3.2. Thus the data suggest that the increase in the ovary weight of D. acuta is associated with the progress of maturity of the ovary.

Further, the percentage occurrence of different categories in different months were calculated to find out the correlation between the gonad index and the spawning season. For this purpose the categories with gonad indices 1.0 to 1.4 and 1.4 to 3.2 were pooled together into one category ranging 1.0 to 3.2, since the maturation starts at index 1.0. This gave three groups, viz. (1) those fishes with gonad index below 1.0, (2) fishes with gonad index between 1.0 and 3.2 and (3) fishes with gonad index above 3.2. The immature fishes of stages I and II came under the first group, the maturing and the mature fishes of stages III, IV and V under the second group and the ripe fishes belonging to stage VI under the third group. The percentage occurrence of these three groups in different months during the period from April 1969 to March 1971 is presented in Table 68 and Plate X, Fig.8. This figure revealed that the first group (immature fish with gonad index below 1.0) occurred in April 1969, July 1969 to March 1970 and September 1970 to March 1971 with peaks in October, November and December during 1969 and 1970. The fishes belonging to the second group (maturing and mature fishes with gonad index between 1.0 and 3.2) were observed from April 1969 to September 1969 with a peak in June,

TABLE 68

PERCENTAGE OCCURRENCE OF DIFFERENT CATEGORIES (BASED ON GONADO - SOMATIC INDEX) IN DIFFERENT MONTHS FOR THE PERIOD APRIL 1969 TO MARCH 1971

Months (1)	Less than 1.0 (2)	1.0-1.4 (3)	1.4-3.2 (4)	3.2 and above (5)
April 1969	5.0	5.0	40.0	5[illegible].0
May	0.0	0.0	50.0	50.0
June	0.0	0.0	95.7	4.3
July	15.0	0.0	82.0	3.0
August	20.0	0.0	80.0	0.0
September	68.0	4.0	28.0	0.0
October	100.0			
November	100.0			
December	100.0			
January 1970	95.0	5.0		
February	86.0	0.0	14.0	
March	22.4	5.6	44.0	

Continued

Table 68(Contd....)

(1)	(2)	(3)	(4)	(5)
April 1970	0.0	0.0	73.2	26.8
May	0.0	0.0	69.2	30.8
June	0.0	0.0	82.0	18.0
July	0.0	15.0	80.0	5.0
August	0.0	18.0	82.0	0.0
September	78.0	22.0		
October	100.0			
November	100.0			
December	100.0			
January 1971	90.0	10.0		
February	60.0	20.0	20.0	
March	20.0	16.0	64.0	

from January 1970 to September 1970 with peaks in April and August and a rapid and steady increase from January 1971 to March 1971. The third group of fishes (ripe with gonad index above 3.2) were noticed from April 1969 to July 1969 with peaks in April and May and from March 1970 to July 1970 with peaks in March to May.

Again, the average gonado-somatic index for each month for the years April 1969 to March 1970 and April 1970 to March 1971 was calculated from the index for individual fish by dividing the total value of the indeces for each month by the number of fish examined. The results are given in Table 69 and are ploted in Plate X, Fig. 7 for two years separately. The curve representing both the years showed almost same pattern. The high values in the gonado-somatic index from March to August (index above 1.5) with a mode in May may be indicative of the spawning period with a peak spawning from March to July or August.

All these observations clearly indicate that this species has a single but rather prolonged spawning season in a year from March to August with a peak in March to July or August.

TABLE 69

AVERAGE MONTHLY GONADO-SOMATIC INDEX OF <u>DUSSUMIERIA ACUTA</u> FOR TWO YEARS FROM APRIL 1969 TO MARCH 1971

Months	1969-70	1970-71
April	3.0495	2.7250
May	3.2154	2.8220
June	2.2830	2.5639
July	2.0190	2.2517
August	2.0663	1.4940
September	0.7651	0.6183
October	0.2421	0.2864
November	0.2850	0.3491
December	0.3577	0.3787
January	0.4610	0.5088
February	0.8389	0.9852
March	2.4450	1.8218

5.8. RELATION BETWEEN THE SIZE OF THE GONAD AND THE SIZE OF THE FISH:

If the size of the gonad shows a constant relation with the size of the fish it may be useful as an index of maturity of a species. In the course of this study on *Dussumieria acuta* it was generally observed that the length of the gonad increased with the length of the fish in both males and females. A total of 419 fish, consisting of 216 females ranging in size between 114 and 162 mm in total length and 203 males ranging in total length between 110 and 159 mm were examined for the study. Since the fully spent ovaries were much shrunken and distorted in appearance they were excluded from this study.

The total length of the fish and the length of the gonad were noted with accuracy along with the stage of maturity for each specimen. Males and females were treated separately. The length of the ovary was plotted against the length of the fish in a scatter diagram (Pl. X, Fig. 9). Similarly the length of the testes was plotted separately against the length of the fish (Pl. X, Fig. 10). From these diagrams it was found that both ovaries and testes show a linear relationship with the length of the fish. Therefore, the linear equation was fitted to the data by the least square method and the values of 'A' and 'B' were obtained by using the formula $Y = A + BX$, where 'A' and 'B' are two constants and 'Y' represents the length of the gonad and 'X' the lengt of the fish. For the ovary the equation was found to be $Y = -9.6375 + 0.4222\ X$. and for testes the equation was $Y = -10.6550 + 0.4247\ X$.

James (1967) observed that in Eupleurogrammus intermedius the length of the ovary and the length of the fish showed a curvilinear relationship but when the length of the ovary was plotted against the cube of the length of the fish it showed a linear relationship. Prabhu (1955) found that in Trichurus haumela (= T. lepturus) the relation between size of gonad and size of fish in males and females was simple and direct. The present observation on D. acuta shows that the relation between the length of the fish and length of the gonad is also simple and direct.

5.9. SIZE AT FIRST MATURITY:

The size at first maturity of Dussumieria acuta was determined by analysing 864 females and 725 males during the year April 1969 to March 1970 and 828 females and 719 males during the year April 1970 to March 1971. Females and males in the ripe and spent stages were rarely available and hence were represented only by a few.

In this study, the fish collected were grouped sex-wise into 5 mm size groups and the percentage occurrence of the fish in different stages of maturity in the size groups was calculated separately for the two years for the two sexes. Fish measuring below 100 mm was not taken into account in this study, since, it was found difficult to fix its sex by naked eye (indeterminate). All fishes belonging to stages I and II were grouped under immature category and stages III to VII under mature category in the calculation of the size at first maturity. The details of the data for females and males for the two years are given in Tables 70 to 73.

From Table 70, it could be noticed that during April 1969 to March 1970 all the female fish upto 115 mm were immature and in stage I. From 116 mm onwards they pass on to stage II and a few of them (2.00%) were found to be in the maturing stage (stage III). Mature fishes in stage IV were first noticed in 121 - 125 mm size group (1.19%). Spent fish was recorded for the first time in 126-130 mm size group. Eventhough fishes belonging to all stages of maturity were observed in 126-130 mm size group, the majority (66.87%) were in the immature category. In 131-135 mm size group more than 50% were in different stages of the mature category (stages III and above) whereas only [illegible].12% was in the immature category. From this size group onwards the percentage of the fish in the mature category gradually increased and 100% of the fish were mature in [illegible]-160 mm size group. Eventhough a small percentage of females was mature in 121-125 mm size group, more than 50% passed on to maturity only in 131-135 mm size group (Pl. XI, Fig. 1). Hence, this size group may be regarded as the size at first maturity of females. Spent individuals were first noticed in 126-130 mm size group and in the size groups above it.

The percentage occurrence of males in different stages of maturity for the period from April 1969 to March 1970 is presented in Table 71. Upto a size of 115 mm all the males were in the immature category. Individuals in stage III started to appear in low percentage (4.65%) in 116-120 mm size group. Upto 126-130 mm size group stage I could be noticed (5.17%) and in this size group the percentage of immature category was also more (77.58%). Ripe males were first observed in 126-130 mm size group. In 131-135 mm size group the percentage of immature males was only 46.5% and the rest belonged to the mature category. The spent individuals (4.72%) were first noticed in 131-135 mm size group. In the subsequent size groups the percentage of mature category gradually increased upto 80% in 151-155 mm size group. Since the percentage of mature category of males increased above 50% in 131-135 mm size group this may be considered as the size at first maturity for males also (Pl. XI, Fig. 4).

TABLE 70

PERCENTAGE OCCURRENCE OF FEMALES IN DIFFERENT STAGES OF MATURITY IN THE VARIOUS SIZE GROUPS IN DUSSUMIERIA ACUTA - APRIL 1969 to MARCH 1970

Size groups T.L. in mm.	No.of fish	Stages of maturity						
		I	II	III	IV	V	VI	VII
101-105	5	100.00						
106-110	10	100.00						
111-115	27	100.00						
116-120	50	86.00	12.00	2.00				
121-125	105	21.90	68.57	7.62	1.91			
126-130	160	3.75	63.12	10.00	16.25	1.88	2.50	2.50
131-135	208		47.12	22.12	15.38	8.17	4.81	2.40
136-140	137		37.95	22.63	21.90	6.57	5.84	5.11
141-145	86		26.74	24.42	27.91	8.14	5.81	6.98
146-150	56		20.57	19.65	25.00	16.07	4.14	11.57
151-155	18		11.11	22.22	22.22	44.45		
156-160	2				100.00			

TABLE 71

PERCENTAGE OCCURRENCE OF MALES IN DIFFERENT STAGES OF MATURITY IN THE VARIOUS SIZE GROUPS OF DUSSUMIERIA ACUTA
APRIL 1969 - MARCH 1970

Size groups T.L in mm.	No.of fish	Stages of maturity						
		I	II	III	IV	V	VI	VII
101-105	5	100.00						
106-110	8	100.00						
111-115	23	91.30	8.70					
116-120	43	83.72	11.63	4.65				
121-125	78	33.34	61.54	2.56	2.56			
126-130	116	5.17	72.41	16.38	3.45	1.73	0.86	
131-135	127		46.45	28.35	12.60	7.09	0.79	4.72
136-140	129		35.66	23.25	20.93	5.43	7.75	6.98
141-145	123		25.20	21.14	21.14	16.63	9.76	8.13
146-150	53		35.85	20.75	13.21	13.21	13.21	3.77
151-155	20		20.00	15.00	35.00	15.00	10.00	5.00

TABLE 72

PERCENTAGE OCCURRENCE OF FEMALES IN DIFFERENT STAGES OF MATURITY IN THE VARIOUS SIZE GROUPS OF DUSSUMIERIA ACUTA

APRIL 1970 - MARCH 1971

Size groups T.L. in mm.	No. of fish	Stages of maturity						
		I	II	III	IV	V	VI	VII
101-105	5	100.00						
106-110	3	100.00						
111-115	28	96.43	3.57					
116-120	44	75.00	15.91	9.09				
121-125	98	48.98	25.51	13.27	8.16	3.06	1.02	
126-130	175	10.29	48.57	24.00	9.71	1.71	2.86	2.86
131-135	178		48.88	25.28	15.17	4.49	4.49	1.69
136-140	158		42.41	27.58	19.62	4.43	2.53	3.16
141-145	92		38.04	32.61	17.39	3.26	3.26	5.44
146-150	35		42.86	17.14	25.71	8.57	5.72	
151-155	11		27.27		63.64	9.09		
156-160	1				100.00			

TABLE 73

PERCENTAGE OCCURRENCE OF MALES IN DIFFERENT STAGES OF MATURITY IN THE VARIOUS SIZE GROUPS OF *DUSSUMIERIA ACUTA*
APRIL 1970 - MARCH 1971

Size groups T.L. in mm.	No. of fish	Stages of maturity						
		I	II	III	IV	V	VI	VII
101-105	4	100.00						
106-110	16	100.00						
111-115	25	92.00	8.00					
116-120	58	72.41	22.41	5.18				
121-125	85	47.06	41.17	8.23	1.18	1.18		1.18
126-130	144	8.33	59.72	20.14	5.56	2.78	0.69	2.78
131-135	149		51.01	28.86	12.75	1.34		6.04
136-140	127		41.73	22.05	15.75	3.15	7.87	9.45
141-145	74		43.24	31.08	12.16	5.41	6.76	1.35
146-150	30		40.00	33.34	3.33	13.33	3.33	6.67
151-155	7		14.28	71.43	14.28			

The data collected on the condition of gonadial maturity for both the sexes during the period April 1970 to March 1971 also gave similar results as above. Data presented in Table 72 shows that females were in the immature category upto 111-115 mm size group. Maturing started in 116-120 mm size group (9.09%). The mature category crossed the 50% level in 131-135 mm size group (Pl. XI, Fig. 2) and its percentage gradually increased thereafter to 100% in 151-155 mm size group. Spent females were first noticed in 126-130 mm size group.

Males during this period (1970-71) were all immature upto 115 mm. In the 136-140 mm size group more than 50% passed on to mature category and it gradually increased in the subsequent groups (Pl. XI, Fig.5). Spent individuals were first recorded in the size group 121-125 mm (Table 73).

From the above Tables (70 to 73) it may be noted that fishes belonging to stage II were present even among fishes of bigger size groups above the size at first maturity. This may be because of the fact that the fully spent fishes which return to a state of stage II (recovering II or IIB) before the next maturity starts, had been considered as stage II. Practically these are not virgin ones, since they had once matured and spawned.

PLATE XI

Fig. 1 – 3 Percentage occurrence of mature females of *D. acuta* in various size-groups (in mm) during the years 1969-70 (Fig.1) & 1970-71 (Fig.2) and the average for two years showing the size at first maturity (Fig. 3).

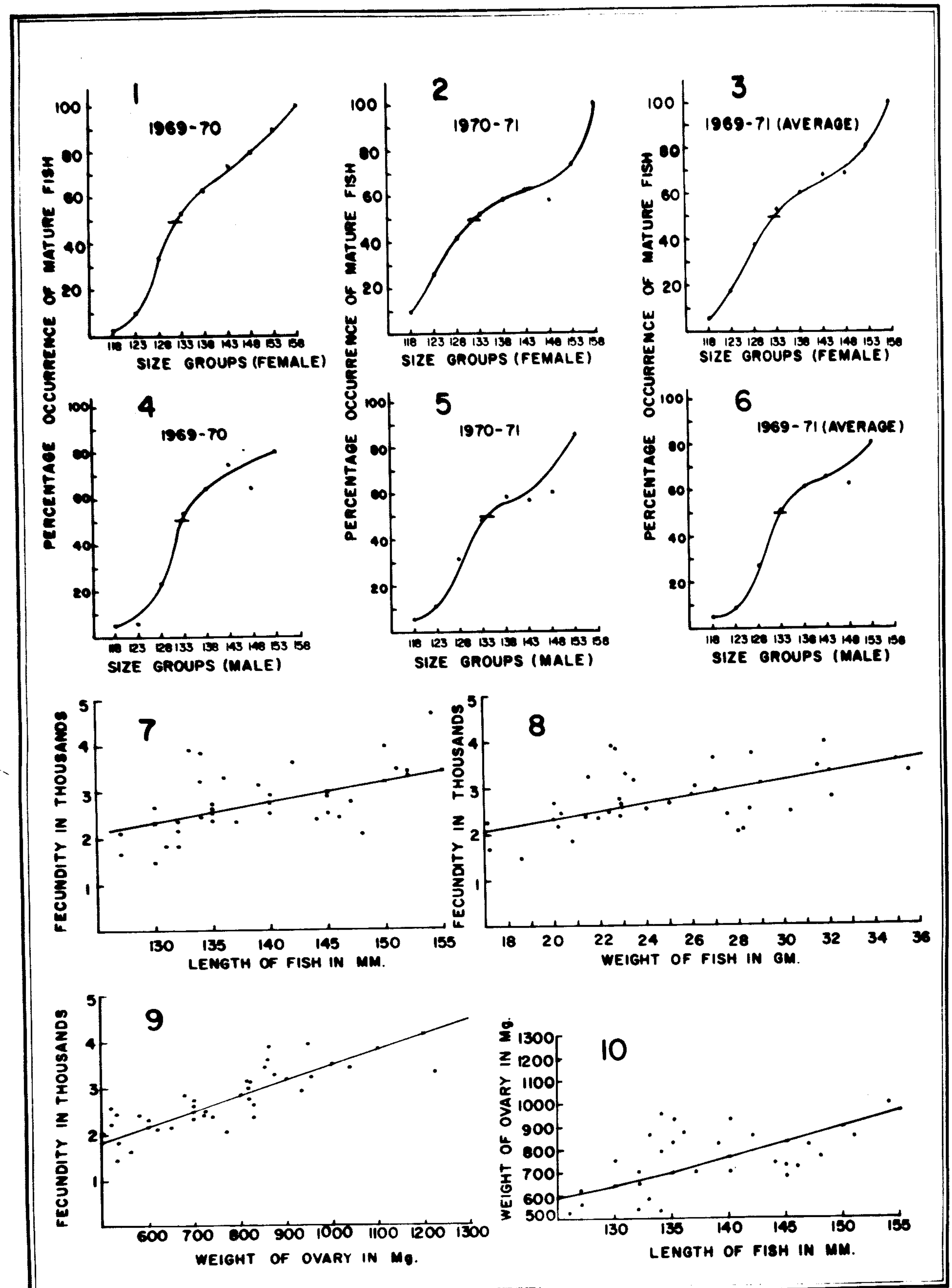
Fig. 4 – 6 Percentage occurrence of mature males of *D. acuta* in various size groups (in mm.) during the years 1969-70 (Fig.4) & 1970-71 (Fig.5) and the average for two years showing the size at first maturity (Fig. 6).

Fig. 7 Relationship between fecundity and total length of *D. acuta*.

Fig. 8 Relationship between fecundity and weight of *D. acuta*.

Fig. 9 Relationship between fecundity and weight of ovary of *D. acuta*.

Fig. 10 Relationship between weight of ovary and length of *D. acuta*.



1
1969-70
2
1970-71
3
1969-71 (AVERAGE)
PERCENTAGE OCCURRENCE OF MATURE FISH
SIZE GROUPS (FEMALE)
4
1969-70
5
1970-71
6
1969-71 (AVERAGE)
SIZE GROUPS (MALE)
7
FECUNDITY IN THOUSANDS
LENGTH OF FISH IN MM.
8
WEIGHT OF FISH IN GM.
9
WEIGHT OF OVARY IN Mg.
10
WEIGHT OF OVARY IN Mg.
LENGTH OF FISH IN MM.

PLATE. XI

An analysis of the above data thus indicates that the females during both 1969-70 and 1970-71 and the males during 1969-70 became practically mature at 131-135 mm size group and the males in 1970-71 at 136-140 mm size group. A further analysis of the above data was done in which the percentage occurrence of females and males in different stages of the mature category were pooled together separately for two sexes f(the years 1969-70 and 1970-71 and the average of both the years for each sex were calculated. Thus Table 74 gives the percentage occurrence of mature females in various size groups for 1969-70 and 1970-71 along with the average for the two years. It may be observed from that 2% in 1969-70 and 9.09% in 1970-71 resulting in an average of 5.54% female mature at 116-120 mm size group. In the subsequent size groups this percentage showed an increase and at 131-135 mm size group average 52% of the females were mature. In higher size groups the percentage gradually increased (See Plate XI, Fig. 3).

In Table 75 the percentage occurrence of mature males in different size groups for the two years and the average for both the years are given. It shows that 4.65% and 5.18% were mature during 1969-70 and 1970-71 respectively resulting in an average of 4.91%. The percentage occurrence above 50% level was noticed at 131-135 mm size group in 1969-70 (53.55%) and at 136-140 mm size group in 1970-71 (58.27%). But the average

TABLE 74

PERCENTAGE OCCURRENCE OF MATURE GROUPS* OF FEMALES IN VARIOUS SIZE GROUPS OF DUSSUMIERIA ACUTA

Size groups in mm.	1969-70	1970-71	Average
116-120	2.00	9.09	5.54
121-125	9.53	24.51	17.52
126-130	33.13	41.14	37.14
131-135	52.88	51.12	52.00
136-140	62.05	57.59	59.82
141-145	73.26	61.96	67.61
146-150	79.43	57.14	68.29
151-155	88.89	72.73	80.81
156-160	100.00	100.00	100.00

*Mature groups comprise all stages above III (III, IV, V, VI & VII)

TABLE 75

PERCENTAGE OCCURRENCE OF MATURE GROUPS* OF MALES IN VARIOUS SIZE GROUPS OF *DUSSUMIERIA ACUTA*

Size groups in mm.	1969-70	1970-71	Average
116-120	4.65	5.18	4.91
121-125	5.12	11.74	8.43
126-130	22.42	31.95	27.19
131-135	53.55	48.99	51.27
136-140	64.34	58.27	61.31
141-145	74.80	56.76	65.78
146-150	64.15	60.00	62.07
151-155	80.00	85.71	80.35

*Mature groups comprise all stage above III (III, IV, V, VI & VII) value for both the years showed that 51.27% males were mature at 131-135 mm size group (Pl. XI, Fig. 6).

From the above analysis it may be inferred that on an average there was no significant variation in the size at first maturity between sexes and between years. On the other hand both females and males were mature at 131-135 mm size group. Hence, this size group may be regarded as the size at first maturity for Dussumieria acuta. To be more specific it may be noticed from Plate XI, Figs. 3 & 6 that size at first maturity for females is 132 mm and for males 132.5 mm (at 50% level) i.e. in 131-135 mm size group.

The minimum size at which the females and males reached maturity was observed at 116-120 mm size group. The females first spawn at 126-130 mm size group (Tables 70 & 72), whereas the males first spawn at 121-125 mm size group (Table 73).

5.10. FECUNDITY:

The reproductive capacity of a population is a function of the fecundity of females. The number of eggs produced may differ in different species of fishes due to several factors such as differences in size, age, etc. The fecundity may vary even within the same species also depending on the geographical distribution, seasonal variations in spawning, etc. In order to estimate the size of the spawning population of a fish, a clear knowledge of the fecundity of the species in question is essential. In fish culture the fecundity studies of the species have a great practical utility in proper planning of the hatching and nursery operations and for achieving a certain target of fish seed production. The number of individuals in a spawning population is estimated from a knowledge of: 1) the total number of eggs produced per year by all females in the population, 2) the average number of eggs produced by each female in the population and 3) the sex-ratio in the population.

Fecundity of any species of fish is usually determined from the total number of mature ova in the ovary that are to be shed in the current spawning season. The demarkation of these groups of eggs varies in different species depending on the spawning habits. According to Hickling and Rutenberg (1936), in herring the eggs destined to be spawned in the ensuing season are ripened simultaneously, for, in ovary af an advanced stage of ripeness, a very clear separation in respect of size may be noticed between the active yolky eggs and the small yolkless ones. Farren (1938) pointed out that in herring all the ripening eggs in an ovary are approximately equal in size and that the number of eggs destined to ripen may be determined at the commencement of the yolk deposition itself. In herring, therefore, the large yolky eggs are the whole of the season's crop, and a count of them gives the absolute fecundity of the fish.

Fecundity of <u>Dussumieria acuta</u> was calculated from 35 mature females ranging in size from 126 to 154 mm in total length, belonging to stages IV, V and VI.

The ova diameter studies revealed that there are three groups of yolked ova in a mature ovary which indicate that the individual fish shed the ova in batches in an extended spawning season. If the number of batches in which they are shed in a year and the time interval between each of them are not known, it is rather difficult to estimate the correct number of ova destined to be spawned in a year. But in the present study it was found that in <u>D. acuta</u> the two advanced groups of ova measuring above 0.46 mm (30 m.d.) are spawned in two successive batches and the smaller and the third group of eggs is resorbed at the end of the spawning season. Further, the ovaries are considered as maturing when they pass on to stage III, where the maturing group of eggs are above 30 m.d. (see Pl. IX, Fig. 9). Hence, it was considered to be more accurate to count all the eggs belonging to the first two groups of developing eggs alone, i.e. those which measure above 0.46 mm (30 m.d.).

The fecundity of the 35 fishes examined are presented in Table 76 along with the total length of the fish, weight of the fish, weight of the ovary, length of the ovary and the stage of maturity of the respective fish. The maximum fecundity (4625 ova) was observed in a fish measuring 154 mm in total length and weighing 33.7 gms. The lowest fecundity (1443 ova) was noticed in a 130 mm-long fish weighing 18.5 gms, eventhough the smallest fish studied was 126 mm long weighing 17.1 gms, the fecundity of which was 2215 ova . The average fecundity was estimated at 2733 ova for a fish of 138.7 mm total length (Table 76).

5.10.1. Relationship between fecundity and length of fish:

Most of the workers have observed non-linear relationship between length and fecundity as that between length and weight of the fish, suggesting thereby that fecundity, like weight, increases in a proportion much greater than the length. Franz (1910 a & b), Kis~~s~~elevich (1923) and Clark (1934) on their studies on *Pleuronectes platessa*, Caspian herrings, and *Sardina caerulea*, respectively, showed that the fecundity of fish increases in a proportion to the square of its length. Clark (1934) observed that the fecundity increases at a rate 1.9868 to the length in the case of Pacific sardine. According to Hickling (1940) in the herring of Southern North Sea, the fecundity increases at a rate above the cube of length. Smith (1947) found a straight line relationship between fecundity and length in the eastern trout. Simpson (1951) in his studies on plaice, *Pleuronectes platessa*, found

TABLE 76

NUMBER OF MATURE OVA IN INDIVIDUALS OF *DUSSUMIERIA ACUTA*

Sl. No. (1)	Total length of fish in mm. (2)	Weight of fish in gms. (3)	Length of ovary in mm. (4)	Weight of ovary in mg. (5)	Total number of ova (6)	Stage of maturity (7)
1	135	22.1	49	830	2348	IV
2	148	28.2	52	770	2033	IV
3	140	24.0	50	700	2508	IV
4	127	17.2	46	560	1637	IV
5	152	33.3	64	1140	3397	IV
6	142	26.1	54	860	3591	IV
7	139	23.5	49	825	3126	IV
8	127	17.8	46	620	2118	IV
9	130	20.0	45	750	2640	IV
10	154	33.7	57	1000	4625	IV
11	151	31.5	59	855	3420	V
12	126	17.1	42	520	2215	IV
13	136	23.1	53	875	3259	IV
14	133	22.5	47	865	3873	IV
15	130	18.5	48	530	1443	IV
16	132	20.2	47	650	2131	V
17	132	21.4	44	700	1338	VI

Continued

Table 76 (Contd.....)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
18	134	22.7	47	790	3816	V
19	150	31.8	57	950	3936	IV
20	146	30.3	52	720	2417	V
21	147	32.1	52	820	2744	IV
22	145	27.0	53	680	2852	VI
23	145	28.5	55	725	2494	IV
24	132	20.8	46	535	1819	IV
25	134	22.4	49	530	2438	IV
26	133	20.3	44	580	2417	IV
27	141	26.1	54	820	2976	V
28	152	35.5	60	1225	3298	V
29	144	27.5	46	740	2359	V
30	137	25.0	44	700	2613	V
31	135	22.9	49	830	2618	IV
32	140	27.0	48	935	2909	V
33	134	21.5	47	955	3202	VI
34	137	21.9	51	600	2314	V
35	135	22.8	50	700	2722	IV
Average:	138.7	24.8	50.2	765.3	2732.7	

that fecundity is related to the volume of the ovary and consequently to the cube of the length. Lehman (1953) observed a straight line relationship between the number of eggs and the length of the fish in the American shad, Alosa sapidissima. Prabhu (1955) in his studies on Trichurus haumela noticed the fecundity increasing with the length at a rate substantially greater than the fourth power. Pillay (1958) found an exponential relationship between fecundity and length of fish in Hilsa ilisha. Palekar and Bal (1961) noted fecundity in Sillago sihama increasing at a rate of fourth power of its legth. Varghese (1973) in his investigations on the fecundity of the Rohu, Labeo rohita, observed that the fecundity increases at a rate of 3.96 times the length.

To find out the relationship between the length of the fish and fecundity in Dussumieria acuta the absolute fecundity estimated for 35 fishes were plotted against their total length in a scatter diagram in Plate XI, Fig. 7. The relationship was calculated using the least square method (logarithmic values) based on the formula:

$$\log F = a + b \log L$$

where F = fecundity, L = total length in mm, 'a' and 'b' = two constants. The fecundity (F) and length (L) relationship can be expressed as:

$$\log F = -1.2163 + 2.1682 \log L.$$

Expected fecundity for length was calculated based on the above formula and a regression line was fitted to the scatter diagram which shows a straight line relationship between these two variables. The correlation coefficient was calculated as r = 0.5000. When the 'r' value was tested for significance, it was found that 't' = 3.3167 was greater than the 't' value at 5% level (1.96). This indicated a fairly good relationship between length and fecundity.

In the length-weight relationship of P.acuta the exponential value was found to be 3.5509 for the pooled data of determinate females and males for two years. This value is higher than that observed in fecundity-length relationship (2.1682). This indicates that fecundity increases at a rate less than that of body weight in relation to total length.

5.10.2. Relationship between fecundity and weight of fish:

Smith (1947) in his studies on the fecundity of Salvelinus fontinalis observed that the number of eggs in an ovary was more related to the weight or volume of the fish rather than to its length. Simpson (1951) found that in plaice, Pleuronectes platessa fecundity is related to the volume of ovary and consequently to the cube of the length, thus directly proportional to fish weight. Allen (1951) while working on brown trout observed that the relationship between the number of ova and the fish weight was curvilinear. Mac Gregor (1957) carried out detailed study on the fecundity of *Sardinops caerulea* with different variables and noticed a better relationship between fecundity-weight than either in fecundity-length or fecundity-age. The existence of a straight line relation between fecundity and weight of fish has been reported by several workers like Sarojini (1957), Pillay (1958), Varghese (1961, 1973), Balan (1965) and others.

The fecundity data obtained for *D. acuta* was plotted against the total weight of the fish in a scatter diagram (Pl. XI, Fig. 8). The calculated regression line equation can be expressed as:

$$\log F = 2.3833 + 0.7540 \log W.$$

where F = fecundity and W = total weight of fish. A straight line relationship was observed between these two variables. The correlation coefficient was found to be 'r' = 0.5889 which when tested for significance showed a fairly significant straight line relationship. The calculated 't' was found to be 't' = 4.1857 which was greater than the 't' value at 5% level (1.96).

The relationship between fecundity and weight of fish may also be calculated theoretically if the length-weight and fecundity-length relationship are known. The derivation can be written as follows:

$$F = al^{b}$$

$$W = Al^{B}$$

$$\frac{W}{A} = l^{B}$$

$$l = \left(\frac{W}{A}\right)^{\frac{1}{B}}$$

$$l^{b} = \left\{\frac{W}{A}\right\}^{\frac{1}{B} \times b}$$

$$F = a\left\{\frac{W}{A}\right\}^{\frac{1}{B} \times b}$$

'a' and 'A' are calculated 'a' values of length-fecundity and length-weight relationships respectively.

'b' and 'B' are calculated exponentials of fecundity-length and length-weight relationships respectively.

In the present study the exponential value of the length-weight relationship (B) for mature females was calculated as 3.0322. The fecundity-length exponential (b) was observed as 2.1682. When these values are substituted, the final equation may be rewritten as follows:

$$F = a\left\{\frac{W}{A}\right\}^{\frac{1}{3} \times 2.1682.} \quad \text{i.e. } F = a\left(\frac{W}{A}\right)^{0.7227.}$$

It may be noticed that this exponential value (0.7227) is closely agreeing with the observed value (0.7540).

In this relationship the value of the exponent (0.7540) is less than unity (unity = 1) and confirms the interpretation that the fecundity increases at a rate less than that of the body weight in relation to length.

5.10.3. <u>Relationship between fecundity and weight of ovary</u>:

According to Hickling (1940) a close relation should be expected between the weight of the ovary and the number of ova produced, for, the main function of the ovary is the production of eggs.

In order to study the relationship between the fecundity and the weight of the ovary of <u>Dussumieria acuta</u> the fecundity was plotted against the weight of the ovary of the respective fish in a scatter diagram (Pl. XI, Fig.9). The relationship between these two variables can be expressed as log F = 0.7620 + 0.9276 log OW in the logarithmic form where F = fecundity and OW = ovary weight. A straight line relationship was observed with a correlation coefficient 'r' = 0.7835. The test of significance showed that the calculated 't' = 7.2430 was greater than the 't' at 5% level (1.96) and hence a significant relationship exists between these two variables.

The exponential value (0.6276) which is less than 1 indicates that fecundity increases at a rate less than that of body weight and ovary weight in relation to a total length.

5.10.4. Relationship between length of fish and weight of ovary:

The weight of the ovaries of 35 specimens belonging to stages IV, V and VI was plotted against the body length of the respective fish in a scatter diagram in Plate XI, Fig. 10, to study the relationship between these two variables. The regression line fitted to the data by least square method showed a slightly curvilinear relationship. In the logarithmic form the equation may be written as:

$$\log OW = -2.0721 + 2.3091 \log L.$$

where OW = ovary weight and L = length of fish.

The correlation coefficient 'r' was estimated as 0.6250 which was found to be significant since the calculated 't' =4.5994 was greater than the 't' at 5% level (1.96).

The exponential value shows that the ovary weight increased at a rate less than that of body weight in relation to total length but slightly greater than fecundity in relation to total length.

This study on the fecundity of Dussumieria acuta and its relationship with other factors such as total length, fish weight and ovary weight shows that a highest degree of correlation exists between fecundity and weight of ovary than between fecundity and any another variables.

5.10.5. Fecundity factors:

Varghese (1973) calculated the average number of ova per gram body weight and per gram ovary weight for Rohu, *Labeo rohita* in order to study whether the fecundity factors are influenced by the size of the fish. A similar attempt was made in the present study on the fecundity of *D. acuta*.

The number of ova per gram body weight and per 0.1 gram ovary weight were calculated for each specimen studied. Since majority of the ovaries weighed less than 1 gram, 0.1 gram was taken as the unit for ovary weight. The number of ova was observed to vary from 72 to 172 per gram body weight and from 264 to 483 per 0.1 gram ovary weight. In order to examine whether these fecundity factors are influenced by the fish size, the data were regrouped at 5 mm size intervals and the average values of each length group were calculated, as shown in Table 77. The table shows that the fecundity factors are not influenced by the size of the fish. Therefore, the data were pooled and the average number of ova per gram body weight and per 0.1 gram ovary weight were calculated and these were found to be 109 and 359 respectively.

TABLE 77

AVERAGE NUMBER OF EGGS PER 1 GRAM WEIGHT OF BODY AND PER 0.1 GRAM WEIGHT OF OVARY IN DIFFERENT SIZE GROUPS OF DUSSUMIERIA ACUTA

Sl. No.	No. of ovary	Size groups (mm)	Average number of eggs per 1 gram weight of body	Average number of eggs per 0.1 gram weight of bvary
1	5	126 - 130	109	337
2	11	131 - 135	123	376
3	6	136 - 140	116	363
4	5	141 - 145	105	373
5	4	146-- 150	90	337
6	4	151 - 155	110	365
Average			109	359

5.11. SEX-RATIO:

In fishery biology investigations on a commercially important fish, detailed analysis of the sex composition in the catch is considered essential for determining whether fishing is more intense on one sex than on the other, and if so, whether the observed dominance of either sex is due to shoaling behaviour or due to other causes like differential accessibility, vulnerability, growth and mortality. The sex-ratio studies also contribute towards stock estimation by the selective removal method by knowing the sex-ratio in each length group (Holt, 1959).

In the present study on Dussumieria acuta an attempt was made to find out the nature and dominance, if any, of either sex by conducting statistical tests to the data collected during a period of two years from April 1969 to March 1971. The samples were classified according to the month of capture and length-groups of 5 mm size intervals to determine whether there were any distinct features of variations in respect of month or size-groups in each year. The observed sex-ratio were tested against an expected ratio of 1:1 by the method of chi-square (Snedecor, 1946).

In Table 78 are presented the monthwise data on the sex-ratio of females and males for the year 1969-70. It may be seen that, except for May, June, July and August, in all other months the females were dominating over the males. The chi-square values showed significant deviation from the expected ratio of 1:1 during April, October, January and March. In July the females to males ratio was 1:1 and in August the males dominated, though not significantly, but close to the 5% significant level (3.48 chi-square value). The domination of males over females in May and June was insignificant. The observed ratio between females and males for the whole year was found to be 1: 0.83, the chi-square value of which showed that it deviated significantly from 1:1 ratio with the females outnumbering the males.

In the subsequent year April 1970 to March 1971 the observed ratio between the females and males was 1:0.87. A chi-square test showed the ratio deviating significantly from 1:1 with the females dominating as in the case of the previous year (table 79). The monthly chi-square test revealed that during April, December, February and March the ratio significantly varied with the dominance of females over males. During July and September the males significantly outnumbered the females. In all other months the dominance of one sex over the other was insignificant.

The ratio of females to males in different size groups were studied separately for two years inorder to know the pattern of sex distribution in various size groups. In Table 80 are given the data for the year 1969-70. In the size groups 96-100 mm and 101-105 mm the ratio was 1:1 and therefrom in all the higher size groups the females were outnumbering the males upto 135 mm. The chi-square values showed that this dominance of females was significant in 121-125, 126-130 and 131-135 mm size groups. Generally the maturity starts in 121-125 mm size group and attains the size at first maturity in 131-135 mm size group. In 136-140 mm size group again 1:1 ratio could be noticed. In size groups between 141 to 155 mm

TABLE 78

CHI-SQUARE TEST FOR SEX-RATIO OF DUSSUMIERIA ACUTA OBTAINED IN DIFFERENT MONTHS DURING APRIL 1969 TO MARCH 1970

Months	No.of fish	Females	Males	Ratio	Chi-square	D.F.
April	187	118	69	1:0.58	12.84*	1
May	183	89	94	1:1.05	0.14	1
June	142	67	75	1:1.12	1.02	1
July	190	95	95	1:1.00	0.00	1
August	127	53	74	1:1.40	3.48	1
September	153	82	71	1:0.87	0.80	1
October	174	107	64	1:0.63	9.20*	1
November	91	52	39	1:0.75	1.86	1
December	118	67	51	1:0.76	2.16	1
January	167	99	68	1:0.69	5.76*	1
February	76	45	31	1:0.69	2.58	1
March	132	79	53	1:0.67	5.22*	1
Total	1740	953	787	1:0.83	15.84*	1

*Significant at 5% level (3.84)

TABLE 79

CHI-SQUARE TEST FOR SEX-RATIO OF DUSSUMIERIA ACUTA OBTAINED IN DIFFERENT MONTHS DURING APRIL 1970 TO MARCH 1971

Months	No.of fish	Females	Males	Ratio	Chi-square	D.F.
April	123	90	33	1:0.37	26.42*	1
May	76	35	41	1:1.17	0.48	1
June	159	70	89	1:1.27	2.28	1
July	126	51	75	1:1.47	4.56*	1
August	130	62	68	1:1.10	0.28	1
September	114	46	68	1:1.48	4.24*	1
October	129	68	61	1:0.90	0.38	1
November	96	48	48	1:1.00	0.00	1
December	200	118	82	1:0.69	6.48*	1
January	121	70	51	1:0.73	2.98	1
February	150	93	57	1:0.61	8.64*	1
March	124	79	45	1:0.57	9.32*	1
Total	1548	830	718	1:0.87	8.10*	1

*Significant at 5% level (3.84)

TABLE 80

CHI-SQUARE TEST FOR SEX-RATIO OF *DUSSUMIERIA ACUTA* IN DIFFERENT SIZE GROUPS DURING APRIL 1969 TO MARCH 1970

Size groups in mm.	No. of fish	Females	Males	Ratio	Chi-square	D.F.
96-100	4	2	2	1:1.00	0.00	1
101-105	6	3	3	1:1.00	0.00	1
106-110	22	12	10	1:0.83	0.18	1
111-115	49	26	23	1:0.88	0.18	1
116-120	103	56	47	1:0.84	0.78	1
121-125	196	120	76	1:0.63	9.88*	1
126-130	298	183	115	1:0.63	15.52*	1
131-135	360	213	147	1:0.69	12.10*	1
136-140	318	159	159	1:1.00	0.00	1
141-145	228	103	125	1:1.21	2.12	1
146-150	115	55	60	1:1.09	0.22	1
151-155	36	16	20	1:1.25	0.44	1
156-160	5	5	--	--	5.00*	1
Total:	1740	953	787	1:0.83	15.84*	1

*Significant at 5% level (3.84)

the males were more than the females but not in a significant level. In 156-160 mm size group males were not available.

During the subsequent year April 1970 to March 1971 the females were more in 111-115 mm size group and in size groups in between 121 and 155 mm (Table 81). Males were not available in 96-100 mm size group and the observed dominance of males in 101-105 mm size group was found to be insignificant with a chi-square value 0.14. At 106-110 mm size group the males outnumbered females resulting a significant chi-square value. In 116-120 and 156-160 mm size groups the males were more than the females but not at a significant level. The chi-square value for 136-140 mm size group, the one next to size at first maturity, showed a significant deviation from 1:1 with the females outnumbering the males. For 126-130 mm size group a high chi-square value, though not significant, may be noticed with females outnumbering the males.

Sex-ratio of immature (stages I and II) and mature (stages III, IV, V and VI) fishes of D. acuta is shown in Table 82. In the years 1969-70 and 1970-71 in both the categories the females were more than the males. But it may be noticed that this observed dominance was insignificant in the immature fish in both the years. On the other hand the chi-square values of the mature fishes showed a significant

TABLE 81

CHI-SQUARE TEST FOR SEX-RATIO OF DUSSUMIERIA ACUTA IN DIFFERENT SIZE GROUPS DURING APRIL 1970 TO MARCH 1971

Size groups in mm	No.of fish	Females	Males	Ratio	Chi-square	D.F.
96-100	3	3	--	--	3.00	1
101-105	7	3	4	1:1.33	0.14	1
106-110	21	5	16	1:3.20	5.76*	1
111-115	51	28	23	1:0.82	0.50	1
116-120	103	45	58	1:1.29	1.64	1
121-125	188	101	87	1:0.86	1.04	1
126-130	332	180	152	1:0.84	2.36	1
131-135	331	175	156	1:0.89	1.10	1
136-140	267	155	112	1:0.72	6.92*	1
141-145	159	88	71	1:0.81	1.82	1
146-150	61	33	28	1:0.85	0.40	1
151-155	19	12	7	1:0.58	1.32	1
156-160	6	2	4	1:2.00	0.66	1
Total	1548	830	718	1:0.87	8.10*	1

*Significant at 5% level (3.84)

dominance of the females over males. So it may be assumed that the ratio of the two sexes differ significantly, females outnumbering the males when the fish starts to mature or attains maturity.

TABLE 82

CHI-SQUARE TEST FOR THE SEX-RATIO OF IMMATURE (STAGES I & II) AND MATURE (STAGES III, IV, V & VI) FISH OF DUSSUMIERIA ACUTA FOR THE PERIOD APRIL 1969 TO MARCH 1971

Years	IMMATURE					MATURE				
	Total fish	Fe-males	Males	Ratio	Chi-square	Total fish	Fe-males	Males	Ratio	Chi-square
1969-70	916	484	432	1:0.89	2.96	653	356	297	1:0.83	5.34*
1970-71	912	459	453	1:0.99	0.05	591	351	240	1:0.68	20.84*

*Ratio significantly deviating.

From the above results of the analysis of the sex-ratio, it may be noticed that in general, females were fished more than the males, in both the years, and this female dominance being often statistically significant. In certain months the dominance of either sex over the other was found to be significant in both the years without any regular pattern that could be correlated to the spawning season. Sex equality was observed only in July 1969 during the course of this observation. So it may be assumed that among *Dussumieria acuta* there may be differential behaviour of the sexes when maturation begins, the sexes probably moving in separate shoals and this possibly resulting in differential fishing, the females being fished more than the males. This segregation of sexes could be noticed in size-wise analysis also and more evident in maturing and mature fishes starting from minimum size of maturity onwards (116-120 mm size group). It is worth mentioning here that the commercial fishery is constituted by fish ranging in size between 116 and 145 mm total length.

In the size-wise analysis it has been shown that in general there were no significant differences between sexes in smaller immature groups. The differences were significant only when maturation started and in fishes ranging in size between 116 and 145 mm which constitute the bulk of the commercial catch. So an attempt was made to find out whether there is any differential growth in different sexes of the adult fish, which may result in differential behaviour. To look in to this possibility, the modal size of both the sexes obtained from the biological data were plotted (Pl. XIV, Fig.4) for the two years from April 1969 to March 1971. It may be seen that in 1969-70 during June and September there is a difference of 5 mm in modal sizes, the females being smaller, and in all other months both the sexes have the same modal size. Similarly in the subsequent year 1970-71, except July, November and December in all other months the modal values could be noticed in July, November and December of which in November the males were smaller, whereas it was the females that were smaller in July and December. Since majority of the months do not show any difference in the modal values between sexes, it may be assumed that two sexes of D. acuta do not show any differential growth rate.

Hickling and Rutenberg (1936) and de Jong (1940) observed that the toleostean fishes exhibit different types of spawning habits. They could make out at least four major types based on the observations on the intraovarian ova in various stages of development and the number and pattern of the mature and maturing batches of ova in advanced ovaries. Similarly, Prabhu (1956) found that fishes exhibit four types of spawning which are nothing but same as has been described by Hickling and Rutenberg (1936) and de Jong (1940). Following these authors Dharmamba (1959), based on her investigations on maturation and spawning of some of the clupeoid fishes of Waltair coast including Dussumieria hasseltii, observed that these fishes exhibit a periodicity in spawning but the duration and frequency of spawning varied from species to species.

The present investigations on the spawning of *Dussumieria acuta* based on the ova diameter frequency of mature ovaries and the percentage occurrence of gonads in different stages of maturity indicate that this species has an extended spawning, the individuals spawning twice in each season as has been observed by Dharmamba (1959) in the case of *Dussumieria hasseltii*.

Dharmamba (1959) observed that the mature ovary of *D. hasseltii* of Lawson's Bay, Waltair, has in addition to the immature stock, three distinct batches of maturing ova represented by modes 'a', 'b' and 'c'. The ova at mode 'a' are the first batch to be spawned in the following season. Even before the first batch of eggs is shed, there is a second batch of fairly mature ova (mode 'b') well differentiated from the immature ova. This batch of ova at 'b' is likely to be shed subsequent to the spawning of the mode 'a' ova. The time interval between two successive spawnings will be much shorter than the time taken by the immature ova to attain maturity. The results of the present study on *D. acuta* also agree with the above observation, but for the fact that among the three batches of maturing ova the second batch (mature) is smaller and is not well differentiated from the third batch (maturing) ova. It is evident from Plate VIII, Fig.12 that the first batch (most mature) that is to be spawned in the following season is clearly differentiated from the second batch (mature). But the second mode representing the second batch (mature) of ova is small and not well separated from the third batch (maturing) of ova, when the most matured batch remains unspawned. When the first batch is spawned this second mode advances further and gets clearly differentiated from the proceeding batch to be spawned a second time. This shows that the majority of the ova are spawned in the first spawning itself and in the second one only a smaller number of ova are drawn from the maturing batch and spawned, evidenced from the sizes of the first and the second modes respectively.

According to Dharmamba (1959) in D. hasseltii the mode at 'c' may not ripen and be spawned during the same season as they are only in stage D (she devides the maturing stages into five as A, B, C, D & E; stage E is equal to stage II of the present study) and they may form the first batch to be spawned in the next season. In the present study in D. acuta also it is assumed that this third batch of ova (maturing batch) may not be spawned in the same season because these ova are too small, below half-way through maturation and hence chances are rather remote for this group of ova to get fully matured and be spawned as a third batch within the same season. It is also rather doubtful whether the fish will be having enough energy to recover the remaining ova for a third spawning in the same season.

In the present study, after the second spawning, (stage VIIB) a few bigger residual ova still remain in the ovary. The mode at 0.31 mm (20 m.d.) noticed in stage VIIB represents fresh and healthy ova similar to those observed at 0.31 mm (20 m.d.) in stage II which has a range upto 0.50 mm (32 m.d.). All the other larger ova that are observed in stage VIIB completely degenerate and are resorbed and finally a stage as observed in stage IIB results which is quite similar to stage II. The second mode observed in stage IIB will be carried over to the next spawning season, as has been observed by Dharmamba (1959) in the case of mode 'c' in her study on D. hasseltii. The assumption of degeneration and resorption in the third batch of ova is further supported by the factors such as steady nature of the third mode in stage V and VI; appearance of fluctuations within the third mode from stage VIIA onwards, resulting in several minor modes within this batch of eggs; gradual decrease in the modal value of this mode from stage VI onwards; presence of unhealthy and degenerating ova in the ovary and, above all, the presence of ovaries as described in stage IIB. Other morphological characters supporting the theory of degeneration and resorption are described in detail in the part dealing with 'frequency of spawning'.

Devanesan and Chacko (1944) from their study of the rainbow sardine (Dussumieria hasseltii) of the Palk Bay and the

Gulf of Mannar, concluded that March to December period constitutes roughly the breeding season for this fish. They collected specimens with fairly mature and transparent ovarian eggs in April, June, September and October and specimens partly and fully spent were seen in April, May, July, September and November. Devanesan and Chidambaram (1948) noticed the spawning season of rainbow sardine extending from March to September. Sekharan (1949) in his studies on the feeding and maturity in relation to muscle fat of D. acuta from Madras observed that this fish breeds in May, June and July. Chacko (1950) also agrees with Devanesan and Chacko (1944). According to Dharmamba (1959) D.hasseltii in Lawson's Bay has a prolonged spawning season extending from February upto July. Basheerudeen and Nayar (1961) were able to collect the larvae of D. hasseltii from Madras waters in March, June, and December. It may be noticed that all these observations generally agree with the fact that the spawning season of D. hasseltii starts in February or March and is rather prolonged. Contrary to this, Mahadevan and Chacko (1962) stated that the spawning season of D. hasseltii is from October to March in the Gulf of Mannar, the peak being "during the period when the current from the Palk Bay with its less saline water sweeps down the Gulf of Mannar due to the advent of Northeast Monsoon". Since these authors have not furnished any data to substantiate their contention, what led them to this conclusion is rather obsecure. Moreover, a perusal of the data they have presented in Table II and III showing percentage of length frequency distribution reveals that the smaller fish measuring below 50 mm standard length, which is scarcely two months old, were collected by them in April, May and July during 1952-53 and in April and May during 1953-54. No juveniles were observed between October and March. All this provides negative evidence to these authors' contention that the spawning season is from October to March. On the other hand it seems to support the general view that spawning starts round about February-March. The present investigation based on two years' data from April 1969 to March 1971 shows that *Dussumieria acuta* at Mandapam area has a prolonged spawning season, once in a year, extending from March to July-August.

Further, the period referred to as the breeding season of *A. hasseltii* by Mahadevan and Chacko (1962), is considered in the case of *D. acuta*, especially from October to December, as the resting period before the next season starts. In these months only immature, developing immature (stage II) and recovering ones (stage IIB) were observed. The maturation process actually starts only by January. The juveniles collected during May and June, along with evidence of other biological data, provide concrete support to the inference that the spawning season of *D. acuta* is from March to September. Moreover, the high values of gonado-somatic index observed from March to September and very low values from October to January further substantiate the conclusion drawn from the present observation.

The size of first maturity in _D. hasseltii_ has been determined as 14 cm by Devanesan and Chacko (1944). According to Mahadevan and Chacko (1962) the spawners are in size range of 120-135 mm standard length. But the present investigation shows that the size at first maturity for both the sexes of _D. acuta_ is around 132 mm total length.

The only earlier work available on the sex-ratio of rainbow sardine is that of Mahadevan and Chacko (1962) in _D. hasseltii_. They observed that the male to female ratio was about 1:2. In the present observation on _D. acuta_ the sex-ratio was statistically tested for significance month-wise and sizewise. The pooled year-wise data show that the sex ratio varied significantly from 1:1, with the females outnumbering the males; but not to the extent as has been observed by Mahadevan and Chacko (1962). According to Antony Raja (1972) the highly significant dominance of females in oil sardine is caused by the differential growth during and after spawning season. But in the present study the month-wise analysis shows that the significant dominance observed in certain months does not show any correlation with the spawning season. It is also proved that no differential growth is exhibited by two sexes of D. acuta. Hence it is assumed that the significant difference in sex-ratio may be due to the differential behaviour between the two sexes, especially among the mature fishes, probably by moving in separate shoals.

The fecundity estimations of D. acuta carried out by earlier workers have provided quite different values. Devanesan and Chacko (1944) estimated 420-500 ova in the right lobe and 25-80 ova in the left lobe of the ovary of D. hasseltii. Mahadevan and Chacko (1962) on the other hand counted in D. hasseltii nearly 300 ripe ova from the ovary of about 50% of the fishes they examined, while the rest in the same state of maturity showed lesser number. They also observed that on an average there are more than 5000 ova of all sizes in the right ovary alone. The lesser number observed by the early workers may be due to the fact that they would have taken in to consideration only the most advanced group of ova. The present examination carried out on 35 fish showed that the fecundity for both the lobes of the ovary varying from 1443 to 4625 ova. Here, along with the most advanced batch, the second batch of ova were counted since these two batches were shed in the same spawning season in two acts of spawning.

The relationship between the gonadosomatic index (GSI) and the degree of maturation of the ovaries had been reported by LeCren (1951), Ghosh and Kar (1952), Malhotra (1970) and Godinho *et al*. (1974) for the species they studied. Haydock (1971) affirms that the GSI measures the degree of sexual maturation, which of course varies with the species. According to Godinho *et al* (1974) the GSI is typical for each stage of gonadial development. In *D. acuta* also in the present study such a correlation was noticed to exist between the GSI and the maturity of the fish. The results showed that the immature fish have a GSI below 1; the maturing and mature fishes have between 1 and 3.2 and the ripe fishes have above 3.2. Godinho *et al* (1974) suggest that in *Pimelodus maculatus* the sexual product start their maturity when the GSI is above 2% and that the females are well prepared for spawning when it reaches the level of 6%. Haydock (1971) concluded that in *Bairdinella icista* when the GSI is around 5% the success of hormonal induction for reproduction is assured. In *D. acuta* it may be presumed that the females are prepared for spawning when the GSI reaches 3.2%.

CHAPTER 6

EARLY DEVELOPMENT

Quite a few authors have studied the planktonic eggs and larval development of the rainbow sardine. Delsman as early as 1925 studied the embryonic and larval history of *Dussumieria hasseltii* from the Java sea. Later Devanesan and Chacko (1944) worked out the bionomics of the same species describing the eggs and larvae. Chacko (1950) could collect the planktonic eggs of *D. hasseltii* from around Krusadai Island. Bapat (1955) in a preliminary study on the pelagic fish eggs and larvae of the Gulf of Mannar and the Palk Bay, provisionally refers the eggs he collected and marked as 'Type G' to *Dussumieria* spp. Kuthalingam (1961) described the eggs and larvae of *D. acuta* based on his collections from the offshore area of Madras coast and traced the development up to 56th day after hatching. Mahadevan and Chacko (1962), while studying the biology of D. hasseltii from the Gulf of Mannar have also briefly delt with its eggs and larvae. Summing all the salient points in the development of rainbow sardines, Nair (1973) has given an exhaustive review in his monograph on Indian sardines.

6.1. DESCRIPTION OF EGG:

The initial examination of the sample could be made only after 14 hours of artificial spawning. The egg was colourless, transparent and spherical with smooth egg membrane and the diameter varied from 1.34 to 1.66 mm. The yolk was segmented and frothy in the characteristic clupeoid fashion with single colourless oil globule at the vegetative pole measuring 0.13 to 0.14 mm in diameter. The proportionate size of the oil globule was 9.22 to 10.16% of the egg diameter. The perivitaline space was narrow, and the outline of the embryo was rather clear (Pl. XII, Fig. 3).

All the unfertilized eggs were carefully sorted out and from this lot 100 eggs at random were measured for their diameter and the percentage frequency was plotted (Pl. XII, Fig. 1). Nearly 86% of the eggs were between 1.45 and 1.57 mm. The range, mean, standard deviation (SD) and standard error were calculated and graphically presented in Plate XII, Fig.2. The values of standard deviation and standard error were estimated at 0.049 mm and 0.0049 mm respectively.

6.2. DEVELOPMENT OF THE EGG:

The embryo after 14 hours of fertilization is slender with a length slightly more than half the circumference of the egg. The head is clearly formed and the eye balls are clearly visible. The rudiment of heart could be traced just behind the head, on the ventral side. The auditory vesicle is faintly seen behind the eye and the myotomes are visible. The yolk is segmented with oil globule at the tail end of the embryo (Pl. XII, Fig. 3). After 17 hours of fertilization the embryo became much more elongated and encircle the yolk reaching nearly $\frac{3}{4}$ of the circumference (Pl. XII, Figs. 4 & 5). The eyes, heart and auditory vesicles became much more developed and the heart started pulsating at this stage. The oil globule attains a position just oposite the head and the yolk is clear and segmented (Pl. XIII, Figs. 1 & 2). The embryo at 20 hrs. is much more elongated and attain a 'C' shaped orientation around the yolk. The heart beat is regular and rhythmic. In this stage movement of the embryo was noticed at times within the egg and the embryo is seen fully adhering to the yolk. As development proceeds, at 23.30 hrs., the embryo attains fuller shape (Pl. XII, Fig.6). Since the length increases slightly more than the circumference of the eggs the tail portion may overlap the head. The head and body, except at the tail end, closely adhere to the yolk. The yolk is segmented and the oil globule is located at the middle portion of the body, opposit the head. The myotomes are clear; the eye lens formed and the auditory vessicle more prominent. The heart at this stage starts pulsating at a rate of 132 beats per minute. Rudiments of the anus is traceable. The frequency of movement of the embryo inside the egg capsule increased at this stage along with independent movement of tail. At 24 hrs. the incubation is completed and the larva hatched out.

6.3. HATCHING:

The larva hatched out after 24 hrs. of incubation. Before hatching, the tilting movement of the embryo due to the muscular contraction and also independent movement of the tail, becomes more frequent and evident. Owing to the lengthening of the embryo it begins to bend at the middle (Pl. XII, Fig. 7) and the shape of the yolk becomes slightly nonspherical. Bulging is noticed in the egg membrane near the head of the embryo. At first it develops as a narrow thinned area on the egg membrane above the head in the form of a ring, but gradually widens and the egg membrane roofing it bulges out forming a hood or cap (Pl. XII, Fig. 7). The embryo starts wriggling with its tail lash inside the egg membrane strongly. Simultaneously, the overlaping nature of the head and tail seen in the advanced stage (23.30 hrs.) is lost and the tail may show signs of moving away from the vicinity of

PLATE XII

Fig. 1 Diameter frequency distribution of spawned eggs of Dussumieria acuta. (Unfertilized eggs).

Fig. 2 Range, mean, standard deviation and standard error of the diameter frequency of the above eggs.
A - B = Range, C - D = Standard deviation,
E - F = Standard error and M = Mean.

Fig. 3 Fertilized egg of D. acuta with 14 hrs. old embryo.

Fig. 4 Egg with 17 hrs. old embryo.

Fig. 5 Another view of the 17 hrs. old embryo.

Fig. 6 Egg with 23 1/2 hrs. old embryo

Fig. 7 Egg with embryo just before hatching.

Fig. 8 Empty shell of the egg after hatching.

Fig. 9 Newly hatched larva.

Fig. 10 Larva 24 hrs. after hatching.

Fig. 11 Larva 39 hrs. after hatching (This larva was dead and slightly shrunken).

Fig. 12 Enlarged view of the head of the 39 hrs. old larva.

Fig. 13 Larva 48 hrs. after hatching (after Delsman).

Fig. 14 Enlarged view of the head of 48 hrs. old larva.
a = anus, df = dorsal finfold, e = eye, g = 1-4 = gill slits, gc = rudiment of gill cover, gt = gut, h= hear m = mouth, og = oil globule, ot = auditory vessicle, p = rudiment of pectoral fin, pv = perivitaline space vf = ventral fin fold, y = yolk and 1,2,3,...48 = myotomes.

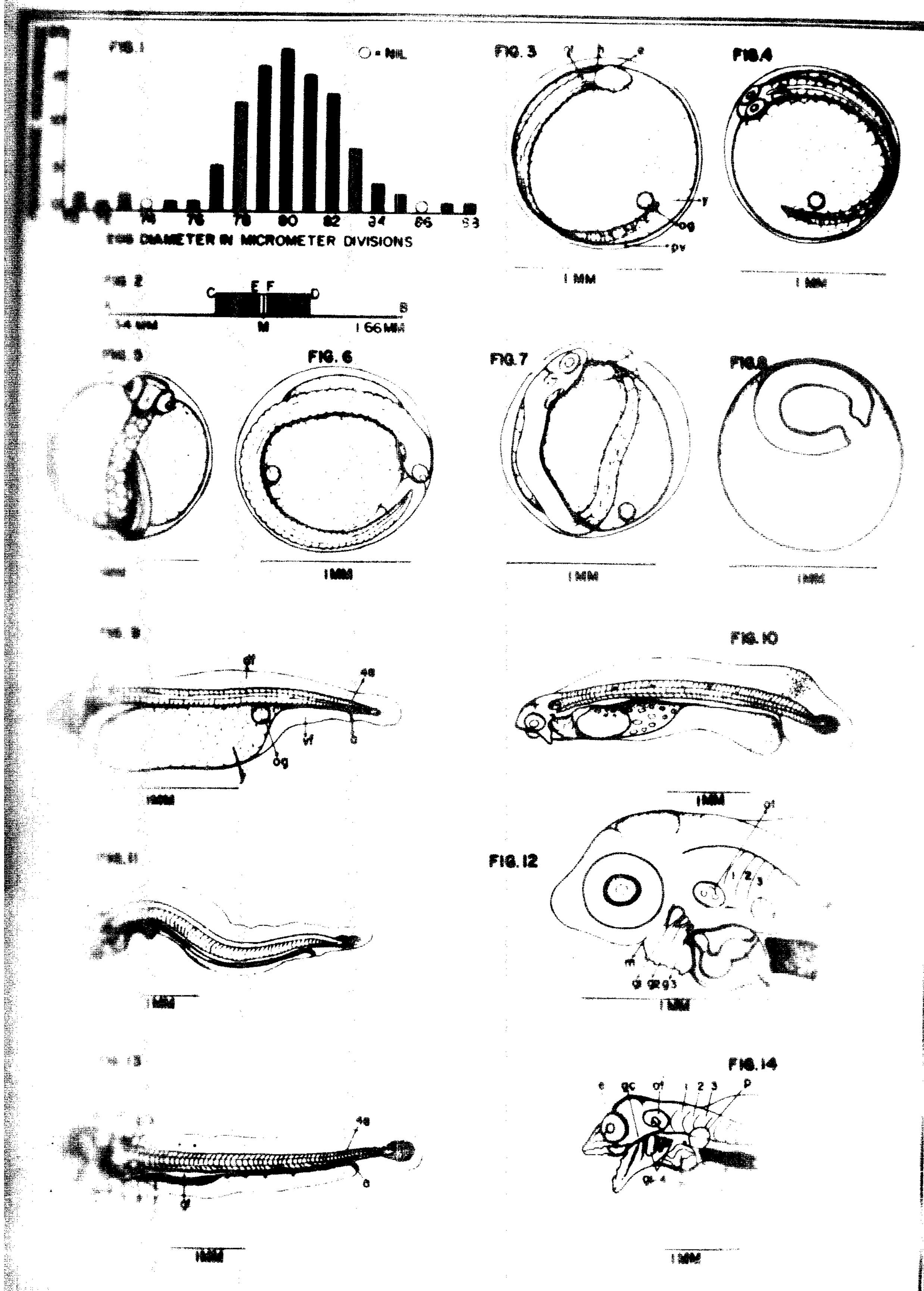


FIG. 3
FIG. 4
FIG. 6
FIG. 7
FIG. 10
FIG. 12
FIG. 14
EGG DIAMETER IN MICROMETER DIVISIONS
1 66MM
1 MM

PLATE. XII

PLATE XIII

Photographs of the developing egg of D. acuta.

Fig. 1 17 hrs. old embryo.

Fig. 2 Another view of the 17 hrs. old embryo.

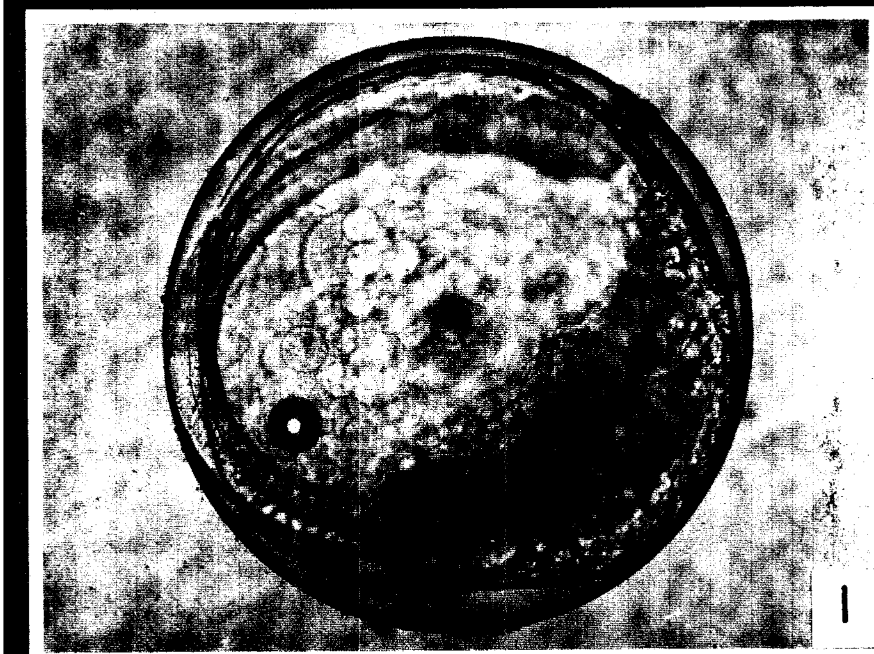


PLATE. XIII.

the head. All these changes indicate that hatching of the egg is imminent. Within a short time, the hood near the head portion breaks off and the head comes out first followed by yolk and tail. The larva swims away by the lashing movement of the tail. The empty egg case is spherical and the bulged out hood remains at the mouth of the case attached to it by means of a short and narrow stalk (Pl. XII, Fig.8).

6.4. NEWLY HATCHED LARVA:

"The newly hatched larva exhibits all clupeoid characteristics, in the first place by the backward position of the anus, in the second place by the segmented yolk and in the third place by the peculiar crossed arrangement of the muscle fibres in the mytomes" (Delsman, 1925). Immediately after hatching the larva is slightly curved dorsally and the oil globule is situated in mid dorsal side of the yolk. But after some time the larva straightens itself and the oil globule shifts its position to the posterior end of the yolk. The larva is transparent and measures 2.4 mm in length (Pl. XII, Fig. 9). The head is closely applied to the yolk. The eyes are unpigmented and some distance behind them are the auditory vesicles. The rudiment of the brain is visible. The heart is pulsating regularly. The anus is situated at the posterior end; 48 preanal myotomes are present. The post anal myotomes are not accurately countable. The yolk sac is elongated and slightly tapering posteriorly with segmented yolk. The fin fold is continuous starting from the dorsal side of the head and ending at the postero-ventral margin of the yolk. Considerable lengthening of the larva is noticed during the first few hours of development. 3 hours after hatching fine black pigment spots are noticed along the myotomes and on the upper surface of the head. Rapid changes in the head of the larva takes place and in the 18 hour-old larva indications of the gill opening are seen below the auditory vessicle. Small pigment spots spread all over the surface of the yolk and also along the gut. At this stage indications of the fin rays are visible at the caudal region.

24 hour-old larva:

24 hours after hatching, the larva attains 4.2 mm length. The unpigmented eye occupies 2/3 of the head. Behind the eye is the much more enlarged auditory vesicle. The lower jaw starts developing (Pl. XI, Fig. 10). The first gill-slit has developed just above the anterior part of the heart. The heart is two chambered. The yolk is reduced and a vertical separation is noticed, dividing it into anterior and posterior portions (Pl. XII, Fig. 9). The split up oil globule is scattered in the posterior section of the yolk with a few spreading into the anterior section also. Small black pigment spots spread over the yolk. The posterior portion of the

intestine is well formed. The anus projects clearly below the 43th myotome. Fine fin rays appear in the caudal fin area. Slight bulging of the fin fold is noticeable on the dorsal side, above the anal region, and on the ventral side just in front of the anus. Fine black pigment spots are more in these areas, while they are scattered in the rest of the fin fold. Black pigment dots are visible in a row along the myotomes, intestine and a few spots on the dorsal side of the head.

39 hour-old larva:

In this stage the larva is much more elongated and slender. The yolk is much reduced but not completely resorbed. The oil globule completely disappears. The mouth is wide open (Pl. XII, Fig. 11). The lower jaw has developed and ossification starts on both the jaws. In high magnification (Pl. XII, Fig. 12) rudiments of the teeth formation are visible. The eye ball covers the major portion of the head. Behind the eye, the first gill slit is more evident in the form of a round hole. Breaking through of two more gill-slits are visible behind the first one. The auditory vesicle is further enlarged. On the postero-dorsal side of the heart, below the third and fourth myotomes is the rudiment of the pectoral fin. The fin rays are clear in the caudal region. The black dots in the fin fold almost disappears.

<u>48 hour-old larva</u>:

At this stage the larva is longer and transparent. The yolk is not completely absorbed but exists as a narrow band on the ventral side. The auditory vesicle is almost of the size of the eye and is slightly oval in shape with ossifications in it. The jaws are well developed, prominent and pointed with rudimentary teeth, nearly six in the lower jaw and four in the upper jaw (Pl. XII, Fig. 13). In higher magnification (Pl. XII, Fig. 14) jaw bones are visible with indications of calcification. It seems that in this stage the jaws cannot be closed. All the gill-slits have broken through in this stage of which the first three are clearly visible and the fourth one is very small. The first one is elongated and slit like. The second one is about 2/3 of the size of the first one and the third one is still smaller. Rudiment of the gill cover is visible extending from the postero-ventral side of the auditory vessicle to the angle of the jaw. The rudiment of the pectoral fin is clearly visible at this stage. The black spots have disappeared from the fin fold and their place is taken by scattered pigment spots in the anterior half. A number of regularly arranged black spots along the under side of the gut and a similar series along the upper half of the myotomes are visible.

Bapat (1955) found that the egg of Dussumieria sp. is spherical and measures 1.41 to 1.67 mm in diameter. The yolk is colourless, transparent and minutely vacuolated and almost fills the egg capsule leaving a narrow perivitaline space. A single colourless oil globule measuring 0.113 to 0.182 mm in diameter is found near the vegetative pole. The embryo, yolk and oil globule are devoid of any pigment cells. Kuthalingam (1961) found that the eggs of D. acuta are perfectly spherical with an average diameter of 1.4 mm. The yolk is opaque, segmented and provided with a colourless oil globule situated at the tail portion of the embryo. He observed that the spherical shape of the eggs become irregular as development advanced and the embryo became fully developed. According to the present observation the size of the egg of D. acuta is 1.34 to 1.66 mm in diameter with an oil globule measuring 0.13 to 0.14 mm and the general discriptions agree with those given above.

The egg of Dussumieria hasseltii has been described by Delsman (1925), Devanesan and Chacko (1944), Chacko (1950) and Mahadevan and Chacko (1962). According to Delsman (1925) the egg diameter varies from 1.45 to 1.55 mm with a small colourless oil globule. Devanesan and Chacko (1944) observed the planktonic egg measuring only 0.88 mm in diameter with an oil globule at the vegetative pole measuring 0.26 mm.

Chacko (1950) also gave 0.88 mm as the diameter of the planktonic egg of D. hasseltii but records a small colourless oil globule. Mahadevan and Chacko (1962) stated that the egg of D. hasseltii measures 1.0 to 1.15 mm in diameter and with an oil globule of 0.26 mm. According to Delsman (1925) the development of the egg of D. hasseltii is completed in one and a half days. The present observation shows that in D. acuta the incubation period is only 24 hours.

According to Kuthalingam (1961) the newly hatched larva of D. acuta is transparent and floats with the head downwards and measures about 2.6 mm in length. The eyes are unpigmented and the auditory vesicles and the vent are clearly seen. There are 49 preanal and 8 post-anal myotomes with muscles showing the typical clupeoid arrangement. The oil globule occupies the centre of the segmented yolk mass. A number of fine black pigment spots is present on the unpaired dorsal and ventral fin folds. Black patches present between the eyes and the auditory vesicles.

Bapat (1955) observed that the ten-hour-old larva of Dussumieria sp. measures 5 mm in length. The yolk tapers posteriorly with oil globule at the far end. He found the anus below 48th myotome with 4 post anal myotomes. The larva possesses melanophore on the head and along the body above the alimentary canal. In the present study the newly hatched larva measured 2.4 mm with 48 preanal myotomes.

Delsman (1925) found that the newly hatched larva of D. hasseltii has the anus below the 50th myotome and the head of the larva is closely applied to the yolk. The eyes are unpigmented and some distance behind them are the auditory vessicles. Fine black pigment spots are scattered along the myotomes and the upper surface of the head. The oil globule occupies the posterior part of the yolk. In 18½ hour- old larva the first gill opening is seen below the auditory vesicle while the rudiment of the second gill opening is seen behind it. The small pigment spots have spread all over the surface of the yolk and along the gut, but have disappeared from the dorsal fin fold. According to Devanesan and Chacko (1944) the newly hatched larva of D. hasseltii measures 1.7 mm in length. They found 48 preanal and 9 post-anal myotomes. The eyes are unpigmented and two rows of brown pigments are present on either side of the larva. They noticed rapid growth and forward shifting of the anus in the initial hours of development. 18 hour-old larva measures 3 mm in length with the anus below 41st myotome. The rudiments of the pectoral fin appeared when the larva is 3 hour-old. Fin rays were noticed in the caudal region when the larva is 6 hour-old. According to Chacko (1950) in D. hasseltii the anus of the larva is under 45-48 myotome and he observed fine black spots scattered along the myotomes. Mahadevan and Chacko (1962) found the hatchlings of

D. hasseltii measure 1.8 mm in length with 42 preanal and 10 post anal myotomes. Six hours after hatching fin rays appeared in the caudal region of the fin fold.

Kuthalingam (1961) observed that the one-day-old larva of D. acuta continues to be transparent measuring 3.1 mm in length. The mouth is not developed and the yolk sac is smaller in size with the oil globule occupying the posterior end of the yolk mass. The eye continues to be unpigmented and the pectoral fin rudiment is seen as a prominent membmaneous fold. Only 47 preanal myotomes are presented in this stage. There was no change in the larva during the next day except its growth and reduction in the yolk.

In D. hasseltii, Devanesan and Chacko (1944) found that the one-day old larva measures 3.12 mm in length with the rudiments of the lower jaw. After 27 hours, the length of the larva is 3.24 mm with two gill-slits and the upper jaw is also differentiated. The anus has moved forwards with 39 preanal and 18 post-anal myotomes. The eyes are unpigmented. Forty-five hours after hatching the larva measures 3.28 mm in length and the pectoral fins are well developed. The yolk has completely disappeared and the mouth is wide open. The eyes are pigmented black and bluish-green. The pigmentation of the fin folds also disappeared and there are two rows of black pigment cells on the sides of the larva. Mahadevan and Chacko (1962) found that in D. hasseltii the yolk sac is completely absorbed after 32 hours when the larva measures 3.4 mm in length. They found 48 preanal and 7 post-anal myotomes.

In the 48 hour-old larva of D. hasseltii, Delsman (1925) found all the gill-slits broken through with very wide openings. The lower jaw is well developed and the rudiments of the teeth begin to appear. The yolk has been nearly absorbed in this stage. There are 48 preanal myotomes. A few scattered pigment spots are present in the anterior half of the dorsal fin-fold. In the older larvae, immediately in front of the pectoral fin is a typical pigment spot and two small pigment spots are found invariably on the dorsal side of the head between the eyes. According to Delsman (1925) the most striking feature of the head of the larva of rainbow sardine is the wide gaping mouth with the pointed jaws and the strongly developed teeth. In this respect the larvae resemble the eel larvae. Apart from these characters the larvae could be easily distinguished from the other clupeoid larvae by the elongated slender appearance and transparency. He found that the yolk sac is absorbed in about 2½ days when the eyes become black, but he could not keep the larvae for more than three days. However, he described a few advanced stages in the development of this rainbow sardine obtained from the plankton collections. Devanesan and Chacko (1944) found the 53-hour-old larva of D. hasseltii measuring 3.46 mm in length and possesses a wide mouth showing a strong dentition on the lower jaw. They found three gill-slits in this stage with clear pigmented eyes.

According to Kuthalingam (1961) the three-day-old larva of D. acuta continue to be transparent and measures 7.2 mm in length. The yolk sac is completely absorbed and the eyes have become black. The auditory vesicles have enlarged and the four gills are seen in this stage. The mouth and the alimentary tract are well defined. The twelve-day-old larva continues to be transparent and measures 14.2 mm in length. The head is distinct and the mouth is well defined. There are 46 preanal and 11 post-anal myotomes. The gills are well developed and the rudiments of teeth are seen in this stage. The pigmentation of the dorsal side is very faint while that of the ventral side has disappeared completely. Two groups of black pigment patches, one above the eye and the other above the auditory vesicles are seen. Fin rays are well developed in the caudal region. He observed that the twenty-one-day old larva measures 20.2 mm in length with 44 pre-anal and 13 post-anal myotomes. The fin rays have appeared in the dorsal and anal regions. He considered thirty-two-day old larva as post larva which measures 28.8 mm.

in length and shows all the general characteristics of the species. The post larva at thirty-nine-day old stage measures 33.3 mm in length without any change in the external features. At this stage the dorsal and anal fins are extremely soft and transparent and pectoral fins are well developed. The post larva at fifty-sixth-day measures 48.2 mm in length and the gills are well developed. According to him these young fishes have a beautiful green colour with a light blue shade along the upper margin of the opercle and along the back of the body. The caudal fin is blue-green in colour and the upper surface of the head and eye is emerald green. The pectoral, ventral and anal fins are white and almost transparent.

These studies on the life history of Dussumieria acuta by Kuthalingam (1961) were based on the planktonic eggs from the tow-net collections from the offshore regions of the Madras harbour. He was able to rear them in the laboratory to the juvenile stages (fifty-sixth-day-old larva) by providing concentrate of fresh plankton as food. Nair (1973) commented on this stating that "it is extremely interesting that he reared them to the juvenile stages in the laboratory without any difficulty when the other workers under similar conditions have failed to rear them beyond the third day". In the present study the larvae could be reared only for two days and the last larva died after 48th hour of hatching.

CHAPTER 7

AGE AND GROWTH

A considerable amount of information on age and growth relating to various fish species is already available. Graham (1929), van Oosten (1929), Menon (1950a) and Chuganova (1959) have given detailed accounts and have reviewed the literature on age determination of fishes. The papers of Thomson (1904), Chuganova (1926), Hickling (1933), Hile (1936), Le Cren (1947), Jones and Hynes (1950), Bagenal (1954) and Kelly and Wolf (1959) are only a few among the outstanding earlier publications on this subject.

From India the age and growth of some commercially important marine and freshwater fishes have been estimated by earlier workers of which the findings of Hornell and Nayudu (1923), Devanesan (1943), Nair (1949) and Chidambaram (1950) on *Sardinella longiceps*; of Seshappa and Bhimachar (1951 & 1954) on *Cynoglossus semifasciatus*; of Sekharan(1955&1959)

on Sardinella spp.; of Jhingran (1957) on Cirrhina mrigala; of Sarojini (1957 & 1958) on Mugil parsia and M. cunnesius; of Pillay (1958) on Hilsa ilisha; of Sekharan (1958) and Seshappa (1958) on Rastrelliger kanagurta; of Rao (1961) on Pseudosciena diacanthus and of Pantulu (1962) on tropical cat-fishes, are a few to mention.

All these workers have used different methods to determine the age of fishes, of which Peterson's method was the most popular. The growth rings on the skeletal structures like scales, otoliths, opercular bones, vertebrae and fin spines were also utilised to determine the age. Since there are more clearcut differences between the seasons in the temperate regions the growth rings are more or less clear and easy to interpret. But to what extent these growth rings are reliable indications of growth or age in the tropical fish, especially the short lived clupeoids, is controversial. Delsman (1929) and Hardenberg (1938) held the view that due to absence of any periodicity in seasons, methods used elsewhere may not be applicable to tropical fishes. However some earlier workers have been able to observe some rings in the hard parts of some of the Indian fishes and they attributed the formation of these rings to different reasons.

Except for a brief mention by Mahadevan and Chacko (1962) in Dussumieria hasseltii no information is available on the length at age and growth rate of rainbow sardines. In the present work an attempt has been made to study the age and growth of D. acuta using Peterson's method of length frequency analysis and probability plot technique of Cassie (1954).

7.1. PETERSON'S METHOD OF LENGTH FREQUENCY ANALYSIS:

The principles underlying Peterson's method of age determination may be summarized as follows:

In a population of a species of fish having a single restricted spawning season, the lengths of the individuals of each age-group are approximately "normally" distributed.

In a sample taken from the population, growth is such that the modes of the length distribution of successive age-groups are separated along the axis and may be readily distinguished.

When the length frequency distribution of a sample containing a number of age-groups is drawn a polymodal curve results, the separate modes of which represent the approximate mean sizes of the constituent age-groups.

In a fish population the age classes represented by the modes depend on the number of spawnings of the species in a year. If the spawning is annual, then the modes represent successive year classes and if it is biannual, the modes represent half-year classes. Using this method it is possible to find out the average size of a few earlier year classes. In older age classes the growth slows down (Ford, 1933) and as a result the modes usually tend to overlap, thereby making their interpretation more difficult. In a population of a fish species without short and specific spawning period, the lengths of various groups entering the fishery overlap. Then the only possible way to determine the age is to trace the age-groups after their entry in to the fishery and find the average monthly growth rate in different stages. From this the values of average size at different ages can be estimated.

The total length measurements of fresh fish collected during the period from April 1969 to March 1971 have been used in this study. The minimum and maximum size as observed during this period were 47 and 167 mm, respectively.

The data: The monthwise percentage frequency of each size group of *D. acuta* is shown in Tables 83 and 84 for two years along with the total number of fish examined in each month. The results are also plotted in the form of length frequency curves for each month during April 1969 to March 1971 (Pl.XIV, Figs. 1 & 2).

An examination of the data presented in Tables 83 and 84 reveals some conspicuous modes together with some smaller modes also. Repetition of some of the conscpicuous modes in successive months may also be noticed which may be attributed to the prolonged spawning season of this fish extending from March to September. Since the young fish appeared only in smaller numbers in the commercial catch the modes within this group were smaller compared to the major modes. In the discription given below such smaller modes were also mentioned as such and were taken into account, along with other modes, in the calculation of growth rate by tracing the modes in the length frequency curves. The positions of different modes in the monthly length frequency curves from April 1969 to March 1971 are given in Plate XIV, Fig. 3.

In April 1969 a unimodal pattern may be noticed with the mode at 133 mm size group, whereas a polymodal nature may be seen in May with three modes, one at 63 mm another smaller one at 93 mm and a more conspicuous one at 138 mm size groups. In June also three modes may be noticed at 73, 98 and 133 mm size groups. Of these the first one is the most conspicuous mode and may be traced back to 63 mm mode of May indicating 10 mm growth. Similarly the mode at 98 mm would have resulted from 93 mm mode of May showing a growth of 5 mm. A trimodal pattern was observed in July with modes at 113, 123 and 138 mm size groups. Of these the 123 mm mode is not so conspicuous as the other two modes. The 113 mm mode would have resulted from the 98 mm mode of June by an addition of 15 mm in growth, while the 138 mm mode may be traced back to 133 mm mode of June. The mode at 123 mm remains untraceable. One minor and two major modes may be seen in the next month, August, at 93, 113 and 138 mm respectively. The 93 mm mode would have resulted from the 73 mm mode of June showing a progression of 20 mm. The modes at 113 mm and 138 mm are repetitions of the modes of the previous month. In September, only one mode may be noticed at 123 mm which can be traced back to 113 mm mode of July and August. Out of the three modes observed in October at 78, 93 and 128 mm, only the 128 mm mode can be traced back to the 123 mm mode of September indicating 5 mm growth increment. A bimodal pattern may be seen in November with a small mode at 88 mm and another major mode at 128 mm size groups. The former one would have been the result of 10 mm growth to the 28 mm mode of October whereas the latter one remains as a repetition of the previous month's mode. In December two modes may be seen one at 103 mm and another at 123 mm size groups. 103 mm mode may be traced back to 88 mm mode of November showing a growth of 15 mm and the 123 mm mode to 93 mm mode of August showing a growth increment of 30 mm for 4 months. In

TABLE 83

PERCENTAGE OF LENGTH FREQUENCY DATA OF *DUSSUMIERIA ACUTA* FROM APRIL 1969 TO MARCH 1970

Months	Size groups (T.L. in mm)												
	46-50	51-55	56-60	61-65	66-70	71-75	76-80	81-85	86-90	91-95	96-100	101-105	106-110
April 1969	—	—	—	—	—	—	—	—	—	—	—	0.82	0.82
May	0.68	2.04	2.93	8.43	7.98	5.62	3.38	1.24	1.13	2.70	2.36	1.35	0.67
June	—	—	0.81	0.40	8.87	24.19	12.10	8.87	3.63	4.03	11.29	8.07	3.23
July	—	—	—	—	—	—	—	—	—	0.44	0.44	1.33	5.78
August	—	—	—	—	—	—	—	—	0.68	2.04	0.68	2.04	6.12
Sept.	—	—	—	—	—	—	—	—	—	—	0.19	0.38	0.96
Oct.	—	—	—	—	—	0.20	1.37	0.39	0.20	0.59	0.39	0.20	—
Nov.	—	—	—	—	—	—	0.17	1.14	1.47	0.17	—	—	—
Dec.	—	—	—	—	—	—	—	—	—	—	0.33	1.32	0.66
Jan. 1970	—	—	—	—	—	—	—	—	—	—	0.55	1.10	2.02
Feb.	—	—	—	—	—	—	—	—	—	—	—	—	0.60
March	—	—	—	—	—	—	—	—	0.30	0.75	0.45	0.15	0.15
Annual %	0.11	0.34	0.53	1.44	1.76	2.11	1.29	0.80	0.61	0.89	1.16	1.00	1.12
Cumulative percentage	0.11	0.45	0.98	2.42	4.18	6.29	7.58	8.38	8.99	9.88	11.04	12.04	13.16

Continued..

Months	Size groups (T.L. in mm)											
	111-115	116-120	121-125	126-130	131-135	136-140	141-145	146-150	151-155	156-160	161-165	Total No. of fish
April 1969	1.64	2.46	3.28	35.24	42.62	10.66	1.64	0.82	—	—	—	122
May	0.11	0.11	0.22	1.91	11.91	20.91	14.62	7.87	1.46	0.34	—	889
June	1.61	1.61	0.40	0.81	6.05	2.82	1.21	—	—	—	—	248
July	15.56	8.89	9.78	4.89	14.67	21.33	15.56	0.89	0.44	—	—	225
August	24.49	14.97	12.25	8.16	9.52	11.57	6.12	1.36	—	—	—	147
Sept.	3.24	18.70	32.63	20.23	9.73	5.73	5.73	2.10	0.38	—	—	524
Oct.	0.39	2.94	13.33	27.05	20.78	14.31	12.35	4.31	0.98	0.20	—	510
Nov.	1.63	2.78	12.09	29.56	25.64	15.04	6.54	2.94	0.82	—	—	612
Dec.	2.63	15.13	24.67	22.69	14.80	7.24	6.25	3.95	0.33	—	—	304
January 1970	4.97	18.75	22.06	20.95	15.81	7.17	3.50	1.84	0.92	0.18	0.18	544
Feb.	7.55	15.51	19.91	23.06	22.01	6.71	2.31	2.10	0.21	—	—	477
March	0.30	1.94	6.41	29.35	28.46	16.54	8.79	5.07	1.04	0.30	—	671
Annual %	3.41	7.87	13.14	18.96	18.22	12.70	7.96	3.64	0.76	0.13	0.02	5273
Cumulative percentage	16.57	24.44	37.58	56.54	74.76	87.46	95.42	99.06	99.82	99.95	99.97	

TABLE 84

PERCENTAGE LENGTH FREQUENCY DATA OF DUSSUMIERIA ACUTA FROM APRIL 1970 TO MARCH 1971

Months	Size groups (T.L. in mm)												
	46-50	51-55	56-60	61-65	66-70	71-75	76-80	81-85	86-90	91-95	96-100	101-105	106-110
April 1970	—	—	—	—	—	—	—	—	—	—	—	0.22	0.89
May	—	—	—	—	2.66	8.85	4.43	2.21	—	—	—	—	0.22
June	—	—	—	—	—	—	—	1.04	2.60	1.57	0.52	1.04	1.04
July	—	—	—	—	—	—	—	—	—	—	0.48	1.20	0.24
August	—	—	—	—	—	—	—	—	—	—	—	—	0.65
September	—	—	—	—	—	—	—	—	—	—	0.39	0.20	0.98
October	—	—	—	—	—	—	—	—	—	—	—	—	—
November	—	—	—	—	—	—	—	—	—	—	—	—	—
December	—	—	—	—	—	—	—	—	—	—	—	1.59	0.36
January 1971	—	—	—	—	—	—	—	—	—	—	—	—	—
February	—	—	—	—	—	—	1.21	2.63	2.02	1.42	0.40	0.20	—
March	—	—	—	—	—	—	—	—	—	—	—	—	—
Annual %	—	—	—	—	0.24	0.79	0.51	0.49	0.29	0.20	0.14	0.37	0.37
Cumulative percentage	—	—	—	—	0.24	1.03	1.54	2.03	2.32	2.52	2.66	3.03	3.40

(Contd......)

Table 84 (Contd.....)

Months	Size groups (T.L. in mm)											
	111-115	116-120	121-125	126-130	131-135	136-140	141-145	146-150	151-155	156-160	161-165	166-170	Total No. of fish
April 1970	0.44	3.11	6.65	17.07	22.61	21.51	14.19	7.76	4.21	0.89	0.22	0.22	451
May	0.22	0.66	4.65	17.48	33.18	16.15	6.64	2.45	0.22	—	—	—	452
June	1.57	4.17	8.85	32.29	26.04	15.10	2.08	2.08	—	—	—	—	192
July	1.92	5.50	9.09	21.29	31.10	20.87	5.74	1.44	1.20	—	—	—	418
August	3.01	7.72	16.95	26.82	22.31	16.09	4.72	1.29	0.22	0.22	—	—	466
September	7.03	10.55	25.07	17.38	16.21	13.67	4.83	2.73	0.78	0.20	—	—	512
October	5.45	17.05	25.68	22.04	13.64	6.59	6.59	1.37	0.46	0.23	—	—	440
November	1.38	9.34	18.96	26.92	26.10	12.64	2.20	1.92	0.27	0.27	—	—	364
December	1.24	3.70	16.22	22.92	23.62	18.87	8.46	1.77	0.71	0.36	0.18	—	567
January 1971	0.85	1.43	5.13	17.66	27.35	23.08	18.23	4.56	1.43	0.28	—	—	351
February	—	0.20	7.03	24.29	23.88	23.28	9.11	3.64	0.61	—	—	—	494
March	0.26	0.52	1.31	21.72	41.88	23.56	9.43	0.80	0.26	—	—	—	382
Annual %	2.04	5.50	12.67	21.19	25.19	17.67	7.84	2.67	0.90	0.22	0.04	0.02	5089
Cumulative percentage	5.44	10.94	23.61	45.44	70.63	88.30	96.14	98.81	99.71	99.93	99.97	99.99	

PLATE XIV

Fig. 1 Length-frequency distribution of D. acuta for the year April 1969 to March 1970.

Fig. 2 Length-frequency distribution of D. acuta for the year April 1970 to March 1971.

Fig. 3 Distribution and progression of modes of length-frequency data of D. acuta during April 1969 to March 1971.

Fig. 4 Distribution of the major modes of the mature males and females of D.acuta during the years April 1969 to March 1970 and April 1970 to March 1971 (data obtained from biological samples).

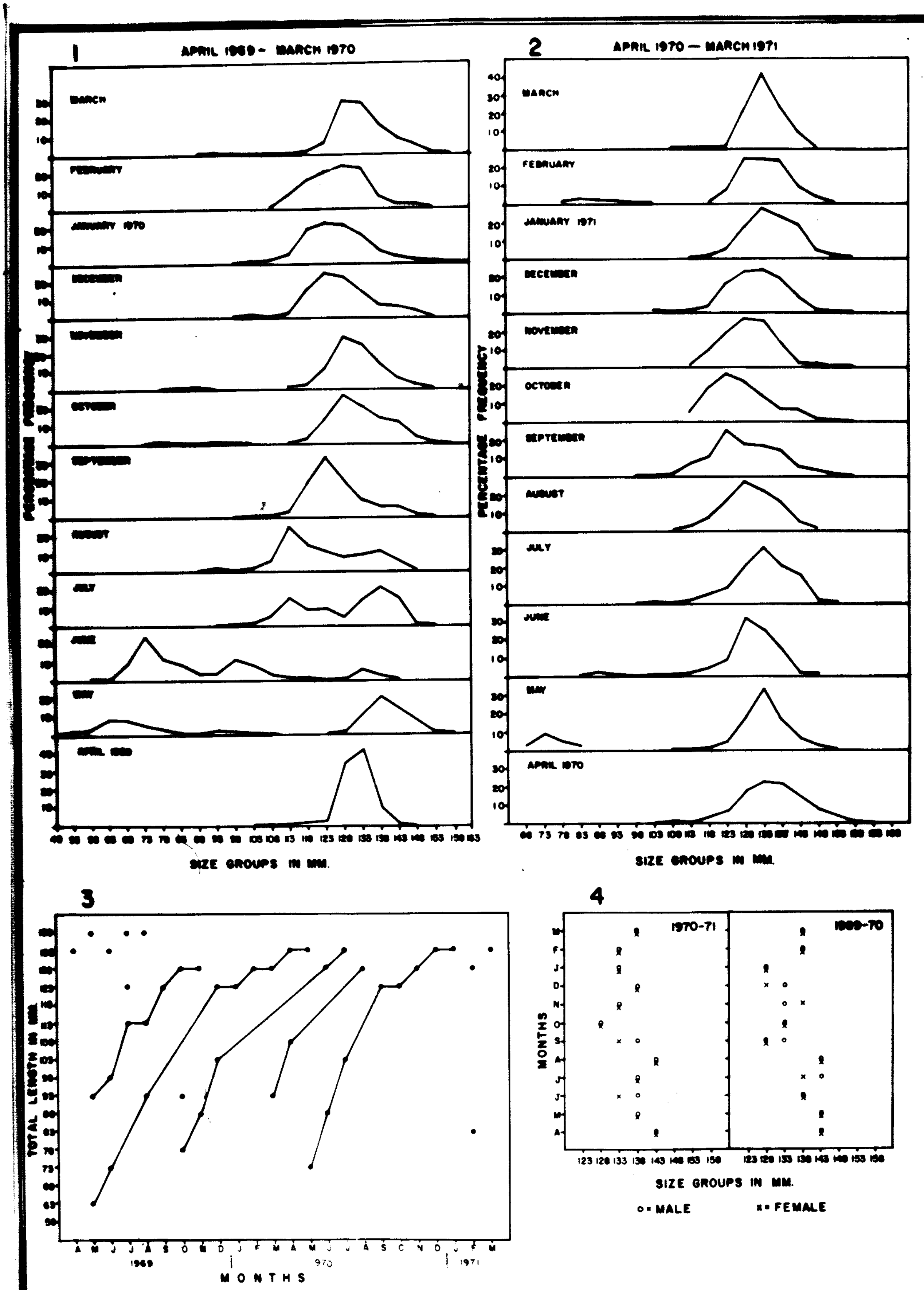

1
APRIL 1969 - MARCH 1970
PERCENTAGE FREQUENCY
SIZE GROUPS IN MM.
2
APRIL 1970 — MARCH 1971
MARCH
FEBRUARY
JANUARY 1971
DECEMBER
NOVEMBER
OCTOBER
SEPTEMBER
AUGUST
JULY
JUNE
MAY
APRIL 1970
PERCENTAGE FREQUENCY
SIZE GROUPS IN MM.
3
TOTAL LENGTH IN MM.
1969
1970
1971
MONTHS
4
1970-71
1969-70
MONTHS
SIZE GROUPS IN MM.
o = MALE
x = FEMALE

PLATE XIV

January 1970 the frequency curve exhibits a unimodal pattern when the 123 mm mode of December 1969 is repeated. In February also it is unimodal with the mode at 128 mm size group which may be traced back to 123 mm mode of the previous month showing an addition of 5 mm growth. In March two modes may be seen at 93 and 128 mm size groups, of which the latter one is the repetition of the mode of the previous month.

Following the progression of modes during the next year from April 1970 to March 1971 two modes make their appearance in April at 108 and 133 mm size groups. The first one may be the result of 15 mm growth of the 93 mm mode and the second one be the result of 5 mm growth of the 128 mm mode of March 1970. The 133 mm mode of March continues in May. In addition to this a juvenile mode at 73 mm size group may also be noticed in May. In June two modes may be seen one at 88 mm size group, traceable back to 73 mm mode of May and another at 128 mm size group, traceable back to 103 mm mode of December 1969. This shows a growth increment of 15 mm for one month in the former case and 25 mm for 5 months in the latter. Two modes may be seen in July at 103 and 133 mm size groups. Of these the 103 mm mode would have resulted from the 88 mm mode and the 133 mm mode from 128 mm mode of June with growth increments of 15 mm and 5 mm respectively. A single mode was observed in August at 128 mm which may be the result of 20 mm growth of the 108 mm mode of April. From

September 1970 to January 1971 also the frequency curves exhibit a unimodal pattern. In September the mode is at 123 mm which would have emerged from 103 mm mode of July adding 20 mm growth to it. This 123 mm mode is repeated in October. The mode at 128 mm in November may be the result of 5 mm growth of the 123 mm mode of the previous month. In December the mode is at 133 mm size group which can be related to 5 mm growth of the 128 mm mode of November. The 133 mm mode is repeated in the next month, January 1971 February has got two modes, a juvenile mode at 83 mm and another major mode at 128 mm, both of which are not traceable back. In March a single mode may be seen at 133 mm which may be the result of 5 mm growth of the 128 mm mode of the previous month.

Growth rate: As mentioned earlier when two years data were put together some of the modes in the length frequency curves could be followed for a certain period, after which the identity of these modes becomes doubtful. Even though the identity of the modes cannot be recognised during all the successive months the possible progressions of 5 important broods which are traceable to a longer period through months from the minimum modal sizes that contributed to the fishery, are given in Plate XIV, Fig. 3. It may be seen that all the modes traced do not give the same rate of growth. Therefore, based on the progression of these modes an average growth rate was calculated following the method adopted by Thomas (1969).

The first column in Table 85 shows the month of first appearance of the brood with the modal size of the brood just following. The subsequent values denote the modal values of the same brood in subsequent months. The position of the first value for each brood has been fixed according to its size and subsequent growth. It may be seen from Table 85 that the growth pattern of each brood is more or less identical and therefore the alignment of modal developments seems to be justified. The bottom row gives the average. It is seen from the average that after a brood enters the fishery its growth for the first month is 10 mm and thereof the average growth per month for the first three months is 7.5 mm. This shows that as the fish becomes older the growth rate decreases. So it may be assumed that the growth rate would have been still faster before it first entered the fishery. From Table 85 it may be noticed that the smallest mode appeared in the fishery is 63 mm noticed in May 1969. The breeding season of D. acuta is observed as March to September. So the 63 mm modal size of May 1969 would have been the brood of March 1969. If it is so the 63 mm mode observed would have been the result of 2 months growth. This shows that in the first quarter this fish grows to a length of 73 mm with an average growth rate of 24.5 mm per month. Like wise it may be seen from the Table that the fish attains 95.5 mm at the end of 6 months (half year),

TABLE 85

PROGRESSION OF VARIOUS BROODS IN SUCCESSIVE MONTHS FOR
DUSSUMIERIA ACUTA

Months	Modal position in mm.												
1969													
May	63	73	—	93	—	—	—	123	123	128	128	133	133
May	—	—	—	—	—	—	93	98	113	113	123	128	128
Oct.	—	—	—	78	88	103	—	—	—	—	—	128	133
1970													
March	—	—	—	—	—	—	93	108	—	—	—	128	—
May	—	—	73	88	103	—	123	123	128	133	133	—	—
Average	63	73	73	86.3	95.5	103	103	113	121.3	124.7	128	129.2	131.3
Age in months	2	3	4	5	6	7	8	9	10	11	12	13	14

113 mm at the end of 9 months and 128 mm at the end of first year, with an average monthly growth rate of 7.5, 5.8 and 5 mm during 2nd quarter, 3rd quarter and 4th quarter respectively. Thereafter it seems rather difficult to trace the growth rate of the fish. In short this fish attains 128 mm total length

at the end of first year giving an average monthly growth rate of 10.75 mm.

An uniform growth rate can not be expected throughout the life span of an individual fish as it is well known that in earlier stages the growth rate will be much higher than in the later stages. This change in growth will be noticeable not only between years but within the year also where the growth rate will be greater in earlier months but will be insignificant as the fish grows older and older. Indications of such differential growth at different stages of life time are noticeable in the present study also.

7.2. PROBABILITY PLOT TECHNIQUE:

The technique by which the probability paper can be used in solving bimodal and polymodal frequency distributions has been described by Harding (1949) and has been revised and improved later by Cassie (1954) by eliminating much of the difficulties encountered in the original work.

In a fish with a single restricted spawning season the modal length of a size group is usually taken to be yearly in nature. The probability plot technique helps to separate the theoretical normal curves from the polymodal frequency distributions. This technique was found to be very helpful in getting a higher degree of accuracy in sorting out the different size groups, resulting from the contributions of various broods. By using this method many of the overlaping flanks could be easily detected, thereby giving a wider range of points for fitting a curve.

The diagnosis of the points of inflexion in the cumulative percentage curve is the vital part of this method. In several cases the limits of the component groups were not distinct. The inaccurate fixing of the points of inflexion might result in the non-linear distribution of points representing the particular normal curve in the probability plot. A fairly accurate choice of points of inflexion was possible to certain extent by trial and error. Thus, in this method, once the correct points of inflexion have been determined, the rest of the process becomes easy and mechanical.

This method has been found to be very effective in sorting out the length at age of Dussumieria acuta which was observed as having a single but extended spawning season from March to September. Hence it may be possible to assign the modal lengths of different size groups to those of yearly modes representing the length at different ages.

In the present study two years' data from April 1969 to March 1971, were used for the purpose and graphs were drawn separately for each year. The length frequency data were pooled year-wise and the cumulative percentage frequencies were calculated (Tables 83 & 84) and ploted in arithmetic probability paper for each year separately. On the curves thus obtained points of inflexion were noted and the modal values were calculated and fitted. (Pl. XV, Figs. 1 & 2).

In the year 1969-70 the graph shows two points of inflexion, one at 10.00 and another at 99.97 percents (Plate XV, Fig. 1). On computation the first modal length was found at 70.50 mm and a second one at 126.4 mm. From the data on Table 83 it could be seen that the mode at 70.50 mm represents the juvenile fish collected during the months of May and June. In probability plot technique, for a fish with a single spawning season in a year the modes are of yearly in nature. In the present data since the spawning season of D. acuta is from March to September, the mode at 70.50 mm appeared in May-June months can not be considered as 1-year old. So it has to be treated as juvenile mode. Further it could be stated that the formation of this mode may be the result of the appearance of small-sized fish during May-June months especially in the shore-seine catch. The second mode at 126.4 mm gives the length of fish when it is 1-year old.

Similarly in the year 1970-71 the points of inflexions are at 2.75 and 99.99 percents (Pl. XV, Fig. 2). Here the estimated modal values were found to be 76.7 mm and 129.6 mm which represent the juvenile mode and 1-year old fish respectively.

PLATE XV

Fig. 1 & 2 Probability plot of the length-frequency distribution (cumulative percentage) of D. acuta with its theoretical normal curve components for two years, April 1969 to March 1970 (Fig.1) and April 1970 to March 1971 (Fig.2).

Fig. 3 Ford-Walford plot of the growth of D. acuta.

Fig. 4 $\log_e (L\infty - L_t)$ plotted against age 't' for the estimation of 't_0'.

Fig. 5 Calculated growth rate and growth increment (in length) of D. acuta in quarter years as estimated by von Bertalanffy's equation.

Fig. 6 Calculated growth in weight and increment at ages of D. acuta in quarter years.

Fig. 7 Relation between otolith length and total length of D. acuta, points represent observed values.

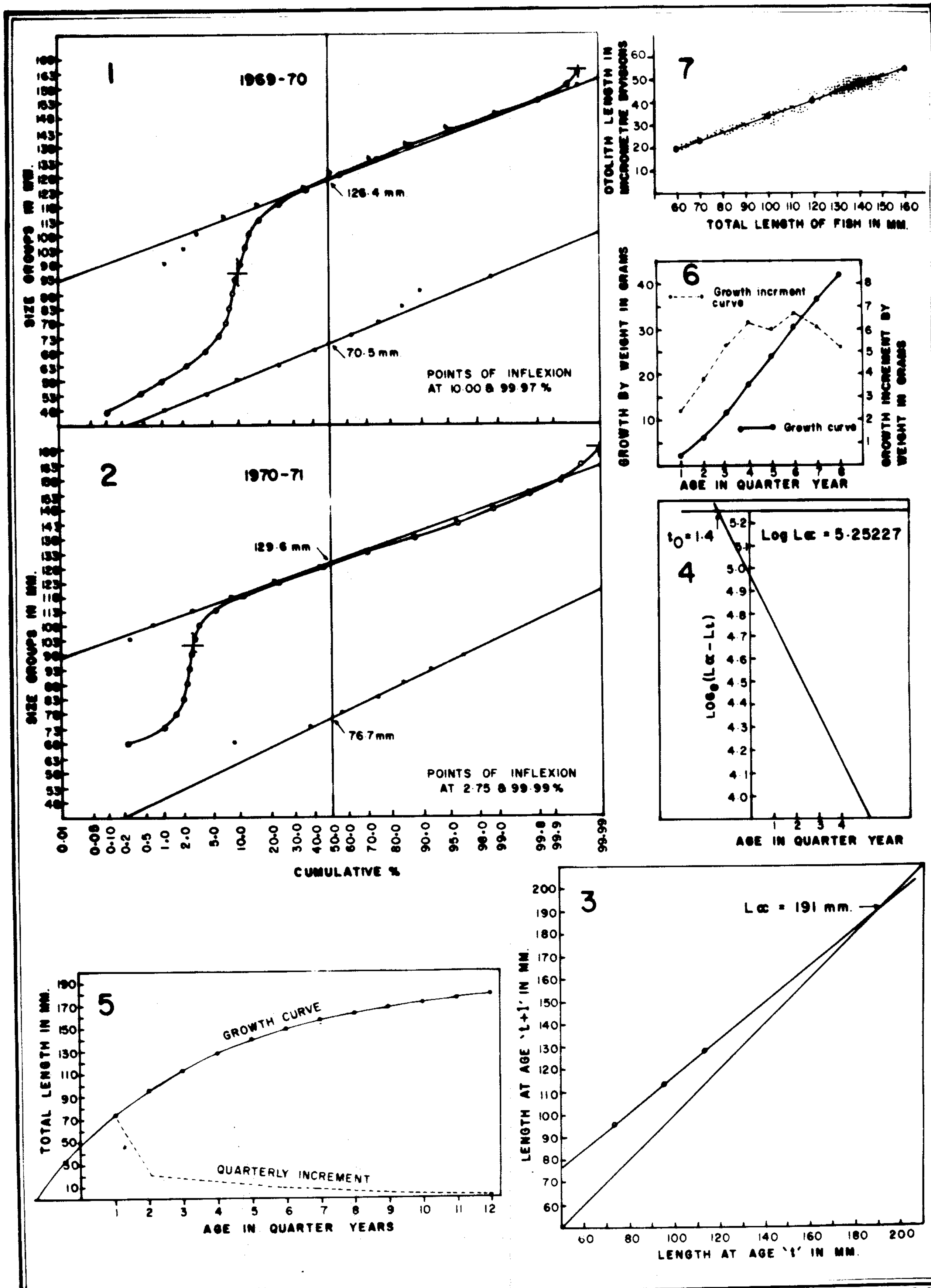

1
1969-70
126·4 mm
70·5 mm
POINTS OF INFLEXION
AT 10·00 & 99·97 %
SIZE GROUPS IN MM.
2
1970-71
129·6 mm
76·7mm
POINTS OF INFLEXION
AT 2·75 & 99·99 %
SIZE GROUPS IN MM.
CUMULATIVE %
7
OTOLITH LENGTH IN MICROMETRE DIVISIONS
TOTAL LENGTH OF FISH IN MM.
6
Growth incrment curve
Growth curve
GROWTH BY WEIGHT IN GRAMS
GROWTH INCREMENT BY WEIGHT IN GRAMS
AGE IN QUARTER YEAR
4
t_0 = 1·4
Log L∝ = 5·25227
$Log_e(L\infty - Lt)$
AGE IN QUARTER YEAR
3
L∝ = 191 mm.
LENGTH AT AGE 't+1' IN MM.
LENGTH AT AGE 't' IN MM.
5
GROWTH CURVE
QUARTERLY INCREMENT
TOTAL LENGTH IN MM.
AGE IN QUARTER YEARS

PLATE.XV

From the above results it can be noticed that the modal sizes in different ages in different years are more or less same. The average values of these two years indicate that *D. acuta* attains a size of 128 mm when it is 1-year old. This shows perfect co-relation with the results obtained by length frequency analysis.

7.3. EXAMINATION OF OTOLITHS:

The otoliths collected from 230 fish were examined to study the growth rings. In some specimens eventhough one or two rings could be observed, they could not be correlated with the length of the fish. Further the rings observed were neither very clear nor continuous. The calculations based on the radius of the rings did not show any agreement with the growth rate obtained by length frequency analysis and probability plot technique. Hence it was concluded that the otoliths of *D. acuta* were not helpful in ascertaining its age.

7.3.1. The relationship between the otolith length and the fish length:

The relationship between the length of fish and its skeletal structures like otoliths and scales have been established by various workers and they have been found to differ from fish to fish. Fairbridge (1951) stated that with regard to the scales the problem becomes a bit complicated because, till the fish reaches certain length the scales do not develop simultaneously, and their subsequent growth in proportion to the fish is also different in different parts of the body. To some extent the study of otolith is simpler.

The otolith of the fish was removed carefully and its length measured in micrometer divisions using an occular micrometer. The total length of the fish in millimeter and the length of otolith in micrometer divisions are graphically ploted in Plate XV, Fig.7. A total of 230 fish ranging in size between 60 and 157 mm were subjected to this study. A straight line relationship was noticed between these two parameters. A regression was fitted using the formula $y = a + bX$, where Y = fish length; X = otolith length and 'a' and 'b' two constants. The values of the constants were estimated as 'a' = -2.3745 and 'b' = 0.3553. Substituting these values the equation can be rewritten as $Y = -2.3745 + 0.3553\ X$. From the above Fig. it may be noticed that the otolith grows in straight proportion to the length of the fish with out showing any marked variation in the growth of otoliths between younger or the older fish.

The attempt made to study the scale length in relation to the fish length in *P. acuta* was not successful due to the fact that the scales of this fish are highly deciduous and hence a systematic collection from a particular part of its body was rather impossible.

7.4. EMPIRICAL GROWTH CURVE - FITTING OF VON BERTALANFFY'S GROWTH EQUATION:

Mathematical expression in fitting growth curves is helpful in interpolation and extrapolation, besides their utility in production computations (Pantalu, 1962; Kamal, 1969). Based on the concept that growth is the net result of anabolism and catabolism, von Bertalanffy (1938) formulated a growth equation which, according to Beverton (1954) and Beverton and Holt (1957), produces a growth curve in length that fits well the growth rate of many species. This equation gives a linear relationship between length at time 't' and at time 't + x' and is expressed as:

$$L_t = L\infty(1 - e^{-k(t - t_0)}) \quad \ldots \quad (1)$$

where L_t = length at age 't'; $L\infty$ = maximum or asymptotic length a fish can theoretically reach; e = base of the naperian or natural logarithm; k = coefficient of catabolism; 't'= age of fish and 't_0' = arbitrary origin of the growth curve.

7.4.1. Estimation of the growth parameters:

Two different methods are in use to estimate the growth parameters mentioned in equation 1 viz. Arithmetic method and Graphic method.

7.4.1.1 Arithmetic method: von Bertalanffy's growth equation can be rewritten in the following form:

$$L_t + 1 = L\infty\ (1 - e^{-k}) + L_t\ e^{-k} \quad \ldots \quad (2)$$

this is a linear equation in terms of $L_t + 1$ and which Bagenal (1955a, 1955b) used to study the growth of Rough dab. This is the same as

$$L_t + 1 = a + b\ L_t \qquad \ldots \qquad \ldots \qquad (3)$$

in which $a = L\infty\ (1 - e^{-k})$ ... .. (4)

and $b = e^{-k}$ ... ... (5)

The constants $L\infty$ and e^{-k} can be solved by applying the least square method (Snedecor, 1946) as shown below; for the following values of L_t and $L_t + 1$ in the age length data of *D. acuta*. Since *D. acuta* is a small fish living for a short period and the age traceable was only upto 1-year, the length it attained in each quarter, obtained by length frequency method was utilized in this study. The time 't' is expressed in quarters:

L_t	$L_t + 1$
73	95.5
95.5	113
113	128

The estimated values of 'b' and 'a' are 'b' = 0.81025 and 'a' = 36.1396.

$$b = e^{-k} = 0.81025 = 0.8103$$

Substituting the values of e^{-k} and 'a' in equation 4 we have

$$36.1396 = L\infty\ (\ 1 - 0.8103\ ) \quad \text{Therefore}$$

$$L\infty = \frac{36.1396}{1 - 0.8103} = \frac{36.1396}{0.1897} = 190.5092$$

that is $L\infty = 191$ mm.

The values of K can be determined from the values of e^{-k} using the formula

$$K = \log_e \frac{1}{e^{-k}} = \log_e \frac{1}{b} = \log_e \frac{1}{0.8103}$$

$$= \log_e 1.2341 = 0.20701$$

t_0 can be determined by using the formula

$$t_o = \frac{1}{K} \left\{ \log_e L\infty - \log_e (L\infty - L_t) \right\} - t \quad \ldots (6)$$

Based on the formula the average value of t_0 calculated for different ages was found to be $t_0 = 1.34$ quarters (Table 86).

Thus the length equation 1, when the values for $L\infty$, K, and t_0 are substituted, becomes

$$L_t = 191 \left\{ 1 - e^{-0.20701(t - (-1.34))} \right\} \quad \ldots \quad (7)$$

TABLE 86

AGE LENGTH DATA: VALUES OF 't_0' AT DIFFERENT AGES

Age 't' in quarters	Length in mm. L_t	$L\infty - L_t$	$\log_e(L\infty - L_t)$	$\log_e L\infty - \log_e(L\infty - L_t)$	$-t_0$
1	73	118.0	4.77068	0.48162	-1.33
2	95.5	95.5	4.55913	0.69314	-1.35
3	113	78.0	4.35671	0.89556	-1.33
4	128	63.0	4.14313	1.10914	-1.36
				Average t_0 =	-1.34

7.4.1.2 Graphical method: The parameters of the growth equation 1 may also be obtained graphically by the method developed by Ford (1933) and Walford (1946) by ploting $L_t + 1$ against L_t (Pl. XV, Fig. 3). The point of interception of the growth line by the bisector gave the value of $L\infty$ as 191 mm. The slope of the growth line is equal to e^{-k} of equation 1, from which K was found to be 0.20701. When the values of $\log_e(L\infty - L_t)$ are plotted against the corresponding ages, a straight line was obtained (Pl. XV, Fig.4) whose Y intercept is equal to $\log_e L\infty - K\ t_0$ which, in this case, was found to be 4.97.

According to the formula of Ricker (1958)

$$t_0 = \frac{(\log_e L\infty + K\, t_0) - \log_e L\infty}{K}$$

Substituting the values to the formula

$t_0 = \frac{4.97 - 5.25}{0.20701} = -1.35$. The t_0 can also be read directly from the graph, where the straight line joins the line drawn the $\log_e L\infty$. In the present case it is -1.4. The direct value is almost the same as derived from Ricker's formula. Thus the equation 1 can be rewritten as:

$$L_t = 191 \left\{ 1 - e^{-0.20701(t - (-1.35))} \right\} \quad \ldots \quad (8)$$

which is almost the same as formula 7 derived by arithmetic method.

Using the equation 7 the theoretical values of L for given ages (in quarters of year) of D. acuta were calculated and presented in Table 87. These values are also presented in Plate XV, Fig. 5 along with the quarterly growth increment. Here the theoretical growth upto 12th quarter (3 years) old fish has been calculated. It may be seen that the fish grows to 128.05 mm when the fish is 1-year old. This is perfectly in correlation with the observed value. At the end of 2nd year it grows to a length of 163.28 mm and at the end of 3rd year to a length of 178.91 mm.

TABLE 87

FIT OF VON BERTALANFFY'S EQUATION TO LENGTH AT AGE DATA FOR <u>DUSSUMIERIA ACUTA</u>

Age in quarters of year	$t - t_0$	$-k(t - t_0)$	$e^{-k(t-t_0)}$	$1-e^{-k(t-t_0)}$	Theoretical length $L_\infty(1-e^{-k(t-t_0)})$	Quarterly growth increment	Observed length in mm
1	2.34	0.4844	0.618783	0.381217	72.81	72.81	73
2	3.34	0.6941	0.501576	0.498424	95.20	22.39	95.5
3	4.34	0.8984	0.406570	0.593430	113.35	18.15	113
4	5.34	1.1054	0.329559	0.670441	128.05	14.70	128
5	6.34	1.3124	0.269820	0.730180	139.46	11.41	
6	7.34	1.5195	0.218712	0.781288	149.23	9.77	
7	8.34	1.7265	0.177284	0.822716	157.14	8.91	
8	9.34	1.9335	0.145148	0.854852	163.28	6.14	
9	10.34	2.1405	0.117655	0.882345	168.53	5.25	
10	11.34	2.3475	0.095369	0.904631	172.78	4.25	
11	12.34	2.5545	0.078082	0.921918	176.09	3.31	
12	13.34	2.7615	0.063292	0.936708	178.91	2.82	

7.5. AGE COMPOSITION OF D. ACUTA IN THE COMMERCIAL CATCH

An accurate knowledge of the age composition of commercial catches for successive years will help in the management of a fishery and in predicting the success or failure of the fisheries in the forthcoming years.

Fairbridge (1952) had suggested a method for calculating the age composition of flat head in the commercial catch. Following this the age composition of *Dussumieria acuta* in commercial catch was studied. This method involves a number of calculations as described in the following lines.

1. Month-wise length frequency distribution was worked out with 5 mm class intervals.
2. From the knowledge of age obtained by fitting von Bertalanffy's growth equation to the length frequency method, the frequencies at each 5 mm group were divided into their age-groups.
3. The mean weight of each 5 mm size group was calculated from the observed weight.
4. The frequencies in each 5 mm size group were multiplied across by corresponding weights and these products were summed up for each age-group. The summed products for each age-group added together gave the total for the month.
5. The proportion of this to the total weight was calculated for each age-group.

6. The monthly total landing of *D. acuta* obtained from particular type of gear was distributed in the same proportion amongst different age-groups.

7. Dividing the calculated weight by the observed total weight for each age-group and then multiplying it by the number of fish in that age-group, the actual number of fish belonging to that age-group in the commercial catch was calculated.

8. Summing up of these calculated weights and numbers in each age-group for twelve months gave the total for the year.

In the present study on *D. acuta* the total catches for different types of gears namely shore-seine, gill net and trawl net were treated separately to know the variation in the age-group composition in different gears. Calculations for the month of April 1970 for shore-seine catch was carried out as an example on the above mentioned lines and presented in Table 88. In a similar manner the complete data were analysed gear-wise and month-wise for the period of the two years from April 1969 to March 1971.

7.5.1. Age composition of *D. acuta* in different gears.

7.5.1.1. Shore-seine catch: The age composition of *D. acuta* in the commercial catch estimated in terms of weight and number of fish landed in shore-seine in and around Mandapam area at Vedalai, Pudumadam, Dhargavalasai and Panaikulam for a period of two years from April 1969 to March 1971 are presented in Tables 89 and 90.

The data for the period from April 1969 to March 1970 (Table 89) shows that 0-year group fish was not represented in April and was present in all other months. It dominated over all other age groups during June and September. The maximum number of fish in this age group was noticed in February 1970 and the minimum in July 1970. Their respective number and weights were 25501 fish weighing 354.25 kg in February and 4832 fish weighing 60.26 kg in July. The number of 1-year group fish was dominant in the shore-seine catch in all the months except in June and September. A maximum of 47776 fish weighing 1036.12 kg. were observed in October. The minimum was in June having 1971 fish weighing 42.66 kg. 2-year group fish was very few in the commercial catch. It was noticed in stray numbers only in January 1970 having 100 fish weighing 4.19 kg. The pooled data for the year 1969-70 shows that (Table 89) out of 394533 fish landed 132200 fish belonged to 0-year group, 262233 numbers belonged to 1-year group and 100 fish to 2-year group. This indicates that 66.47% of the total number of fish landed were of 1-year group. The percentage of 2-year group was very meagre being 0.02 and the rest belonged to 0-year group (33.51%).

TABLE 88

AGE COMPOSITION OF DUSSUMIERIA ACUTA BY WEIGHT AND NUMBER OF INDIVIDUALS FOR APRIL 1970 IN THE CATCH BY SHORE-SEINE

Age groups	Size groups in mm.	Frequency	Mean weight in gms.	Weight for each size group in gms	Sum of Wt. for year group	% of sum of Wt. in the total	Wt. in the total landings in gms	Calculated number of fish
0	101-105	1	8.04	8.04	716.73	7.18	108275	7704
	106-110	4	9.69	38.76				
	111-115	2	11.39	22.78				
	116-120	14	13.27	185.75				
	121-125	30	15.38	461.40				
1	126-130	77	17.71	1363.67	9182.26	91.94	1386455	60095
	131-135	102	20.31	2071.62				
	136-140	97	23.14	2244.58				
	141-145	64	26.25	1680.00				
	146-150	35	29.67	1038.45				
	151-155	19	33.38	634.22				
	156-160	4	37.43	149.72				
2	161-165	1	41.79	41.79	88.30	0.88	13270	301
	166-170	1	46.51	46.51				
Total					9987.29		1508000	68100

TABLE 89

AGE COMPOSITION OF DUSSUMIERIA ACUTA BY WEIGHT AND NUMBER IN SHORE-SEINE FROM APRIL 1969 TO MARCH 1970

Months	AGE GROUPS					
	0-year		1-year		2-year	
	Weight in Kg.	Calculated No.	Weight in Kg.	Calculated No.	Weight in Kg.	Calculated No.
April	—	—	250.00	10391	—	—
May	18.30	5122	180.20	7394	—	—
June	107.34	22776	42.66	1971	—	—
July	60.26	4832	209.74	9069	—	—
August	167.94	13548	372.06	16933	—	—
September	239.51	16427	267.49	12850	—	—
October	157.89	11942	1030.12	47776	—	—
November	148.63	11323	977.34	46899	—	—
December	146.51	9485	312.49	15397	—	—
January	81.44	5978	251.88	12056	4.19	100
February	354.25	25501	735.75	36315	—	—
March	70.33	5266	962.47	45182	—	—
Total	1552.40	132200	5592.20	262233	4.19	100

TABLE 90

AGE COMPOSITION OF DUSSUMIERIA ACUTA BY WEIGHT AND NUMBER IN SHORE-SEINE FROM APRIL 1970 TO MARCH 1971

Months	AGE GROUPS					
	0-Year		1-Year		2-Year	
	Weight in Kg.	Calculated No.	Weight in Kg.	Calculated No.	Weight in Kg.	Calculated No.
April	108.28	7704	1386.46	60095	13.27	301
May	38.27	6447	434.34	20537	—	—
June	26.33	2506	183.17	8819	—	—
July	47.86	3528	330.15	15626	—	—
August	108.60	7620	397.70	19284	—	—
September	376.58	26885	728.42	34017	—	—
October	224.00	15813	340.51	16399	—	—
November	284.51	19697	872.49	43019	—	—
December	221.55	14801	1410.62	65809	13.83	331
January	20.92	1483	330.08	14009	—	—
February	48.87	5240	625.14	28963	—	—
March	5.32	385	335.68	19911	—	—
Total	1511.09	112109	7374.76	346488	27.10	632

During the 2nd year from April 1970 to March 1971 the data show that (Table 90) the 0-year group occured in the catch in all the months. The maximum number of this group was noticed in September, being 26885 fish and the minimum in March, being 385 fish. In these months the fish weighed 376.58 kg and 5.32 kg, respectively. The 1-year group fish yielded a maximum number of 65809 in December and a minimum of 8819 fish in June, and the corresponding weights were 1410.62 kg and 183.17 kg respectively. The 2-year group fish were present in the catch only in April and December 1969. Their values were 301 fish weighing 13.27 kg in April and 331 fish weighing 13.83 kg. in December. When pooled together for the year, the number of fish in different age groups were 112109 fish in 0-year group, 346488 fish in 1-year group and 632 fish in 2-year group. Their respective weights were 1511.09 kg. 7374.76 kg and 27.10 kg (Table 90). It may be noticed that during the second year also the main shore-seine fishery was dependant on fish belonging to 1-year group which formed 75.45% of the total number of fish (459229) landed in this year. 0-year group and 2-year group formed only 24.41% and 0.14% respectively.

7.5.1.2. Gill net catch:

Dussumieria acuta was landed by gill net around Mandapam area at Vedalai and Kilakkarai on the Gulf of Mannar side. The operation of this gear was regular in these centres. Except for January and February 1970, D. acuta caught in gill nets was available in all other months during the period from April 1969 to March 1971. The results of the analysis are presented in Tables 91 and 92.

During the year 1969-70 (Table 91) 0-year group was present in varying numbers ranging from a minimum of 18 fish in April 1969 to a maximum of 6280 fish in October 1969. Their respective weights were 0.28 and 91.67 kg. The 1-year group had the maximum number of 15478 fish having a total weight of 346.64 kg in September and a minimum of 2250 fish weighing 46.79 kg in December. The 2-year group fish was not found in the catch during this year. Out of 102076 fish landed during the 1969-70, 79815 fish forming 78.19% belonged to 1-year group and 0-year group formed 21.81%.

During the subsequent year from April 1970 to March 1971 (Table 92) gill net catch of D. acuta was available in all the months. Fish belonging to 0-year group was absent in April. The maximum number noticed in this group was 6479 fish in September 1970 with a weight of 99.05 kg as the minimum was 546 fish weighing 8.33 kg in January 1971. The number of 1-year group fish ranged from a minimum of 2585 fish weighing 53.67 kg in January 1971 to a maximum of 20288 fish

TABLE 91

AGE COMPOSITION OF DUSSUMIERIA ACUTA BY WEIGHT AND NUMBER IN GILL NET FROM APRIL 1969 TO MARCH 1970

Months	AGE GROUPS					
	0-year		1-year		2-year	
	Weight in kg.	Calcu-lated No.	Weight in kg.	Calcu-lated No.	Weight in kg.	Calcu-lated No.
April	0.28	18	59.72	2442	--	--
May	0.44	28	82.16	3214	--	--
June	5.84	624	78.16	3274	--	--
July	29.04	2094	180.96	7595	--	--
August	45.92	3113	284.68	12543	--	--
September	53.36	3658	346.64	15478	--	--
October	91.67	6280	291.73	14385	--	--
November	36.95	2470	213.05	10379	--	--
December	15.22	1044	46.79	2250	--	--
January	No catch					
February	No catch					
March	43.70	2929	163.30	8255	--	--
Total:	322.42	22261	1747.19	79815	--	--

TABLE 92

AGE COMPOSITION OF DUSSUMIERIA ACUTA BY WEIGHT AND NUMBER IN GILL NET FROM APRIL 1970 TO MARCH 1971

Months	AGE GROUPS					
	0-year		1-year		2-year	
	Weight in kg.	Calculated No.	Weight in kg.	Calculated No.	Weight in kg.	Calculated No.
April	—	—	90.00	3591	—	—
May	8.68	564	115.32	5585	—	—
June	15.64	1323	98.36	4727	—	—
July	75.40	5680	110.60	5334	—	—
August	33.55	2195	96.75	4790	—	—
September	99.05	6479	350.96	16901	—	—
October	88.65	5795	211.05	10923	—	—
November	53.84	3667	216.16	10779	—	—
December	40.92	2728	424.08	20288	—	—
January	8.33	546	53.67	2585	—	—
February	66.66	4545	269.34	13434	—	—
March	16.64	1082	231.36	10932	—	—
Total	507.36	34604	2267.65	109869	—	—

weighing 424.08 kg in December 1970. 2-year group fish was completely absent during this year also. It is evident from Table 92 that during this year also fish belonging to 1-year group dominated in the gill net catches. The total number of fish landed was 144473, out of which 0-year group formed 23.95% and 1-year group formed 76.05%.

7.5.1.3 Trawl net Catch:

The age composition of *D. acuta* in the trawl catches at Mandapam was also studied and the results are presented in Tables 93 and 94. Though the trawling operations at Mandapam was regular round the year, the data on the landings of *D. acuta* were available only for a period of 7 months during the year 1969-70; in April, June to August and December 1969 and January and February 1970. Of this 0-year group was available in all these months and the maximum number was 22476 fish observed in July and the minimum was 987 fish observed in April. Their values by weight were 265.79 and 12.73 kg respectively. This year-group dominated in the catch in all the months except in April when 1-year group gominated. The 1-year group ranged from a minimum of 3202 fish in August to a maximum of 13146 fish in January. Their respective weights were 70.15 and 270.55 kg. 2-year group fish was completely absent. It may be noticed that a total

TABLE 93

AGE COMPOSITION OF DUSSUMIERIA ACUTA BY WEIGHT AND NUMBER IN TRAWL NET FROM APRIL 1969 TO MARCH 1970.

Months	AGE GROUPS					
	0-year		1-year		2-year	
	Weight in kg.	Calculated No.	Weight in kg.	Calculated No.	Weight in kg.	Calculated No.
April	12.73	987	197.27	9950	—	—
May	No catch					
June	162.97	16452	242.03	11388	—	—
July	265.79	22476	124.22	5993	—	—
August	239.85	20286	70.15	3202	—	—
September	No catch					
October	No catch					
November	No catch					
December	222.74	15945	242.27	11623	—	—
January	246.16	17957	270.55	13146	—	—
February	159.53	11740	64.47	3425	—	—
March	No catch					
Total	1309.77	105843	1210.96	58727	—	—

TABLE 94

AGE COMPOSITION OF DUSUMIERIA ACUTA BY WEIGHT AND NUMBER IN TRAWL NET FROM APRIL 1970 TO MARCH 1971.

Months	AGE GROUPS					
	0-year		1-year		2-year	
	Weight in kg.	Calculated No.	Weight in kg.	Calculated No.	Weight in kg.	Calculated No.
April			No catch			
May			No catch			
June	56.10	4234	273.90	14287	--	--
July			No catch			
August			No catch			
September			No catch			
October			No catch			
November	15.48	1007	884.52	42320	--	--
December	136.68	9865	571.12	26972	--	--
January	39.88	2629	952.12	45722	--	--
February	45.65	2968	374.35	18233	--	--
March			No catch			
Total	293.79	20703	3056.01	147534	--	--

of 164570 fish weighing 2520.71 kg was landed in trawl nets during the first year of which 64.31% belonged to 0-year group and 35.69% to 1-year group.

During the subsequent year from April 1970 to March 1971 (Table 94) trawl catch of D. acuta was available only for 5 months in June, November and December 1970 and January and February 1971. The 0-year group fish was noticed in all these months. The maximum number in this group was noticed in December, being 9865 fish with a weight of 136.68 kg. The minimum was 1007 fish observed in November weighing a total of 15.48 kg. The 1-year grouped ranged from a minimum of 14287 fish in June to a maximum of 45722 fish in January. Their weights were 273.90 and 952.12 kg respectively. This year-group dominated in the catch in all the months. The 2-year group fish was completely absent. During this year out of a a total of 168237 fish landed 12.31% belonged to 0-year group as against 64.31% during the first year period, and 87.69% belonged to 1-year group as against 35.69% in the first year. It shows that in the trawl catches during the first year 0-year group dominated in the catch but in the subsequent year it was 1-year group that dominated.

7.5.2. Month-wise comparison of the age-group composition of commercial catch from different types of gears:

A comparative study of the age-group composition of D. acuta landed by the different gears, viz., shore-seine, gill net and trawl net, in different month was made. The percentage number of fish in various age-groups was estimated month-wise for the period from April 1969 to March 1971 and the results presented in Plate XVI, Figs. 1 and 2, and Table 95 and 96.

During the year 1969-70, in April the pattern of age-group curve was almost same in gill net and trawl net with the domination of the 1-year group. In shore-seine 100% catch belonged to 1-year group. In gill net and trawl net 99.2% and 91.0% respectively were of 1-year group and 0.7% formed 0-year group in gill net catch. In trawl net 9.0% belonged to 0-year group. In May 1969 no trawl samples were available and in gill net 99.1% belonged to 1-year group and 0.9% to 0-year group where as in the shore-seine catch 59.1% were 1-year group and 40.9% 0-year group. During June, 1969, in shore-seine and trawl net the 0-year group dominated being 92.0% and 59.1%, respectively while in gill net 84.0% belonged to 1-year group. In shore-seine the domination of the 0-year group over 1-year group was predominant where as in trawl net the difference between these age-groups was very little. 2-year group fish was not present in any of these gears in this month. July showed almost similar pattern in the case of shore-seine and gill net with a domination of the 1-year group fish, but in the trawl catch 78.9% belonged to 0-year group and the rest to 1-year group. In August the dominative

TABLE 95

A COMPARISON OF THE MONTHLY AGE-GROUP COMPOSITION OF DUSSUMIERIA ACUTA (IN PERCENTAGE OF THE NUMBER OF FISH) IN DIFFERENT GEARS FOR 1969-70

Months	Shore-seine			Gill net			Trawl net		
	0-year	1-year	2-year	0-year	1-year	2-year	0-year	1-year	2-year
April	—	100.0	—	0.7	99.2	—	9.0	91.0	—
May	40.9	59.1	—	0.9	99.1	—	No catch		
June	92.0	8.0	—	16.0	84.0	—	59.1	40.9	—
July	34.8	65.2	—	21.6	78.4	—	78.9	21.1	—
August	44.5	55.5	—	19.9	80.1	—	86.4	13.6	—
September	56.1	43.9	—	19.1	80.9	—	No catch		
October	20.0	80.0	—	30.4	69.6	—	No catch		
November	19.5	80.5	—	19.2	80.8	—	No catch		
December	38.1	61.9	—	31.7	68.3	—	57.8	42.2	—
January	33.0	66.5	0.5	No catch			57.7	42.3	—
February	41.3	58.7	—	No catch			77.4	22.6	—
March	10.4	89.6	—	26.2	73.8	—	No catch		

TABLE 96

A COMPARISON OF THE MONTHLY AGE-GROUP COMPOSITION OF DUSSUMIERIA ACUTA (IN PERCENTAGE OF THE NUMBER OF FISH) IN DIFFERENT GEARS FOR 1970-71

Months	Shore-seine			Gill net			Trawl net		
	0-year	1-year	2-year	0-year	1-year	2-year	0-year	1-year	2-year
April	11.3	87.4	1.3	—	100.0	—		No catch	
May	23.9	76.1	—	9.2	90.8	—		No catch	
June	22.1	77.9	—	21.7	78.3	—	22.9	77.1	—
July	18.4	81.6	—	51.6	48.4	—		No catch	
August	28.3	71.7	—	31.4	68.6	—		No catch	
September	44.1	55.9	—	27.7	72.3	—		No catch	
October	49.1	56.9	—	34.7	65.3	—		No catch	
November	31.4	68.6	—	25.4	74.6	—	19.2	80.8	—
December	18.3	81.3	0.4	11.9	88.1	—	26.8	73.2	—
January	9.6	90.4	—	17.4	82.6	—	5.4	94.6	—
February	15.3	84.7	—	25.3	74.7	—	14.0	86.0	—
March	2.4	97.6	—	9.0	91.0	—		No catch	

difference of the 1-year group over 0-year group in shore-seine was only 11.0%, their values being 55.5%, and 44.5% respectively. In gill net catch 80.1% fish were of 1 year group and 19.9% of 0-year group. On the contrary, in trawl catch 86.4% belonged to 0-year group and the rest to 1-year group. During September trawl data was not available. In the other two geare 0-year group fish dominated in shore-seine occurring 56.1%, the rest were 1-year group and in gill net 1-year group dominated, being 80.9%. The rest, 19.1% formed 0-year group. In October also trawl data was lacking and both in shore-seine and gill net the 1-year group dominated over 0-year group. The pattern of age composition in shore-seine and gill net was exactly the same in November 1969 with the domination of the 1-year group which formed 81% in both gears. Trawl data was not available. Similarly in December 1969 also 1-year group dominated in shore-seine and gill net catches, the ratio being 61.9% in shore seine and 69.3% in gill net and the rest formed 0-year group. But the trawl catch presented an entirely different picture where the 0-year group forming 57.8% dominated over the 1-year group which formed only 42.2%. In January 1970 gill net data was not available. In shore seine the 1-year group which formed 66.5% dominated over the 33.0% of 0-year group and 0.5% of 2-year group fish. In the trawl catch 57.7% 0-year group and 42.3% 1-year group were observed. In February also gill net data was absent and

PLATE XVI

Figs.1 & 2 Age-group composition of D.acuta in the commercial catch of Mandapam area during the years April 1969 to March 1970 (Fig.1) and April 1970 to March 1971 (Fig.2).

Fig. 3 Length-weight relationship of D. acuta - observed values of length and weight.

Fig. 4 Length-weight relationship of D. acuta - Logarithmic values of length and weight.

Fig. 5 Length-weight relationship of D. hasseltii - observed values of length and weight.

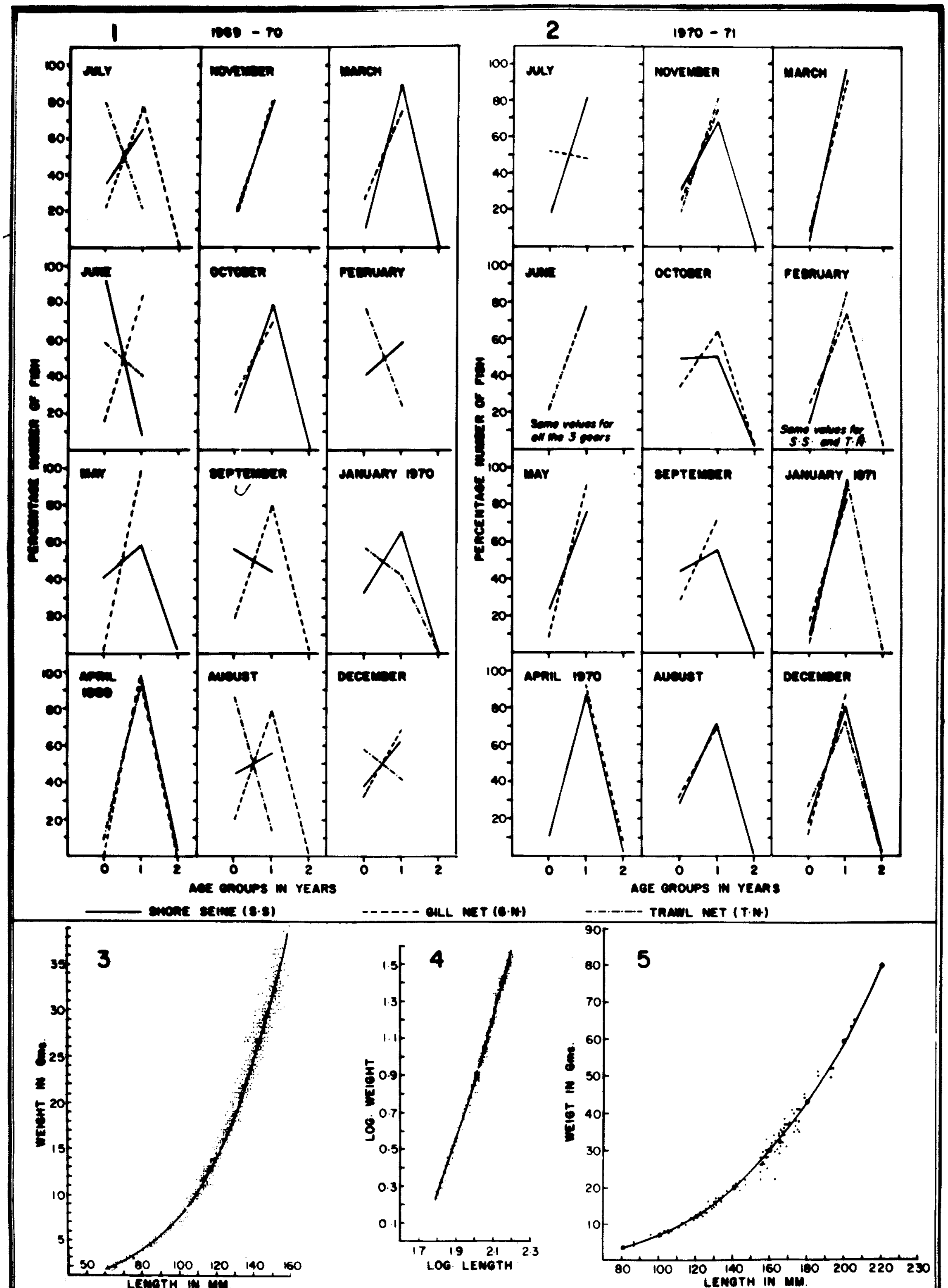

1
1969 - 70
2
1970 - 71
JULY
NOVEMBER
MARCH
JUNE
OCTOBER
FEBRUARY
MAY
SEPTEMBER
JANUARY 1970
JANUARY 1971
APRIL 1969
APRIL 1970
AUGUST
DECEMBER
Same values for all the 3 gears
Same values for S·S· and T·N·
PERCENTAGE NUMBER OF FISH
AGE GROUPS IN YEARS
SHORE SEINE (S·S)
GILL NET (G·N)
TRAWL NET (T·N)
3
WEIGHT IN Gms.
LENGTH IN MM.
4
LOG. WEIGHT
LOG. LENGTH
5
WEIGT IN Gms.
LENGTH IN MM.

PLATE. X VI

in the shore seine catch 1-year group dominated forming 58.7% and in trawl net 0-year group dominated forming 77.4%. 2-year group was completely absent in these two gears. In March 1970 in shore seine 89.6% fish belonged to 1-year group and 10.4% to 0-year group. In gill net the 1-year group dominated. The values were 26.2% for 0-year group and 73.8% for 1-year group. Trawl data were lacking for the month.

During the subsequent year from April 1970 to March 1971 the study was continued and the results are presented in Plate XVI, Fig. 2 and Table 96. In April 1970 trawl data was not available. In shore seine catches the 1-year group dominated over the other age groups which formed 87.4% where as in the gill net catches 100% belonged to 1-year group. In shore seine 0-year and 2-year groups reached 11.3% and 1.3% respectively. In May also data was available only for shore seine and gill net. In both these gears 2-year group was absent and the 1-year group formed the main catch being 76.1% in the case of shore seine and 90.8% in the case of gill net catches. The rest belonged to 0-year group. During June 1970, age-group pattern in the three gears were almost similar, nearly 77.9% in shore seine, 78.3% in gill net and 77.1% in Trawl net belonged to 1-year group and the rest to 0-year group. 2-year group was absent. From July 1970 to October 1970 data were available only for shore seine and gill net. In July 81.6% of the shore seine catch belonged to 1-year group and the rest to 0-year group. On the other hand in the gill net catch 0-year group and 1-year group were almost equally represented with a slight dominance of the former, being 51.6% as against 48.4% of 1-year group. The data for August 1970 showed almost similar pattern in the percentage curve of the age group composition of shore seine and gill net catches. In gill net catch 68.8% formed 1-year group and the rest were 0-year group. In shore seine 71.7% belonged to 1-year group and 28.3% to 0-year group. In September 1970 much difference was not noticed between 0-year and 1-year groups in shore seine catch. The values were 44.1% and 55.9% respectively. In the gill net catch only 27.7% were 0-year group and the rest, 72.3%, formed 1-year group. In October the 0-year and 1-year groups were almost equally represented in the shore seine catch, being 49.1% and 50.9% respectively. But in the gill net catch 65.3% formed 1-year group and 34.7% formed 0-year group. November 1970 to February 1971 catches from all the three gears were available for comparison. In November, 1-year group dominated in all the three gears presenting 68.6% in shore seine catch, 74.6% in gill net catches and 80.8% in trawl catch where as the 0-year group formed only 31.4%, 25.4% and 19.2% respectively. In December 1970 also in all the three gears the bulk of the catch belonged to the 1-year group representing 81.3% in shore seine, 88.1% in gill net and 73.2% in trawl net. 0.4% of 2-year group was noticed in shore seine catch. The rest belonged to 0-year group. During January 1971, 90.4% of the shore seine catch was of 1-year group and the rest belonged to 0-year group. In gill net and trawl nets also the trend was almost the same. 82.6% in gill net and 94.6% in trawl net belonged to 1-year group. The rest in both these gears belonged to 0-year group. In February the trend was almost the same in shore seine and trawl net, where 84.7% in shore seine and 86.0% in trawl net belonged to 1-year group and the rest to 0-year group. But among the gill net catches only 74.7% were in the 1-year group. 25.3% belonged to 0-year group. Trawl data was lacking in the month of March 1971. But in the other two gears above 90% belonged to 1-year group, 97.6% in shore seine and 91.0% in gill net. The rest formed the 0-year group.

In general it may be noticed that in the shore seine catches except for June 1969 and September 1969, when the 0-year group dominated, in all other months during a period of two years from April 1969 to March 1971 the 1-year group fish dominated in the catch. On the other hand in the gill net catch in all the 24 months 1-year group dominated in the catch without exception. Contrary to this the trawl net catch showed wide variation between the two years. In this gear during the first year period 0-year group was dominant in all months when data were available except for April 1969 when the 1-year group dominated. During the second year from April 1970 to March 1971, in all the months for which data were available, the 1-year group dominated in the catch. This phenominon may be due to the lack of adequate catch data for this gear in both the years.

7.6. GROWTH IN WEIGHT

In this study an attempt was made to evaluate the growth of D. acuta by weight in relation to growth in length at different ages. Theoretical length at age, determined by von Bertalanffy growth equation, was made use of in splitting up the sample in to their constituent age groups, since these values did not show any significant variation from the actual length at age determined by means of length frequency method. The lengths at age in different quarters of the year, roundedup to nearest mm, were taken as age and their corresponding calculated weights were estimated from the following length-weight relationship equation of the determinate group (see the Chapter on Length-weight relationship).

$$W = 0.0000006294 \; L^{3.5362} \quad \text{or}$$
$$\text{Log } W = -6.2011 + 3.5362 \text{ Log } L.$$

Likewise the calculated weight of D. acuta for length at first 8 quarters (two years) were estimated. (The total life span of

D. acuta rarely exceeds two years). The calculated weight and the quarterly growth increment in weight are given in Table 97. The data showed that the weight in grams for first to eightth quarters were 2.4, 6.2, 11.5, 17.8, 23.8, 30.5, 36.6 and 41.8 respectively.

The growth in weight in quarter after quarter and the corresponding weight increments are ploted in Plate XV, Fig.6. The weight increased steadily from 1st quarter to 8th quarter of life. But the increment curve showed that there is a steady increase upto 6th quarter of life when the length in 149 mm and thereafter the weight increment decreases steadly. It could be further noticed that the length increment decreases with age (Pl. XV, Fig.5) and contrary to the weight

TABLE 97

THE GROWTH RATE OF DUSSUMIERIA ACUTA IN WEIGHT ESTIMATED TO LENGTH AT AGE IN DIFFERENT QUARTERS OF THE YEAR

Age in quarter year	Growth attained in length mm	Calculated weight in gms	Growth increment by weight
1	73	2.4	2.4
2	95	6.2	3.8
3	113	11.5	5.3
4	128	17.8	6.3
5	139	23.8	6.0
6	149	30.5	6.7
7	157	36.6	6.1
8	163	41.8	5.2

increment increases first upto certain age and thereafter decreases (Pl. XV, Fig.6). This shows that the optimum age for exploitation of D. acuta is when the fish is 1 to 1/2 years old.

The age and growth rate of D. acuta was determined mainly by employing Peterson's method of length frequency analysis. Using this method the age and growth of the fish upto one year could be determined and thereafter the modes were not clear and identifiable in the commercial catch. The probability plot technique of Cassie (1954) was also used to determine the age and growth of D. acuta. Eventhough this method has several limitations, it gives additional evidence to corroborate the Peterson method. By the probability plot technique the growth rate upto one year could be determined and found that it gave a perfect corelation with the results obtained by Peterson method. In addition to these the von Bertalanffy's growth equation was employed to estimate the theoretical growth ~~of the fish it may attain~~ in successive years. Further the hard parts like scales and otoliths were also examined to study the growth rings and it was found that none of these parts were helpful in this study.

The age and growth of rainbow sardines, Dussumieria spp., have not been studied till now except for a brief resume by Mahadevan and Chacko (1962) in D. hasseltii. These authors were not able to trace the growth using the length frequency data. But they observed a single growth ring in the otolith of a fish measuring 130 mm. In fish less than 110 mm in size no growth ring could be observed by them. In the present study no clear rings could be observed in the otolith. Out of a large number of otoliths examined only in a very few numbers some sort of a ring like marking could be noticed which showed no correlation with the length of the respective fish. So it is assumed that these rings were false ones which could have formed due to several other reasons than those which may reflect yearly nature.

The life span of D. hasseltii has been observed by Mahadevan and Chacko (1962) as one year only by which time they spawn and perpetuate the species. The present study in D. acuta also shows that the commercial catch mainly depended on the 1-year class and 2-year class groups appear only very rarely, in very few numbers. This shows that D. acuta is a short lived species with a maximum life span of two years.

CHAPTER 8

LENGTH-WEIGHT RELATIONSHIP AND RELATIVE CONDITION FACTOR

The study of the relationship between length and weight in fishes, according to Le Cren (1951) has been mainly directed towards two objectives; namely to provide a mathematical relationship between two variables, length and weight, as a means of interconversion; and secondly, to measure the variations from the expected weight for length of individual fish or groups of fish as indications of fatness, general well being or gonad development, in short to calculate the 'condition factor'. In a species of commercial importance, the former object has been found essential to convert the catch statistics of that species from weight to numbers in order to obtain the abundance of stock in space and time (Antony Raja, 1967). Further, the relationship between length and weight in the growth of the fish is important in that the knowledge of the size at which the fish increases most rapidly in weight is of value in determining the size at which it may be usefully harvested. In the interconversion of length and weight and in the determination of 'condition factor' an important aspect to be considered is whether a single equation will suffice or separate equations are required to describe the relationship between length and weight of different sexes at various times of the year and phases of life history. In view of these practical utilities, an attempt was made to determine the length-weight relationship of rainbow sardines, the details of which are presented in the following account.

8.1. LENGTH-WEIGHT RELATIONSHIP

It is well established that the weight of a fish increases with increase in length but in a much more rapid manner, thereby showing that the weight is a function of length. Since length is a linear measure and weight a measure of volume, the weight of fishes was generally found to increase approximately as the cube of its length, as demonstrated by Hagerman (1952). This can be expressed by a hypothetical cube law $W - cL^3$, where 'W' represents the weight of fish, 'L' its length and 'c' a constant. If the form and the specific gravity of the fish remain constant throughout life such a formula can be applied to serve as the basis for the calculation of the weight of fish of known length or _vice versa_. But Le Cren (1951) has pointed out that a more general parabolic equation of the form $W = aL^n$ would serve better than the cubic formula to express the relationship between the two factors where 'W' and 'L' represent weight and length of fish respectively, 'a' a constant equivalent to 'c' and 'n' a constant to be determined from the data.

The applicability of the cube relationship of weight and length of fishes has been much discussed. If the fish does not change form or density as it grows, the weight will be proportional to the cube of any linear dimension. Allen (1938) has shown that for ideal fish which maintain constant shape n = 3. However the change in morphology due to increase in age often causes the coefficient of regression of logarithm of weight on logarithm of length to depart substantially from 3. According to Hile (1936) and Martin (1949) the value of the exponent 'n' in the parabolic equation usually lies between 2.5 and 4.0. Beverton and Holt (1957) have stated that the values of 'a' and 'b' may vary within wide limits for very similar data and are sensitive to quite unimportant variations in the latter. They further proceeded to remark that instances of important variations from isometric growth (p = 3) in adult fishes are rare. Based on his studies on the Australian barracouta, (Thyrsites atun) Blackburn (1960) has shown that the value of 'n' was considerably below 3.0. Antony Raja (1967) in a detailed study on the length-weight relationship of oil sardine, Sardinella longiceps, from Calicut region has shown that in the groups indeterminate, immature and mature the values of 'n' in the majority were between 2.5 and 3.0, although in some instances most extreme values on the lower and higher sides were significantly different from isometric growth. The constant 'a', which is calculated after 'n' is established, can be used to compare an individual with others of the same species. Since the specific gravity of the fish flesh does not vary much within a species, the values of 'a' will depend on the fatness, being high in fat fishes and low in thin fishes, (Brown, 1957). In the light of all these observations it seemed more desirable in the case of rainbow sardines to fit the general equation $W = aL^n$.

8.1.1. *Dussumieria acuta*:

The general equation $W = aL^n$ can be written as log W = log 'a' + 'n' log L, or Y = A + BX where Y = log W, A = log 'a', B = 'n' and X = log L, which is a linear relationship between Y and X. This linear equation was fitted separately to the data of indeterminate, male and female categories collected during the years, April 1969 to March 1970 and April 1970 to March 1971. The estimates of the parameters 'A' and 'B' for each of these categories for two years were obtained by the method of least squares.

In Table 98, the sum of squares and products of X and Y of all the categories for two successive years are presented and in Table 99 the corresponding corrected sum of squares and products along with estimate of the regression coefficient 'B' and the deviation from the regression for each case are presented. The length-weight relationship equation fitted for each of these categories were found to be:

Indeterminate	1969-70	W =	$0.000004876\ L^{3.0906}$
Female	1969-70	W =	$0.0000006317\ L^{3.5325}$
Male	1969-70	W =	$0.0000004469\ L^{3.6063}$
Indeterminate	1970-71	W =	$0.00001597\ L^{2.8316}$

TABLE 98

SUM OF SQUARES AND PRODUCTS OF LENGTH-WEIGHT DATA OF DIFFERENT GROUPS OF *DUSSUMIERIA ACUTA* FOR TWO YEARS

Groups	No.of fish	SX	SY	SX^2	SY^2	SXY
Indeterminate 1969-70	35	68.8792	26.9634	135.6046	21.2963	53.2238
Female 1969-70	399	846.0347	515.4353	1794.4491	672.7949	1094.7861
Male 1969-70	388	823.5622	506.3192	1748.5602	668.8769	1076.4395
Indeterminate 1970-71	26	51.9149	22.2837	103.6696	19.2009	44.5214
Female 1970-71	392	829.1048	502.6133	1754.2191	653.7676	1065.2596
Male 1970-71	394	833.2653	503.6783	1762.8710	652.5776	1076.3126

SX, SY, = Sum of X and Y; SX^2, SY^2, SXY = Sum of squares and products.

TABLE 99

CORRECTED SUM OF SQUARES AND PRODUCTS OF LENGTH-WEIGHT DATA, REGRESSION COEFFICIENT AND DEVIATION FROM REGRESSION OF DIFFERENT GROUPS OF DUSSUMIERIA ACUTA FOR TWO YEARS

Groups	D.F	Sum of squares and products			B	Errors of estimate	
		x^2	y^2	xy		d.f	S.S
Indeterminate 1969-70	34	0.0519	0.5242	0.1604	3.0906	33	0.0285
Female 1969-70	398	0.5275	6.9464	1.8634	3.5325	397	0.3639
Male 1969-70	387	0.4811	8.1575	1.7350	3.6063	386	1.9005
Indeterminate 1970-71	25	0.0095	0.1023	0.0269	2.8316	24	0.0261
Female 1970-71	391	0.6100	9.3285	2.2007	3.6077	390	1.3890
Male 1970-71	393	0.6094	8.6897	2.0901	3.4298	392	1.5211

D.F and d.f. = Degrees of freedom; x^2, y^2, xy = Corrected sum of squares and products; B = Regression coefficient; S.S = Sum of squares.

Female	1970-71	$W = 0.0000004483\ L^{3.6067}$
Male	1970-71	$W = 0.000001059\ L^{3.4298}$

The corresponding logarithmic equations may be written as:

Indeterminate	1969-70	$\log W = -5.3119 + 3.0906 \log L$
Female	1969-70	$\log W = -6.1985 + 3.5325 \log L$
Male	1969-70	$\log W = -6.3498 + 3.6063 \log L$
Indeterminate	1970-71	$\log W = -4.7968 + 2.8316 \log L$
Female	1970-71	$\log W = -6.3484 + 3.6067 \log L$
Male	1970-71	$\log W = -5.9753 + 3.4298 \log L$

The analysis of covariance was employed to test whether th regression of Y on X of these categories is significantly differen in both its slope and elevation. In Tables 100 and 101 the results of the analysis of covariance done for female and male of the year 1969-70 are given, which showed that the differences found in the slope and elevation of the regressions of these two sexes were nonsignificant and hence the data were pooled together and a common length-weight relationship equation was drawn as $W = 0.0000005298\ L^{3.5702}$ for the year 1969-70. The corresponding logarithmic equation may be written as $\log W = -6.2759 + 3.5702 \log L$. Similarly for the year 1970-71 the females and males were also tested and the regressions did not have any significant differences in their slope or elevations (Tables 102 and 103). So these two sexes of the second-year also were pooled together and a common equation was derived as $W = 0.0000006890\ L^{3.5187}$, the corresponding logarithmic form of which is $\log W = -6.1618 + 3.5187 \log L$.

Then the slopes and elevations of the regressions thus obtained by pooling the two sexes of different years were tested for significance. The results presented in Tables 104 and 105 have shown that there were no significant differences in these two regressions of Y on X between years. Therefore the entire data of both the sexes for two years were pooled and a general equation was derived as follows:

$$W = 0.0000006294\ L^{3.5362}$$

The corresponding logarithmic equation of this may be expressed as

$$\log W = -6.2011 + 3.5362 \log L.$$

Further, the indeterminate categories of the two years were tested to find whether the differences in slope and elevation of the regressions of these categories were significant or not. Tables 106 and 107 show that the regressions of the indeterminate groups of two successive years did not bear any significant differences either in their slopes or in elevations, hence the data for indeterminate fish of both the years were pooled and a single equation was derived as follows:

$$W = 0.000006037\ L^{3.0434} \quad \text{or} \quad \log W = -5.2192 + 3.0434 \log L.$$

The analysis of covariance was further employed to test whether the estimate of regression coefficients differed significantly between indeterminate (pooled for two years) and the determinate (pooled data of two sexes of two years) categories. The details are presented in Tables 108 and 109. The results obtained revealed that the slope of the regressions of these two categories differed significantly at 5% level.

The observed values of length-weight data of D. acuta collected during April 1969 to March 1971 were plotted in Plate XVI, Fig. 3. The calculated length-weight curves, using the respective formulae , were fitted for indeterminate and determinate fishes separately. Since the relationship is curvilinear, the logarithmic values of observed length and the corresponding weight were plotted in a scatter diagram in Plate XVI, Fig.4. The regressions fitted separately for indeterminate and determinate fishes indicated as straightline relationship between the two variables viz. length and weight.

While the above two, one for the pooled data of indeterminate of the two years and another for the pooled data of both the sexes of two years, hold good for the length-weight relationship of D. acuta, the significance of variation in the estimate of 'B' for these two categories from the expected values of the ideal fish (3.0) were tested by the 't' test as given by the formula $'t' = \frac{b - B}{Sb}$. The test applied to the determinate showed that $t = \frac{3.0434 - 3.0000}{0.1104} = 0.3931$ which

TABLE 100

SUM OF SQUARES AND PRODUCTS OF LENGTH-WEIGHT DATA OF FEMALES AND MALES OF DUSSUMIERIA ACUTA OF THE YEAR 1969-70

Groups	No.of fish	SX	SY	SX^2	SY^2	SXY
Female	399	846.0347	515.4353	1794.4491	672.7949	1094.7861
Male	388	823.5622	506.3192	1748.8602	668.8769	1076.4395
Peoled together	787	1669.5969	1021.7545	3543.0093	1341.6718	2171.2256

SX, SY = Sum of X and Y; SX^2, SY^2, SXY = Sum of squares and products.

TABLE 101

CORRECTED SUM OF SQUARES AND PRODUCTS, REGRESSION COEFFICIENT AND ANALYSIS OF COVARIANCE OF THE LENGTH-WEIGHT DATA OF FEMALE AND MALE OF <u>DUSSUMIERIA ACUTA</u> OF THE YEAR 1969-70

Groups	D.F.	Sx^2	Sy^2	Sxy	B	d.f	S.S.	M.S
Female	398	0.5275	6.9464	1.8634	3.5325	397	0.3639	
Male	387	0.4811	8.1575	1.7350	3.6063	386	1.9005	
						783	2.2644	0.0029
Pooled within	785	1.0086	15.1039	3.5984		784	2.2658	0.0029
	Difference between slopes					1	0.0014	0.0014
Wxb	786	1.0095	15.1378	3.6041	3.5702	785	2.2705	
	Difference between adjusted means					1	0.0047	0.0047
	1	0.0009	0.0339	0.0057				

Comparison of slopes; $F = \frac{0.0029}{0.0014} = 2.07$ (5% F = 254.3)Not significa

Comparison of elevation: $F = \frac{0.0047}{0.0029} = 1.62$ (5% F= 3.84)Not significa

D.F. and d.f = degrees of freedom; Sx^2, Sy^2, Sxy = corrected sum of squares and products; B = regression coefficient; S.S.= sum of squares; M.S. = mean square.

TABLE 102

SUM OF SQUARES AND PRODUCTS OF LENGTH-WEIGHT DATA OF FEMALES AND MALES OF *DUSSUMIERIA ACUTA* OF THE YEAR 1970-71

Groups	No. of fish	SX	SY	SX^2	SY^2	SXY
Female	392	829.1048	502.6133	1754.2191	653.7676	1065.2596
Male	394	833.2653	503.6783	1762.8710	652.5776	1067.3126
Pooled together	786	1662.3701	1006.2916	3517.0901	1306.3452	2132.5722

SX, SY = sum of X and Y; SX^2, SY^2, SXY = sum of squares and products.

TABLE 103

CORRECTED SUM OF SQUARES AND PRODUCTS, REGRESSION COEFFICIENT AND ANALYSIS OF COVARIANCE OF THE LENGTH-WEIGHT DATA OF FEMALE AND MALE OF <u>DUSSUMIERIA ACUTA</u> OF THE YEAR 1970-71

Groups	D.F	Sx^2	Sy^2	Sxy	B	d.f	S.S	M.S
Female	391	0.6100	9.3285	2.2007	3.6077	390	1.3890	
Male	393	0.6094	8.6897	2.0901	3.4298	392	1.5211	
						782	2.9101	0.0037
Pooled within	784	1.2194	18.0182	4.2908		783	2.9198	0.0037
	Difference between slopes					1	0.0097	0.0097
W x b	785	1.2195	18.0211	4.2910	3.5187	784	2.9227	
	Difference between adjusted means					1	0.0029	0.0029
	1	0.0001	0.0029	0.0002				

Comparison of slopes: $F = \frac{0.0097}{0.0037} = 2.62$ (5% f =3.84)Not significant

Comparison of elevation: $F= \frac{0.0037}{0.0029} = 1.28$ (5% F= 254.3)Not significant

D.F. and d.f = degrees of freedom; Sx^2, Sy^2, Sxy = corrected sum of squares and products; B = regression coefficient; S.S.= sum of squares; M.S. = mean square.

TABLE 104

SUM OF SQUARES AND PRODUCTS OF POOLED LENGTH-WEIGHT DATA OF TWO SEXES OF DUSSUMIERIA ACUTA FOR TWO YEARS - 1969-70 AND 1970-71

Groups	No. of fish	SX	SY	SX^2	SY^2	SXY
1969-70	787	1669.5969	1021.7545	3543.0093	1341.6718	2171.2256
1970-71	786	1662.3701	1006.2916	3517.0901	1306.3452	2132.5722
Pooled together	1573	3331.9670	2028.0461	7060.0994	2648.0170	4303.7978

SX, SY = sum of X and Y; SX^2, SY^2, SXY = sum of squares and products.

TABLE 105

CORRECTED SUM OF SQUARES AND PRODUCTS, REGRESSION COEFFICIENT AND ANALYSIS OF COVARIANCE OF THE LENGTH-WEIGHT DATA OF TWO SEXES OF DUSSUMIERIA ACUTA FOR TWO YEARS 1969-70 AND 1970-71

Groups	D.F	Sx^2	Sy^2	Sxy	B	d.f	S.S	M.S
1969-70	786	1.0095	15.1378	3.6041	3.5702	785	2.2705	
1970-71	785	1.2195	18.0211	4.2910	3.5187	784	2.9227	
						1569	5.1932	0.0033
Pooled within	1571	2.2290	33.1589	7.8951		1570	5.1945	0.0033
	Difference between slopes					1	0.0013	0.0013
W x b	1572	2.2456	33.2866	7.9410		1571	5.2052	
	Difference between adjusted means					1	0.0107	0.0107
	1	0.0166	0. 1277	0.0459				

Comparison of slopes: $F = \frac{0.0033}{0.0013} = 2.54$ (5% F =254.3). Not significant

Comparison of elevation: $F = \frac{0.0107}{0.0033} = 3.24$ (5% F = 3.84). Not significant

D.F. and d.f = degree of freedom; Sx^2, Sy^2, Sxy = corrected sum of squares and products; B = regression coefficient; S.S = sum of squares; M.S. = mean square.

TABLE 106

SUM OF SQUARES AND PRODUCTS OF LENGTH-WEIGHT DATA OF INDETERMINATE CATEGORY OF DUSSUMIERIA ACUTA FOR TWO YEARS 1969-70 AND 1970-71

Groups	No.of fish	SX	SY	SX^2	SY^2	SXY
1969-70	35	68.8792	26.9634	135.6046	21.2963	53.2238
1970-71	26	51.9149	22.2837	103.6694	19.2009	44.5214
Pooled together	61	120.7941	49.2471	239.2740	40.4972	97.7452

SX, SY = sum of X and Y; SX^2, SY^2, SXY = sum of squares and products.

TABLE 107

CORRECTED SUM OF SQUARES AND PRODUCTS, REGRESSION COEFFICIENT ANALYSIS OF COVARIANCE OF LENGTH-WEIGHT DATA OF INDETERMINATE CATEGORY OF DUSSUMIERIA ACTUA FOR TWO YEARS 1969-70 AND 1970-71

Groups	D.F	Sx^2	Sy^2	Sxy	B	d.f	S.S	M.S
1969-70	34	0.0519	0.5242	0.1604	3.0906	33	0.0285	
1970-71	25	0.0095	0.1023	0.0269	2.8316	24	0.0261	
						57	0.0546	0.0010
Pooled within	59	0.0614	0.6265	0.1873		58	0.0551	0.0010
	Difference between slopes					1	0.0005	0.0005
Wxb	60	0.0738	0.7386	0.2246		59	0.0551	
	Difference between adjusted means					1	0.0000	0.0000
	1	0.0124	0.1121	0.0375				

Comparison of slopes: $F = \frac{0.0010}{0.0005} = 2.00$ (5% F = 254.3) Not significant

Comparison of elevation: $F = \frac{0.0010}{0.0000} = 0$ (5% F = 254.3) Not significant.

D.F. and d.f = degree of freedom; Sx^2, Sy^2, Sxy = corrected sum of squares and products; B = regression coefficient; S.S. = sum of squares; M.S = mean square.

TABLE 108

SUM OF SQUARES AND PRODUCTS OF LENGTH-WEIGHT DATA OF INDETERMINATE (POOLED FOR TWO YEARS) AND DETERMINATE (ALL THE MALES AND FEMALES OF TWO YEARS POOLED TOGETHER) CATEGORIES OF DUSSUMIERIA ACUTA.

Groups	No. of fish	SX	SY	SX^2	SY^2	SXY
Indeterminate	61	120.7941	49.2471	239.7440	40.4972	97.7452
Determinate	1573	3331.9670	2028.0461	7060.0994	2648.0170	4303.7978
Pooled together	1634	3452.7611	2077.2932	7299.3734	2688.5142	4401.5430

SX, SY = sum of X and Y; SX^2, SY^2, SXY = sum of squares and products.

TABLE 109

CORRECTED SUM OF SQUARES AND PRODUCTS, REGRESSION COEFFICIENT AND ANALYSIS OF COVARIANCE OF LENGTH-WEIGHT DATA OF INDETERMINATE AND DETERMINATE CATEGORIES OF DUSSUMIERIA ACUTA

Groups	D.F	Sx^2	Sy^2	Sxy	B	d.f	S.S	M.S
Indeterminate	60	0.0738	0.7386	0.2246	3.0434	59	0.0551	
Determinate	1572	2.2456	33.2866	7.9410	3.5362	1571	5.2052	
						1630	5.2603	0.0032
Pooled within	1632	2.3194	34.0252	8.1656		1631	5.2777	0.0032
	Difference between slopes					1	0.0174	0.0174
W x b	1633	3.3480	47.6658	12.0716		1632	5.2797	
	Difference between adjusted means					1	0.0020	0.0020
	1	1.1186	13.6406	3.9105				

Comparison of slopes: $F = \frac{0.0174}{0.0032} = 5.44$ (5% F = 3.84) Significant at 5% level

Comparison of elevation: $F = \frac{0.0032}{0.0020} = 1.60$ (5% F=254.3) Not significant

D.F. and d.f. = degree of freedom; Sx^2, Sy^2, Sxy = corrected sum of squares and products; B = regression coefficient; S S = sum of squares; M.S. = mean square.

was found to be nonsignificant (5% level = 1.98). The determinate group showed that the value of t $= \frac{3.5362-3.0000}{0.0373} =$ 14.3753 which was found to be highly significant at 1% level (=2.58). These results indicate that in *D. acuta* the cube law of the length-weight relationship will not be a proper representation for the determinate fishes. The exponent 'B' in this category is clearly greater than 3.0. But, as far as the indeterminate fishes are concerned the exponent (3.0434) is very close to 3.0 and hence the cube law may be applicable. These results show that in *D. acuta* the length-weight relationship follows the cube law till the sex differentiation starts and thereafter it deviates significantly from the cube law. Therefore, it is assumed that the best estimate of 'n' in these two categories based on the two years data are 3.0434 for indeterminate group and 3.5362 for determinate group.

8.1.2. DUSSUMIERIA HASSELTII:

To make a comparison of the length-weight relationship of D. acuta, the length-weight relationship of *D. hasseltii* from Indian waters was also studied. The sum of squares and products of X and Y were as follows: Number of fish = 110; SX = 238.5443; SY = 150.0046; SX^2 = 518.0478; SY^2 = 211.8456 and SXY = 327.6106 (SX, SY = sum of X and Y; SX^2, SY^2 and SXY = sum of squares and products), and the corresponding corrected values were D.F. = 109; Sx^2 = 0.7443; Sy^2=7.2876; Sxy = 2.3129. The values of 'A' and 'B' were estimated as -5.3752 and 3.1075 respectively. The mlength-weight relationship equation was found to be:

$$W = 0.000004215 + L^{3.1075}$$

the corresponding logarithmic equation may be written as

$$\log W = -5.3752 + 3.1075 \log L.$$

The observed values of weight for length of D. hasseltii was plotted in Plate XVI, Fig.5. When the calculated length-weight curve (regression) was fitted to the diagram using the formula it showed a curvilinear relationship.

To know the difference in the slope and elevation of the regressions between D. hasseltii and determinate category of D. acuta, analysis of covariance was done and the details presented in Tables 110 and 111.

TABLE 110

SUM OF SQUARES AND PRODUCTS OF LENGTH-WEIGHT DATA OF DUSSUMIERIA HASSELTII AND DETERMINATE CATEGORY OF DUSSUMIERIA ACUTA.

Groups	No.of fish	SX	SY	SX^2	SY^2	SXY
D.acuta	1573	3331.9670	2028.0461	7060.0994	2648.0170	4303.7978
D.hasseltii	110	238.5443	150.0046	518.0478	211.8456	327.6106
Pooled together	1683	3570.5113	2178.0507	7578.1472	2859.8626	4631.4084

SX, SY, sum of X and Y; SX^2, SY^2, SXY = sum of squares and products.

TABLE 111

CORRECTED SUM OF SQUARES AND PRODUCTS, REGRESSION COEFFICIENT AND ANALYSIS OF COVARIANCE OF THE LENGTH-WEIGHT DATA OF *DUSSUMIERIA HASSELTII* AND DETERMINATE CATEGORY OF *DUSSUMIERIA ACUTA*

Groups	D.F	Sx^2	Sy^2	Sxy	B	d.f	S.S	M.S
D.acuta	1572	2.2456	33.2866	7.9410	3.5362	1571	5.2052	
D.hasseltii	109	0.7443	7.2876	2.3129	3.1075	108	0.1003	
						1679	5.3055	0.0032
Pooled within	1681	2.9899	40.5742	10.2539		1680	5.4083	0.0032
	Difference between slopes					1	0.1028	0.1028
W x b	1682	3.2566	41.1450	10.6424		1681	6.3662	
	Difference between adjusted means					1	0.9579	0.9579
	1	0.2667	0.5708	0.3885				

Comparison of slopes: $F = \frac{0.1028}{0.0032} = 32.1250$ (1% F = 6.64) Highly significant

Comparison of elevation: $F = \frac{0.9579}{0.0032} = 299.3438$

(1% F = 6.64) Highly significant

D.F. and d.f. = degree of freedom; Sx^2, Sy^2, Sxy = corrected sum of squares and products; b = regression coefficient; S.S. = sum of squares; M.S. = mean square.

It was found that the regressions varied significantly in slope as well as in elevation.

Further, the significance of variation in the estimate of 'B' for D. hasseltii from the expected values of the ideal fish (3.0) was tested by the 't' test and it showed that

$$'t' = \frac{3.1075 - 3.0000}{0.0169} = 6.3609$$

was highly significant at 1% level.

't' test was again applied to study the significance of variation in the 'B' value of D. hasseltii from the 'B' value of D. acuta and it was found that

$$'t' = \frac{3.5362 - 3.1075}{0.0164} = 26.1402$$

varied significantly at 1% level.

8.2. RELATIVE CONDITION FACTOR

The variation of the observed weight from the expected weight for length of individual fish or groups of individuals is indicative of fatness, general well being or gonad development of the fish. Tester (1940) has shown that the specific gravity of the fish flesh varies and the importance of this variation had been discussed by Kestevan (1947) in his studies on 'condition factor'. The density in most of the fishes is maintained as the same as that of the surrounding water and the specific gravity of the fish flesh, according to Brown (1957), does not vary much within a species. Hence, changes in weight for length of fish are due to changes in form or volume and not specific gravity. These changes are being studied by the condition factor which is the ratio between the observed weight and length cubed (Brown, 1957). The condition factor is also termed as coefficient of condition or Ponderal Index (Thompson, 1943; Hile, 1936).

Condition factor can be expressed by the formula $K = \frac{100\ W}{L^3}$ where 'K' represents the condition factor, 'W' the weight and 'L' the length of the fish. This formula is true for an ideal fish where the cube law is maintained in its length-weight relationship. But in most of the fish this is not the case. In such fishes where the cube law is not followed and the value of 'n' varies with length, the condition factor 'K' will be affected. The values of 'K' may also be affected indirectly through the values of 'n' by factors like age, sex, maturity, racial differences, food supply, degree of parasitisation, environment and selection in sampling. According to Le Gren (1951) by using an empirical, calculated length-weight relationship formula, $W = aL^n$ these factors affecting 'K' could be eliminated. The condition factor thus calculated is called 'relative condition factor' or 'Kn' and is expressed by the formula $Kn = \frac{W}{\bar{W}}$ where 'W' represents the observed weight and '$\bar{W}$' the calculated weight for length obtained by using the logarithmic formula. The difference between the condition factor (K) and the relative condition factor (Kn) is that, the first one gives the deviation of an individual from the average weight of an individual for length, whereas the second one gives the deviation from the hypothetical ideal fish.

It was pointed out by Hickling (1930), Hart (1946) and Morrow (1951) that the point of inflexion in the curve showing diminution of 'K' with increasing length is a good indication of the length at which sexual maturity is attained. This was found to be applicable in poor-cod (*Gadus minutus*) (Menon, 1950); in grey mullet, *Mugil tade* (Pillay, 1954) and in *Mugil parsia* (Sarojini, 1957). Hart (1946) also observed that with increase in age there is lower level of condition throughout the seasonal cycle consequent upon the increased metabolic strain of spawning. On these grounds the relative condition factor 'Kn' of *D. acuta* was calculated and its variation in different size groups and in different seasons were studied.

In *D. acuta*, since the regression coefficients for inditerminate and for the pooled data of two sexes for two years were found varying at significant level, separate equations as derived from length-weight relationship were used for these two categories. The equations were found to be:

$W = 0.000006037\ L^{3.0434}$ for indeterminate fishes and

$W = 0.0000006294\ L^{3.5362}$ for determinate fishes.

The corresponding logarithmic equations were found to be:

$\text{Log } W = -5.2192 + 3.0434 \log L$ and

$\text{Log } W = -6.2011 + 3.5362 \log L$

Using these formulae the calculated weight of the individual fish was estimated. The relative condition factor 'Kn' was obtained by dividing the observed weight by calculated weight after individual fishes.

A study of the variation in relative condition factor in different size groups of D. acuta was made. For this the length measurements were grouped in to 5 mm size groups. The values of the geometrical mean for each size group was calculated and the results are presented in Table 112 and Plate XVII, Fig.1. The figure shows that the condition is very low for smaller fishes. It increases rapidly to a peak at 76-80 mm size group from which it drops down slowly to a 'Kn' value of 0.931 at 89-90 size groups. From there onwards the 'Kn' increases slowly to 1.024 at 101-105 mm group from which it gradually declines to a value of 0.985 at 116-120 mm size group. The increase thereafter is also gradual and reaches a value of 1.020 at 136-140 mm size group. Much variation in the condition was not noticeable thereafter. The value slightly increases to 0.993 at 146-150 mm size group and gradually decreases to 0.963 at 156-160 mm group. The increase in 'Kn' starting from 91-95 mm size group cannot be the indication of sexual maturity because the fish at this size is too small and even the differentiation of gonad is not possible. The increase of condition from 121-125 size group onwards can be attributed to the gonadial maturity, since the maturation starts at this size. The size at first maturity at 50% level was found to be around 132 mm. The sudden inflexion at 141-145 mm size group indicates subsequent spawning, diminution of 'Kn' after 76-80 mm size group and 101-105 mm size group seems to have no relation to sexual maturity and it may be due to some other unknown reasons.

Since one of the main objects of the study of relative condition factor was to trace the condition cycle of the fish through the months in a year and through successive years and its relation to maturity, the fishes were classified into two categories as 'immature' (fishes in stages I and II) and 'mature' (fishes in stages III, IV, V, VI and VII). The geometrical means of the 'Kn' for monthly samples of D. acuta were calculated for the above two categories for the two years. The results are presented in Tables 113 and 114 along with the number of samples observed in each month and the weighted average for each year.

The fluctuations in the 'Kn' for immature fish for two years from April 1969 to March 1971 are plotted in Plate XVII, Fig. 2. It may be seen that during the year, April 1969 to March 1970 the immature fish had its condition factor below unity (Unity = 1) in May, June, July, November, February and March. When the value were checked against the weighted

TABLE 112

GEOMETRICAL MEAN OF 'Kn' IN DIFFERENT SIZE GROUPS OF DUSSUMIERIA ACUTA

Size groups	No.of fish	'Kn'
61- 65	6	0.704
66- 70	2	0.799
71- 75	3	0.930
76- 80	5	0.995
81- 85	7	0.979
86- 90	9	0.931
91- 95	10	0.958
96- 100	14	1.011
101- 105	19	1.024
106- 110	20	1.002
111- 115	45	0.989
116- 120	67	0.985
121- 125	80	1.004
126- 130	93	1.007
131- 135	92	1.018
136- 140	97	1.020
141- 145	86	0.983
146- 150	62	0.993
151- 155	34	0.991
156- 160	5	0.963

TABLE 113

GEOMETRICAL MEANS OF CONDITION FACTOR OF DUSSUMIERIA ACUTA (APRIL 1969 TO MARCH 1970)

Month	Immature fish		Mature fish	
	No. of fish	'Kn'	No.of fish	'Kn'
April	8	1.021	20	1.091
May	8	0.897	19	1.016
June	20	0.999	19	1.007
July	20	0.990	20	0.983
August	14	1.024	17	1.036
September	20	1.010	18	1.026
October	19	1.016	14	1.004
November	24	0.979	12	0.971
December	17	1.024	9	0.984
January	20	1.000	15	0.986
February	16	0.939	10	0.922
March	12	0.998	17	1.016
Weighted average for the year	198	0.994	190	1.010

TABLE 114

GEOMETRICAL MEANS OF CONDITION FACTOR OF DUSSUMIERIA ACUTA (APRIL 1970 TO MARCH 1971)

Months	Immature fish		Mature fish	
	No. of fish	'Kn'	No. of fish	'Kn'
April	10	1.021	15	1.025
May	9	0.954	17	1.019
June	22	0.977	14	0.980
July	20	1.014	15	1.016
August	16	0.978	18	1.010
September	20	0.964	15	1.040
October	13	1.006	18	1.048
November	15	1.015	15	1.015
December	19	1.008	13	1.012
January	12	1.034	14	1.028
February	13	0.996	19	0.988
March	11	0.992	15	0.995
Weighted average for the year	180	0.996	188	1.015

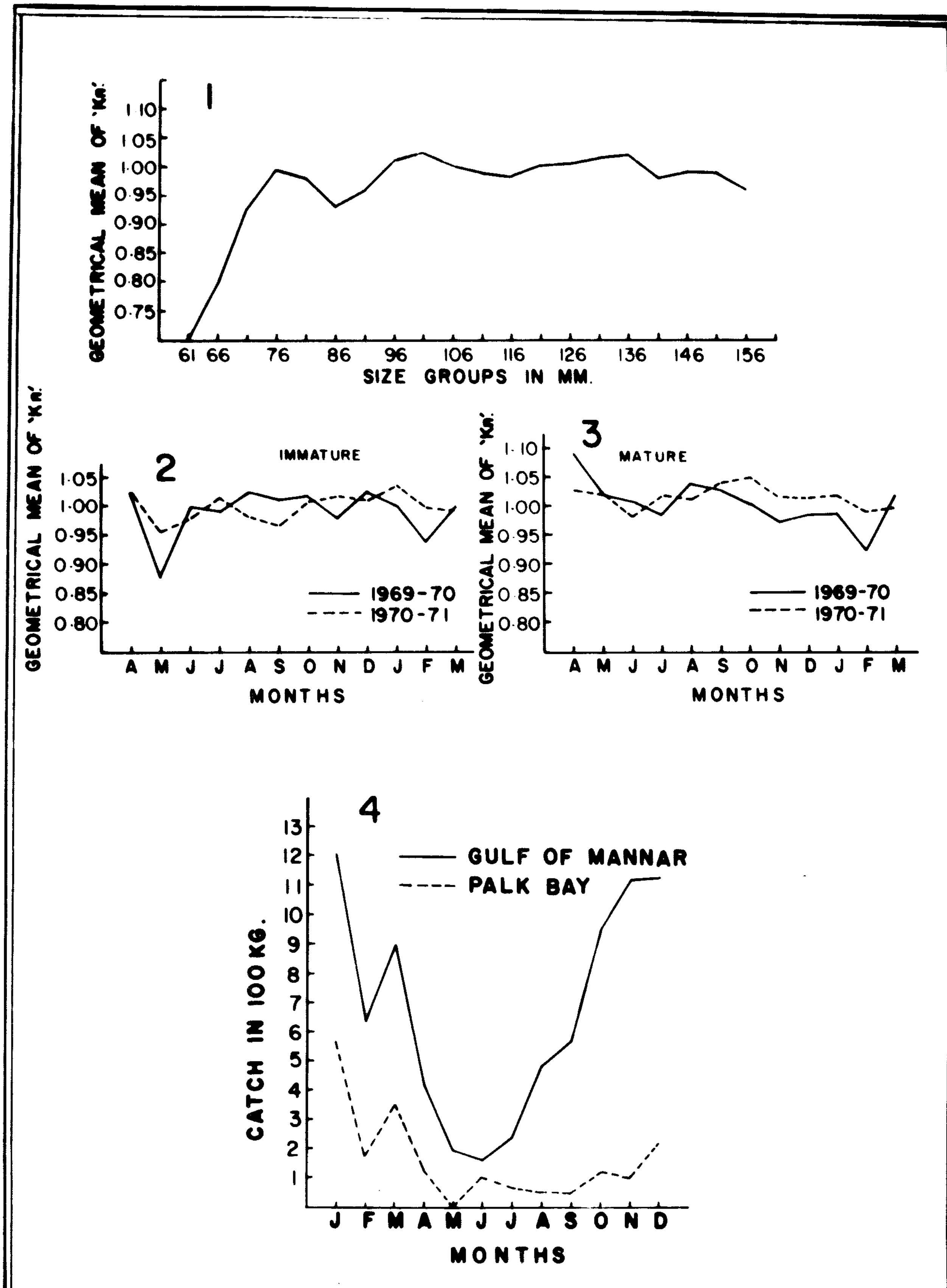
PLATE XVII

Fig.1 The relative condition factor (Kn) of D.*acuta* in various size groups.

Fig.2 The relative condition factor (Kn) for the immature fish of D. *acuta* in different months from April 1969 to March 1971.

Fig.3 The relative condition factor (Kn) for the mature fish of D. *acuta* in different months from April 1969 to March 1971.

Fig.4 Seasonal trend of fishery of D.*acuta* in the Gulf of Mannar and the Palk Bay. Average monthly catch for a period from April 1969 to December 1975.



1
GEOMETRICAL MEAN OF 'Kn'
1.10
1.05
1.00
0.95
0.90
0.85
0.80
0.75
61 66 76 86 96 106 116 126 136 146 156
SIZE GROUPS IN MM.
2
IMMATURE
GEOMETRICAL MEAN OF 'Kn'
1.05
1.00
0.95
0.90
0.85
0.80
1969-70
1970-71
A M J J A S O N D J F M
MONTHS
3
MATURE
GEOMETRICAL MEAN OF 'Kn'
1.10
1.05
1.00
0.95
0.90
0.85
0.80
1969-70
1970-71
A M J J A S O N D J F M
MONTHS
4
GULF OF MANNAR
PALK BAY
CATCH IN 100 KG.
13
12
11
10
9
8
7
6
5
4
3
2
1
J F M A M J J A S O N D
MONTHS

PLATE. XVII

average for the whole year they were found to be less than that in May, July, November and February. The lowest value observed was 0.877 in May. During the second year, April 1970 to March 1971 the values of immature fish were found to be lower than unity in May, June, August, September, February and March and in comparison with the weighted average, the 'Kn' was less than it in May, June, August, September and March. The lowest 'Kn' (0.954) was noticed in May.

Plate XVII, Fig. 3 shows the plotted values of 'Kn' for mature fish for two years from April 1969 to March 1971. During the first year (1969-70) the values were lower than 1.000 in July and November to February and less than the weighted average in June, July and October to February. The lowest 'Kn' in this year was 0.922 in February. During the second year (1970-71) the pattern of the 'Kn' curve for mature fish was almost similar to that of the first year in its ascents and descents. The values were found to be below 1.000 in June, February and March and lower than the weighted average in June, August, December, February and March. The lowest value observed was 0.980 in June.

Earlier authors working on different fishes, have attributed the fluctuations in the condition to different factors. Thompson (1943) pointed out that in plaice, Pleuronectes platessa the high and low conditions are found before and after spawning. The low and high conditions before and after spawning in cornish pilchard, Sardina pilchardus was explained by Hickling (1945) as due to sexual cycle and availability of food respectively. Morrow (1951) found that at the start of the spawning season, a peak of condition is reached in longhorn sculpin, which could be associated with the prespawning growth of the gonads. A striking correlation between the seasonal cycles in the relative condition and the gonad weight of the perch (Perca fluviatilis) was noticed by Le Cren (1951) which was also observed by Sarojini (1957) in Mugil parsia of Bengal. Menon (1950) in his study on the poor-cod and Pillay (1954) in his study of the biology of Mugil tade have found it possible to determine the spawning season and its extent from the seasonal fluctuations in the Ponderal Index. Qasim (1957) explained that in the shanny, Blennius pholis the increase and decrease of condition are probably due to general building up and loss of reserves respectively. Blackburn (1960) in his studies on the Australian barracouta, Thyrsites atun, remarked that it was not possible to interpret the changes of condition in this fish basing on sexual cycle or the feeding intensity and that it may depend on several other factors.

In the case of Dussumieria acuta though the condition of immature and mature fish differs in various months, it may be seen that at least in certain months the condition of both immature and mature fish are either low or high, indicating that probably factors other than sexual cycle may be responsible for variation in the condition. Again it was also noticed that the variations in condition factor have not shown any striking relation to differences in the intensity of feeding in immature or mature fish. Brown (1957) stated that the balance between maintenance and growth may vary with physico-chemical factors of the environment and physiological state of the fish. Hence, from the available data it may be presumed that the changes in condition of *D. acuta* in different months are probably related to many other factors including the reproductive cycle and the feeding habits.

CHAPTER 9

FISHERY

Rainbow sardines are widely distributed throughout the northern Indian Ocean and Western Central Pacific to northern tip of Australia, extending westward to East Africa and Medagascar and northward to Foochow. In India, two species are widely recognised, namely *Dussumieria acuta* and *Dussumieria hasseltii* and are common all along the coasts, especially Andhra Pradesh, Tamil Nadu, ~~Porto Novo~~, Kerala, Karnataka and Bombay coasts. Though not abundant, they form fishery of some magnitude along these coasts in certain seasons. In different states the rainbow sardines are known in various vernacular names such as "Morava" in Telugu; "Thondan", "Poonduvirinjan" and "Madha Kandai" in Tamil; "Mural", "Muthupolappan", "Kolakoyan" and "Kolachi" in Malayalam and "Lolu baige", "Siriande" and "Mennethe" in Kannada. In the catch statistics of the marine fisheries of India, the rainbow sardines are grouped together with "Other Clupeoids" and hence separate catch statistics are not available so far. The present account on the fishery of rainbow sardines is restricted to the information collected by the author for a period of nearly 7 years during April 1969 to December 1975 from the fish landing centres along the Palk Bay and the Gulf of Mannar, on the mainland side in and around Mandapam area. This account further deals with the fishing methods, fishing seasons, trend of fishery, disposal of catch and catch data in this locality.

Rainbow sardines support a minor fishery at Mandapam area along the Gulf of Mannar and the Palk Bay coasts. Though a minor fishery, it is found almost throughout the year in one place or the other along these coasts in one or the other gears. _Dussumieria acuta_ is the dominant species, while _D. hasseltii_ is noticed only rarely, in stray numbers, and never formed a fishery in this area.

9.1. FISHING METHODS

The main gears employed in the fishery of rainbow sardine along the Palk Bay and the Gulf of Mannar are shore seine (Karai valai), gill net (Choodai valai), bag net (Madi valai) and trawl net. The major contribution to the fishery was made by shore seine and next to it was by gill net.

9.1.1. Shore seine:

At many places along the Palk Bay and the Gulf of Mannar rainbow sardines are caught mainly in shore seine, locally called "Karai valai" (Karai = shore; valai = net), operated in the inshore waters at depths varying from 4 to 6 metres at a distance of 1/2 to 2 kilometres from the shore. The net is operated from a 'Tuticorin type' of boat called "Vallam" generally rowed by 8 to 10 persons while paying out the net.

The net consists of a bag and side wings. The bag which measures nearly 10 metres is divided into belly and cod end. The cod end has the smallest mesh of 1.5 cm. The belly is preceded by the cotton wings each measuring about 39 metres which are in turn followed by the hemp wings. At the junction of these two parts the mesh size is about 23 cm. and as the hemp wing joins the warps the size of the mesh increases progressively. The hemp wing on either side measures about 480 metres and is bounded by head rope and a foot rope to which are attached floats and sinkers respectively - the floats at 2.8 metres apart and the sinkers at 9.1 metres. At the centre of the mouth of the bag the head rope is provided with a master float and two smaller floats on either side. There are 12 to 15 warps each measuring about 60 metres attached to each hemp wing. Sometimes the number of warps is reduced to only 4 or 5.

The entire net is loaded in the 'Tuticorin type' of boat and the boat is launched into the sea with one end of the warp on the shore held by a person. For paying out the net, the boat is manned by 8 to 10 men, six of whom will be rowing it in the required direction, one person at the rudder and another to sight shoals of fish by standing at the bow of the boat. As soon as shoal is sighted, the whole net is quickly payed out around the shoal and the other end is brought to the shore, some distance away from the starting point (Pl. XVIII, Fig.1). On each side 10 to 20 men drag the net. As the net is pulled, the two parties progressively come closer till the net has come close to the shore (Pl. XVIII, Fig. 2 & 3). As the net is hauled up, the wings are carefully guarded to remain as walls to prevent escape of fish and the mouth of net is closed till it is completely pulled on to the shore.

The shore seine is normally operated in fore-noon hours, starting in the early morning even before sun rise. If the catch is good the operation is repeated and will be continued in the day time till evening. In and around Mandapam area and Rameswaran island shore seine is the widely used gear especially at Panaikulam, Athankarai, Dhargavalasai and Rameswaram to Dhanushkodi area in the Palk Bay side and at Muthupettai, Pudumadam, Vedalai and Kundugal Point to Dhanushkodi in the Gulf of Mannar side.

9.1.2. <u>Gill net</u>:

Gill nets are of different types depending on the mesh size of the net. The one used to catch rainbow sardines and lesser sardines are locally called "Choodai Valai" (Choodai = local name for lesser sardines; Valai = net). This net is operated from "Tuticorin type" of boat or still smaller boats locally called "Vallam" or "Vathai".

The "choodai valai" is a wall-like net made of cotton with a stretched mesh size of about 2.5 to 3 cm. and is vertically floated in the sea by the help of plastic or synthetic floats in the head rope and lead sinkers in the foot rope. In early days wooden floats and stone sinkers were used. A normal sized "choodai valai" is approximately 96 metres long and 7-8 metres wide consisting 6 to 8 equal pieces.

The gill nets are normally operated during day time. One boat and 3-4 men are engaged in the operation. It is operated 8 to 9 Km. away from the shore, some times up to 13 Km, at depths of about 10 to 15 metres. The operation of net consists in paying the net in the fishing ground with one end of the net secured to the boat. Then the boat and the net are allowed to drift in the current and the tide. The fish while moving about are gilled or entangled in the net. After a few hours, the net is hauled up and the fish collected. The gill nets are usually taken out of the boat only when shoals are sighted. In Mandapam area gill net is widely used at Kilakkarai, Pamban and Thankachimadam. (Pl. XIX, Figs. 1 & 2).

9.1.3. Bag net:

The bag net is operated from the Catamarans which are made up of three logs of wood tied in such a way that the middle one is at a lower level than the other two at the sides. The catamarans work in pairs. One in each pair is slightly longer and wider than the other. A light bamboo of about 10 metres length which serves as a mast, carries a triangular sail of cotton cloth. The two crafts are tied together at the anterior ends in a converging manner to minimise friction in sailing. The mast and sail are common to each pair of catamarns. Two men form the crew of each catamaran.

The net called "Madi Valai" (madi = bag; valai = net) consists of a bag-like portion with side wings. The bag is about 9 metres long and 1.8 metres wide at the mouth. The cod end measures about 60 cm. and has a mesh of 0.5 cm. The bag is preceded by the hemp wings which measure 46 metres on either side and are in turn followed by the warps of the same length. At the junction of the hemp wing and the warp a single float is attached to the head rope and sinker to the foot rope. The net is shot from two catamarans which simultaneously move apart and proceed in the direction of the wind. After 15 to 30 minutes the two catamarans come close together and at the same time pulling the warps of the net. When the two catamarans lie side by side, the bag portion of the net comes to the surface. The almost total absence of free board in catamarans enables this net to be hauled with ease. The fishes are transfered from the cod end of the net to palmyra-leaf baskets. The operations are repeated till the baskets are full or it is time for their return to the shore. The main centre of bag net operation are Mandapam, Pamban and Rameswaram.

9.1.4. Other trawl net:

The typical otter trawl operated at Mandapam area is drag net operated from mechanised vessels of 30 to 40 feet fitted with 36 to 48 HP diessel engines. In most of the vessels winches are fitted to haul the net. In the vessels in which winches are absent, the crew drag in the whole net by hand. Each vessel has a 5 member crew. The trawling speed is normally 2 to 2.5 knots and the duration of each haul is 2 to 3 hours (Pl. XX, Fig.1).

The trawl net has two wings which are spreadout with the help of a pair of otter boards, one on each side, which tend to diverge outwards and keep the mouth of the net open. This net is usually dragged along the bottom, but is also used in midwater trawling by suitably adjusting the weight of the sinkers as well as the speed of tow. The trawl net used at Mandapam area has a total length of 35 metres. The net is made of nylon thread. The wings are about 12 metres long. The length of the body and the cod end together is 23 metres and the head rope 13 - 15 metres. The wings have stretched mesh size of 5 cm. The mesh size of the belly is 4 cm. and of the cod end is 2 cm.

In Mandapam area trawling is carried out both during day and night, depending on the availability of prawns and silver bellies which form important fisheries. Small quantities of rainbow sardines are also caught in trawls during day and hight operations. The trawelers are concentrated at Rameswaram and Mandapam on the Palk Bay side and Mandapam and Ervadi on the Gulf of Mannar side.

In this context it should be pointed out that none of the above mentioned gears are designed or operated solely for rainbow sardines. Infact the intention of the fishermen is to catch other fishes of much more commercial value, but rainbow sardines also form a part of their catch.

9.2. FISHING SEASONS:

In general the fishing along the Palk Bay and the Gulf of Mannar is seasonal because of the weather conditions at different times. During the period of north-east monsoon (November to March) the Palk Bay becomes rough and choppy and fishing is made difficult (mainly by trawlers, gill nets and bag nets) at most of the places along the coast. However, at some places fishing is continued (especially shore seine) in this season also except for a few days when the sea becomes very rough. But during this period the Gulf of Mannar is relatively calm and fishing cativity is conmemtrated along the Gulf of Mannar side. The south-west monsoon commences in March-April and continues upto October-November, when the Gulf of Mannar becomes rough and majority of the fishing operations remain suspended. During this period intense fishing is done on the Palk Bay side. But at some centres (mainly shore seine centre) where favourable conditions prevail the fishing is continued.

9.3. TREND OF FISHERY

The rainbow sardines are caught round the year from the Gulf of Mannar and the Palk Bay in varied intensities depending on the weather conditions mentioned above, but the catch is fairly abundant on the Gulf of Mannar side than on the Palk Bay side. The seasonal trend of this fishery is presented in Plate XVII, Fig. 4. The catch is very high in the Gulf of Mannar side in all the months compared to the Palk Bay. On the Gulf of Mannar side the peak period is from September-October to March-April. On the Palk Bay side also the trend is almost same with good catches from December to March or April. In general the fishery season of rainbow sardine is during north-east monsoon period when fishing is rather difficult on the Palk Bay side and hence may be the reason for comparatively poor catch from this side. At this period the Gulf of Mannar side in highly favourable for fishery activities and hence the catch is also very high.

9.4. DISPOSAL OF CATCH

Rainbow sardines are consumed by all classes of people and being cheap compared to other quality fishes, are preferred especially by the poor. In coastal Tamil Nadu, compared to lesser sardines, the local people prefer rainbow sardines and hence the price is also relatively higher than sardine. In most cases the complete catch goes to the local markets and are consumed fresh. During times of abundance they are sun dried in the beach without salt (Pl. XX, Fig. 2). The fish caught in trawl nets are normally placed in cement tanks, since it will mostly be spoiled, along with miscellaneous fishes and salt is added in layers. These are allowed to remain in the tanks one or two days and then thoroughly washed in the brine and sun dried. The dried products (especially dried without salt) is also consumed locally or exported to Sri Lanka, where there is great demand for the cured fish.

9.5. CATCH DATA:

As stated earlier, in the catch statistics of marine fishes of India, the rainbow sardine landings are not recorded separately and hence no catch data, either area-wise, state-wise or on all India basis, are available for comparison or percentage estimation. The total landings of the Palk Bay and the Gulf of Mannar sides of Mandapam area, as estimated by the author, for a period of nearly 7 years from 1969 to 1975 (for 1969 the catch data are from April to December and for other years it is from January to December) are given in Table 115.

TABLE 115

THE ANNUAL LANDINGS OF RAINBOW SARDINE (IN Kg.) FROM THE GULF OF MANNAR AND THE PALK BAY DURING 1969 TO 1975

Areas	Years							Average
	1969	1970	1971	1972	1973	1974	1975	
Gulf of Mannar	6012	12292	8175	4935	9663	3020	9264	7623.0
Palk Bay	2320	2732	1013	932	2457	1442	1645	1791.6
Total	8332	15024	9188	5867	12120	4462	10909	9414.5

According to Devanesan and Chidambaram (1953) the two species of rainbow sardines are not easily distinguishable from each other but they form an important fishery in the east and west coasts. Their observations from 1934-35 to 1938-39 showed that in the east coast of Tamil Nadu (part of erstwhile Madras State) from Gopalpur (Visakhapatnam District) to Sippikulam (Tirunelveli District) the main fishery seasons for rainbow sardine were February - March in 1934-35; March in 1935-36; February-March in 1936-37; November, February and March in 1937-38 and September-October in 1938-39. According to Krishnamurthi (1957) the rainbow sardine (_D. hasseltii_) catch in Rameswaram Island during 1952-53 and 1953-54 ranked 8th and 7th respectively among the important fishes which constituted the commercial catch of the island. He concluded that the peak fishery season was in the months of September, November and April and the major contribution to the fisheries was made by shore seine and occasionally landed also by "Kola Vala". Mahadevan and Chacko (1962) also reported that the rainbow sardine (D. hasseltii) contributed to the commercial fishery around Rameswaram Island in the north sector of the Gulf of Mannar and shoaled in large numbers almost throughout the year, but with a peak from May to October during the period 1952-54.

PLATE XVIII

The photographs showing three stages of shore-seine operation.

Fig.1 The boat returning after paying out the shore-seine.

Fig.2 The net being hauled from the shore.

Fig.3 The bag portion of the net approaching the shore.

1

2

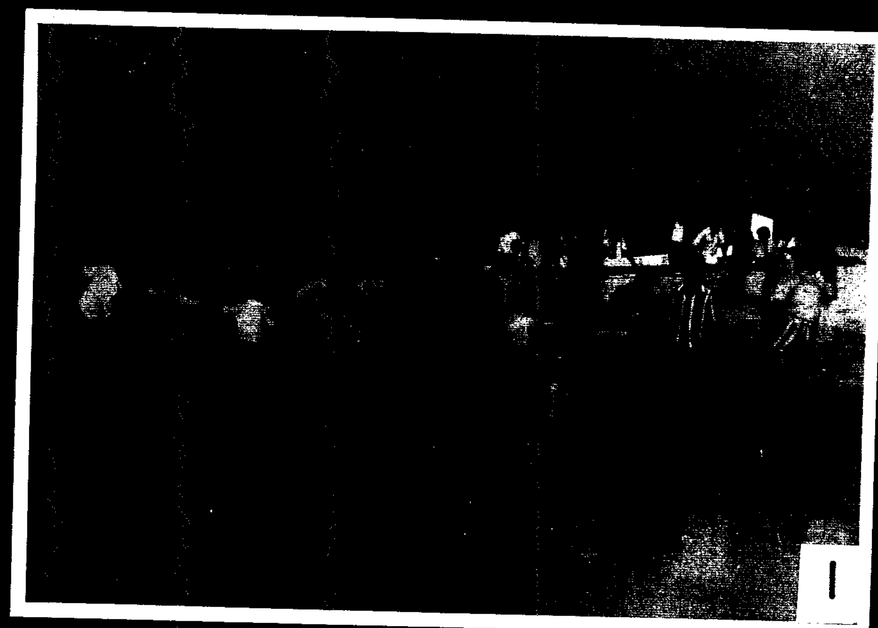
3

PLATE. XVIII.

PLATE XII

Fig. 1 Photograph showing the gill net boat being beached after fishing.

Fig. 2 Photograph showing the fish entangled in the gill net.



1

2

PLATE. XIX.

PLATE XX

Fig. 1 Photograph showing the trawlers at Mandapam boat jetty.

Fig. 2 The dried product of D. acuta (sun dried).

1

2

PLATE. XX.

CHAPTER 10

SUMMARY

The present study deals with the systematics, biology and fishery of rainbow sardines of India belonging to the genus *Dussumieria* of the family Dussumieriidae with special reference to *Dussumieria acuta* Val., the most abundant species in Palk Bay and Gulf of Mannar around Mandapam area. Comparison of biological aspects has also been made, wherever possible, with the only other species viz. *D. hasseltii* Blkr. which was occasionally met with in the commercial catches in small numbers. These investigations have been based on the regular samples collected from the commercial catches in and around Mandapam over a period of two years from April 1969 to March 1971. The collection of fishery data was continued till December 1975.

The systematic position of the species of *Dussumieria* has been reviewed. Samples of rainbow saridines were collected from different centres along the southern coast of India and were analysed morphometrically and meristically, employing standard statistical methods, and the existence of two species, viz. *D. acuta* and *D. hasseltii* under the genus has been established beyond doubt. This is contrary to the view of Whitehead (1963) who observed that there is only one species, namely, *D. acuta* Val. under the genus *Dussumieria*. The distinguishing characters, synonyms and the descriptions of the two species are given in detail.

The food and feeding habits of *D. acuta* were studied by analysing the stomach contents, employing the method of 'Index of Preponderance'. The stomachs were analysed qualitatively and quantitatively, separately for the Palk Bay and the Gulf of Mannar samples, for a period of two years from April 1969 to March 1971. *D. acuta* is a zooplankton feeder, feeding mainly on planktonic crustaceans, both adults and larvae, which included *Lucifer*, young prawns, mysis, copepods, *Porcellana* and larval forms like alima, megalopa, zoea, phyllosoma and mysis stage of prawns. Larval and juvenile fishes, mainly *Stolephorus* spp., bivalve larvae and plant materials such as pieces of sea grass and sea weeds, also formed its food. Diurnal variation in feeding habit was noticed in D. acuta. The fish caught in the night had completely empty and shrunken stomach. Contrary to this, the fish caught in the day time had stomach with various degrees of fullness and only very few stomachs were empty. This phenomenon was noticed in both the years. In general, in the day sample only 6.05% stomachs during the first year and 2.57% stomachs during the second year were empty, whereas in the night samples 98.33% stomachs during the first year and 98.16% during the second year were either empty or with negligible contents.

A comparison of the food items of D. acuta from the Gulf of Mannar and the Palk Bay indicated that the major food constituents were essentially the same in both these localities. Whatever differences were noticed in the number of food items and the relative importance of any given item at one locality were due to the abundance of that item in the environment there. A study of the year to year variations of food revealed no significant differences either in quality or quantity. The major food items such as Lucifer, alima, megalopa, crustacean remains, juvenile fishes and plant materials did not show any major variation in their occurrence between the years and remained as the major items throughout. The occurrence of food items in various size groups showed that, compared to the bigger fishes, the smaller fishes generally consumed smaller organisms from among their favourite food items. *Lucifer* and crustacean remains were found in the stomach of fish of all sizes. Other food items like zoea, young prawns, juvenile fishes and plant materials were consumed by fishes belonging to a wide size-range. Alima, megalopa, phyllosoma, mysids, amphipods, isopods, *Porcellana*, *Acetes* and fish eggs were dominant in fishes above 100 mm total length, whereas others like copepods and bivalve larves were restricted to fishes measuring below 100 mm total length. Zoea, megalopa, mysis and copepods were observed in higher percentages in fish of smaller size than in the larger size groups. It was also noticed that as the fish grows bigger the number of items in the diet also increased. In general, the feeding intensity was higher in fish below the size at first maturity (132 mm total length) than in those above it. In certain months the feeding intensity was high and above the annual average in both immature and mature fish. No correlation was noticed between feeding intensity and maturation. A comparative study of the feeding habit of *D. hasseltii* showed that this species also is a zooplankton feeder like *D. acuta*, feeding mainly on smaller and larval crustaceans like *Lucifer*, *Acetes*, *Porcellana*, alima, megalopa, young prawns etc. Young and larval fishes were also abundant in the stomach contents of *D. hasseltii*.

The gonads in *D. acuta* are bilobed and distinctly asymmetrical in their size, the right lobe being bigger than the left lobe. Based on the state of maturity the gonads were classified into 9 stages, namely, immature (stage I), developing immature (Stage II a) recovering spent (stage II b), maturing (stage III), mature (stage IV), advanced mature (stage V), ripe (stage VI), partially spent (stage VII a) and fully spent (stage VII b). The distribution of ova in the different regions of both the lobes of the ovary, were found to be uniform. Ova diameter studies from stages I to VII b were made. Ovaries typical of the nine stages were selected and their ova diameter frequencies and the progression of maturing ova were studied in detail. In a ripe ovary of stage VI, in addition to the immature group of ova, three groups of ova could be noticed. The first group (fully mature) ranged in size from 0.80 to 1.12 mm (51 to 72 m.d) with a mode at 0.94 mm (60 m.d). This group is to be spawned soon and is clearly separated from the second group of ova (mature) which ranged in size from 0.55 to 0.80 mm (35 to 51 m.d.) with a mode at 0.62 mm. (40 m.d.). A third group (maturing) ranging in size from 0.23 to 0.55 mm (15 to 35 m.d.) with a mode at 0.41 mm (26 m.d) was also noticed following the second group. Below 0.23 mm (15m.d) is the immature stock. When the first group of ova are shed (partially spent, stage VII a) the second group advances for a second spawning within a short period (fully spent, stage VII b). The rest of the maturing yolked eggs left over after the second spout will degenerate and be resorbed (stage II b). D. acuta has a definite but prolonged spawning season once in a year extending from March to September with a peak period from March to July or August and the individual fish sheds the ripe eggs in two batches. At the end of each spawning season there is a resting period extending for three months from October to December.

The spawning season of D. acuta was also ascertained by estimating the gonado-somatic index. The indices were, 1.00 for immature ovaries of stages I & II, between 1.00 and 1.4 for maturing ovaries of stage III, between 1.4 and 3.2 for mature ovaries of stages IV and V, and above 3.2 for ovaries of stage VI. This showed that the increase in the ovary weight was associated with the progress of maturity. A direct and simple relationship was noticed between the size of the gonad and size of the fish. The regression values were estimated as Y = -9.6375 + 0.4222 X for ovary and Y = -10.6550 + 0.4247X for testes (Y = length of gonad and X = length of fish.

Regarding the size at first maturity no significant variation was noticed between the two sexes of D. acuta. 50% of the fish attained maturity at a total length of 132 mm among females and 132.5 mm among males i.e. in 131-135 mm size group in both the sexes. The minimum size at which the females and males reached maturity was observed at 116-120 mm size group. The females spawned first at 126-130 mm and males at

121-125 mm size groups.

The fecundity varied from 1443 ova in a fish of 130 mm total length to 4625 ova in a fish of 154 mm. The average fecundity was estimated at 2733 ova in a fish of average length of 139 mm. The relationship between fecundity and fish length was expressed by the equation log F = -1.2163 + 2.1682 log L. The correlation coefficient was calculated as 'r' = 0.5000 indicating a fairly high level relationship between fish length and fecundity. The fecundity was shown an increase to the power of $L^{2.1682}$ and it appears that fecundity increases at a rate less than that of body weight in relation to total length ('b' = 3.5509). The fecundity-fish weight relationship was expressed by the equation log F = 2.3833 + 0.7540 log W and the 'r' value was estimated to be 0.5889, which when tested for significance showed a fairly significant straight line relationship. The value of the exponent (0.7540) in this relationship was less than unity (unity = 1) and showed that the fecundity increased at a rate less than that of body weight in relation to length. The relationship between fecundity and weight of ovary could be expressed as log F = 0.7620 + 0.9276 log W which showed a straight line relationship with a correlation coefficient 'r' = 0.7835. The test of significance ('t' test) showed a significant relationship between fecundity and weight of ovary. The exponential value (0.6276) which was less than unity indicated that fecundity increased at a rate less than that of body weight and ovary weight in relation to total length. The relationship between length of fish and weight of ovary was also studied which gave an equation, log OW = -2.0721 + 2.3091 logL. The value of 'r' was estimated as 0.6250 which was found to be significant on 't' test. The exponential values showed that the ovary weight increased at a rate less than that of body weight in relation to total length but slightly greater than fecundity-total length relationship. The fecundity factors were also estimated and it was found that the average number of ova was 109 per gram body weight and 359 per 0.1 gram ovary weight.

The sex-ratio of D. acuta showed a significant dominance of females over males in both the years. The female to male ratio was 1: 0.83 during 1969-70 and 1: 0.87 during 1970-71. The sex-ratio among the immature fish did not show any significant variation but it varied significantly among the mature group with the dominance of females indicating that the ratio of the two sexes differ significantly when the fish starts to mature or attains maturity. So it may be assumed that in D. acuta there may be differential behaviour of the sexes when maturation begins, the sexes probably moving in separate shoals. No differential growth was observed between the two sexes of D. acuta.

The early development of the embryo and the larvae of D. acuta was studied based on the artificial spawning of the males and females and subsequent fertilization of the eggs. The ripe and oozing males and females were collected from the trawl catch and by gentle pressure on their bellies the milt and ova were passed on into a bucket of filtered sea water. The fertilized eggs hatched out in the laboratory 24 hours after fertilization. The development of the embryo, hatching process and the larval development upto 48 hours after hatching were closely observed and described. The newly hatched larva measured 2.4 mm in length and exhibited all the clupeoid characteristics such as backward position of the anus, segmented yolk and the crossed arrangement of the muscle fibres in the myotome. The embryo had a single oil globule at the tail end of it and in the newly hatched larva it was located at the posterior end of the yolk sac. In 24 hour-old larva the oil globule had split up into droplets and it disappeared completely in the 39 hour-old larva. Even in the 48 hour-old larva the yolk sac was not completely absorbed. The first gillslit was noticed in the 24 hour-old larva and all the gillslits were broken through in the 48-hour-old larva. The lower jaw started developing when the larva was 24 hour-old and the ossification started in it when the larva was 39 hours old. Rudiments of teeth were also visible at this stage. In the 48 hour-old larva the jaws were well developed, prominent and pointed with rudimentary teeth. The mouth was wide open. The rudiment of the pectoral fin was clearly visible in the 39 hour-old larva.

The age and growth of *D. acuta* were studied based on the length frequency distribution. The Peterson's method of length frequency anlysis of the random samples showed a growth to 73 mm at the end of 3 months, 95.5 mm at the end of 6 months, 113 mm at the end of 9 months and 128 mm at the end of first year resulting in an average growth rate of 10.75 mm per month during the first year. The modes beyond one year group were not traceable. The probability plot technique of Cassie (1954) was also employed to the cumulative percentage of the annual length frequency data. The results indicated that *D. acuta* attained 128 mm when it is one year old which showed perfect correlation with the results obtained by Peterson's method. Von Bertalanffy's growth equation of $L_t = L\infty \left\{ 1 - e^{-k\,(t - t_o)} \right\}$ was fitted to the quarterly values of age - length data to estimate the theoretical growth. The growth parameters were estimated arithmetically and graphically which gave identical values. The estimated values were $L\infty = 191$ mm, $K = 0.20701$ and $t_o = -1.34$ quarters by arithmetical method and $L\infty = 191$ mm, $K = 0.20701$ and $t_o = -1.35$ quarters by graphical method of Ford-Walford fitting. Using the formula obtained by the arithmetic method the theoretical growth of *D. acuta* was estimated upto three years old fish. It could be noticed that the fish grows to a length of 128.05 mm at the end of 1 year, 163.28 mm at the end of 2 year and 178.91 mm at the end of 3 year. No growth rings were traceable in the otoliths. But a straight line relationship could be obtained between the lengths of otoliths and the fish. The regression equation was estimated as $Y = -2.3745 + 0.3553X$.

The study of the age composition of D. acuta in the commercial catches during 1969-71 showed that at Mandapam area in the shore seine catch, except for June 1969 and September 1969 when 0-year group dominated, in all other months, the 1-year group fish dominated. On the other hand in the gill net catch 1-year group dominated throughout the period. Contrary to this the trawl catch showed wide variation between the two years. In this gear during the first year 0-year group was dominant except for April 1969 when 1-year group dominated. During the second year in all the months when data were available, the 1-year group dominated in the catch. The study on the growth in weight showed that the optimum age for the exploitation of D. acuta is when the fish is 1 to 1/2 years old.

The length-weight relationship of D. acuta was determined using the general parabolic formula $W = a\,L^b$. The fishes were categorised into indeterminate, females and males, separately for two years and the length-weight equations were calculated separately for each category. Analysis of coveriance showed that among the males and females of both the years there were no significant variations either in slope or elevation. Hence they were pooled together and a common formula was derived as $W = 0.0000006294\ L^{3.5362}$. This formed the determinate category. Similarly the indeterminate group of both the years were also tested which showed no significant difference either in slope or elevation of their regressions. So a common formula was derived for this category as $W = 0.0000006037\ L^{3.0434}$. The analysis of covariance test between the regressions of indeterminate and the pooled data of determinate categories showed that the slope of the regressions differed significantly at 5% level. The value of the exponent 'b' of the indeterminate category did not show any significant difference from the cubical relationship, but that of the determinate category differed significantly, showing that the cube law of the length-weight relationship will not be a proper representation for it. As a comparison to D. acuta, the length-weight relationship of D. hasseltii was also studied and the equation was found to be $W = 0.000004215 + L^{3.1075}$ for determinate fish. The convariance test conducted between D. hasseltii and the determinate category of D. acuta revealed that the regressions varied significantly in slope as well as elevation. The 't' test employed on the 'b' values of these two species showed significant variation between the two. The estimate of 'b' of D. hasseltii also varied significantly from the cube law.

Based on the above the relative condition factor, 'Kn' for each fish and fish in each month were calculated for indeterminate and determinate categories for two years. During the year 1969-70 the value of 'Kn' of immature fish was below unity (Unity = 1) in May to July, November, February and March; and for mature fish in July and November to February. During the subsequent year, 1970-71, the 'Kn' of immature fish was less than unity in May, June, August, September, February and March; and for mature fish in June, February and March. Variation in the 'Kn' value was noticed in different size groups also. It was less than unity in the size groups from 61 to 95 mm, 111 to 120 mm and 141 to 160 mm total length.

The rainbow sardines are caught from the coastal waters of India all along the coasts. Though not abundant, they form fisheries of some magnitude in certain seasons along the coasts of Andhra Pradesh, Tamil Nadu, Kerala, Karnataka and Bombay. At Mandapam area, along the Palk Bay and the Gulf of Mannar, D. acuta forms the fishery and is caught almost throughout the year in one place or the other, by one gear or the other. D. hasseltii was noticed only very rarely, that too in very few numbers. The major fishing gears, namely, shore seine, gill net, bag net and trawl net, and their methods of operations are described in detail. The fishing seasons at Mandapam area is generally dependent on the north-east and south-west monsoons when the Palk Bay and the Gulf of Mannar, respectively, become rough and choppy, rendering fishing activities difficult. Despite this the rainbow sardines are caught round the year around Mandapam area, in varying intensities. The catch is generally higher on the Gulf of Mannar side where the peak period is from September-October to March-April, than on Palk Bay side, from December to March or April. In most cases the complete catch goes to the market in fresh condition for consumption. At times of abundance they are sun-dried too. Trawl catches are generally salted in cement tanks and later sun-dried after thorough washing in brine. The catch data of rainbow sardine at Mandapam area, as estimated by the author, for a period of 7 years from April 1969 to December 1975 showed an annual average of 9415 Kg.

CHAPTER 11.

R E F E R E N C E S

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