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POPULATION CHARACTERISTICS OF TUNA LIVE BAITS IN LAKSHADWEEP*

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ABSTRACT

Availability and abundance of both migratory and resident species of tuna live baits in desired quantity during the fishing season in the lagoons and adjacent waters coupled with their location, capture and transportation determine the success or failure of pole and line tuna fishery. It is evident that at Minicoy, capture and effective utilisation of different species of live baits has been in vogue since more than a century but in the northern group of islands where mechanised pole and line fishery is prevailing since 1963, the aimed live bait species are sprats, which are collected from shallow sand flats from near or above coral reefs. The present study reveals the occurrence and abundance of other suitable live baits with desired qualities in the deeper parts of the lagoonal ecosystem in the northern islands, the utilization of which would reduce substantial fishing pressure on the local fragile baitfish stock of sprat.

Fishery and population characteristics of seventeen species of tuna live baits collected from areas of importance to tuna pole and line fishery in the Lakshadweep are presented and discussed. Evaluation of different species is made based on their body form, colouration, behaviour pattern and survival in captivity. Habitat and seasonal distribution pattern and catch rate of different bait species are communicated. Data needs for stock assessment of these species are emphasised and strategies for the development and managemen t of baitfish fishery in the Lakshadweep is discussed.

INTRODUCTION

THE SIGNIFICANCE of live baits as limiting factor in the successful production of tunas by pole and line (live-bait) tuna fishery is generally understood. About 160 species belonging to 31 families have been identified from the world oceans for tuna pole and line fishery of which only about a dozen species chiefly belonging to Apogonidae, Caesionidae, Clupeidae, Dussumieridae and Engraulidae are the principal baits used in the major Pacific and Indian Ocean fisheries (Jones, 1964; Baldwin, 1977; Ben Yami, 1980; Silas and Pillai, 1982; Sakagava, 1987). Expansion of pole and line tuna fishing is limited by the availability of suitable live baits in quantity, their maintenance and transportation, availability of tuna schools in the fishing ground, response to chumming expertise of fishermen, etc. In Lakshadweep, the only place in India where a traditional pole and line fishery is in vogue, it is reported that the scarcity of live bait often brings about abrupt suspension of tuna fishing even during the peak tuna fishing season (Jones, 1958, 1960). A knowledge of the distribution and abundance of the natural stocks of principal tuna baitfish species with respect to their capacity for supporting the skipjack pole and line fishery is an essential prerequisite for recommending specific actions

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for the development and management of natural baitfish resources in the area. In addition, there is need to investigate the biological and population characteristics of the different species of live baits for estimating the exploitable stocks of these species and also to ascertain the suitability of culturing some of these species to supplement the natural resources.

Investigations on the live bait fishes of Lakshadweep were largely confined to Minicoy Island. The informations available are mainly from Jones (1958, 1960 a, b, 1964), Thomas (1964), Silas and Pillai (1982), Pillai *et al.* (1986), Pillai and Madan Mohan (1986), Madan Mohan and Kunhikoya (1986); Madan Mohan *et al.* (1986), Gopakumar and Mathew (1986), James *et al.* (1987), Varghese and Shanmugam (1987), Kumaran *et al.* (1989), Gopakumar and Pillai (1988, MS) and Gopakumar (1991). However, till now focused studies such as exploratory surveys on these non-target species in and around the island system is wanting. As part of the implementation of the objectives and technical programmes under the research project of the CMFR Institute entitled 'Investigations on the natural stocks and cultured tuna live baits' an exploratory tuna live-bait resource survey was carried out around the islands and *par* areas of importance to tuna fishery such as Bitra, Chetlat, Kadamat, Perumul Par, Tinnakara-Bangaram-Parali group, Agatti, Kavaratti, Suheli Par, Kalpeni-Tilakkam-Cheriyam group and Minicoy during October 1986 to March 1987. The highlights emanated from it was published (CMFRI, 1986) and part of the first hand information documented in James *et al.* (1987), Kumaran *et al.* (1989) and Gopakumar (1991). In the present document, the distribution, abundance and population characteristics such as size composition, length-weight relationship, sex ratio, size at first maturity, fecundity and food and feeding are presented. Seasonal distribution pattern in the catch of major groups of live baits utilised in the pole and line fishery at Minicoy is communicated. The species are ranked based on the desired characteristics of a good live bait fish as given by Baldwin (1975, 1977), Yuen (1977) and Smith (1977). The imperative necessity of data on the catch, effort and size composition of different species currently utilised in the fishery is emphasised for meaningful assessment of stocks of the species for the future development and management measures. The live bait scarcity problem and some of the options for solving it are also discussed.

The authors are thankful to Dr. P. S. B. R. James, Director, CMFRI for his kind encouragement and guidance for this study. They are also thankful to Shri D. Kojan Koya and Shri O. Ismail of Minicoy Research Centre of CMFRI for their field assistance.

MATERIAL AND METHODS

Mechanised pole and line fishing boats were used for the survey. Two types of live bait nets were employed—(i) *Encircling net :* It is made of nylon mosquito netting, 47.0 × 1.45 m in size with lead sinkers and wooden floats. The net was employed for encircling the schools of sprat *Spratelloides delicatulus* which is an inhabitant of shallow sandy areas of the lagoons and (ii) *Lift net :* Made of nylon netting of 6 mm mesh, 5.87 × 5.3 m in size and operated by means of poles. First, the baitfish colonies were located by a diver and the net was lowered and kept spread in water over the colony with the help of poles. Fish meat paste was rubbed on a coir padding at the end of a bamboo pole and it was pushed up and down over the spread net. Baitfishes, thus lured gathered over the net. When sufficient number of fishes were gathered over the net, it was quickly raised and the baits collected were transferred to the baitfish tank. For baitfishes dwelling in the crevices of coral colonies like apogonids, 'drive in' method by

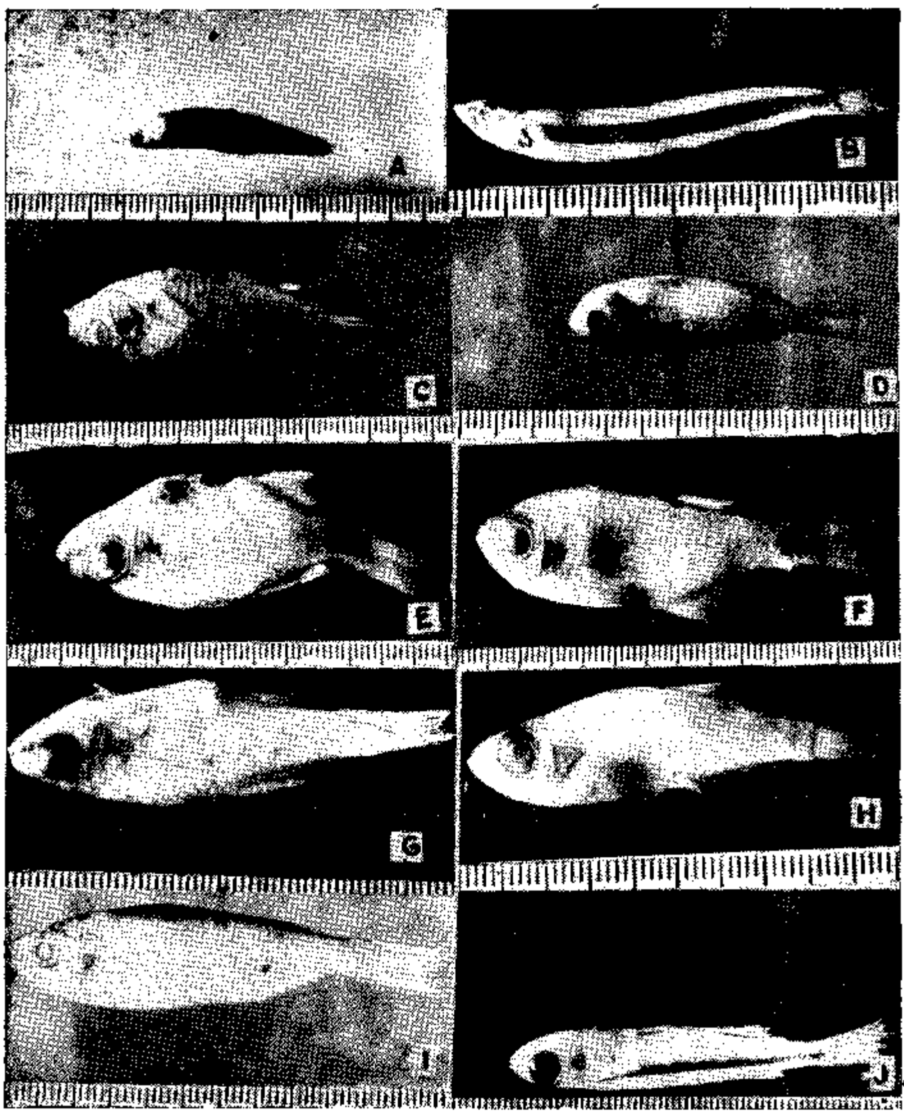

PLATE I. The common live-bait fishes of Lakshadweep: A. *spratelloides delicatulus*, B. *S. gracilis*, C. *Chromis caeruleus*, D. *Lepidozygus tapeinosoma*, E. *Archamia fucata*, F. *Apogon sangiensis*, G. *Rhabdamia gracilis*, H. *Ostorhynchus quadrifasciatus*, I. *Caesio caerulaureus* and J. *Pranesus pinguis*.

employing scare line prepared with palm leaves attached all along its length was practised. The net was used for collecting silver sprat· apogonids, caesionids and pomacentrids from the deeper parts of the lagoons.

Initially the entire lagoon was surveyed by the divers for the location of baitfish colonies and the areas of distribution were marked in the maps. Experimental fishing was done at a few randomly selected colonies from each lagoon to assess the catch rate and species composition. The samples were preserved and analysed for studying the biological characteristics. The studies on species-wise seasonality in the abundance of baitfishes at Minicoy were done by estimating the species-wise baitfish catch taken by the commercial pole and line fishing boats from September 84 to May 87.

Baitfishes

Eventhough Jones (1964) listed 45 species belonging to 30 genera and 19 families, only 21 species belonging to five families *viz.* Dussumieridae, Apogonidae, Caesionidae, Pomacentridae and Atherinidae were commonly caught in good numbers during the investigations (Pl. I). The taxonomy followed here is based on Jones and Kumaran (1980) and Fischer and Bianchi (1984).

Dussumieridae : Sprats are slender, elongate, silvery with deciduous scales that are easily shed. Very delicate fishes and hence large scale mortality occurs at the time of capture and handling. Two species are employed commonly as live bait *viz. Spratelloides delicatulus* and *S. gracilis*. The former is the most common live bait of Lakshadweep and it is distributed in the shallow coral sand areas of the lagoons. The fish moves in schools and is caught by encircling nets. The schools are attracted towards night lights. *S. gracilis* is comparatively a deeper water species associated mostly with massive coral colonies and often coexists with an apogonid *Rhabdamia gracilis*. *S. gracilis* is more hardy than *S. delicatulus* and survives for longer periods in live bait tanks. Sprat colonies were located in all the lagoons surveyed.

Apogonidae : They are small, nocturnal and often brightly coloured resident fishes associated with corymbose, pedicellate corals with reticulately coalescent branches. Since during day time they take shelter in the crevices of coral colonies, first they are driven out from there and then fished by means of lift net. Apogonids are employed as live bait only at Minicoy Island where they are reported to be very effective live bait. They are relatively slower in movement. All the species are very hardy and can be kept in the bait tanks for prolonged periods. Eventhough 22 species are recorded from Lakshadweep, only seven species were caught in good quantities during the present study *viz. Archaemia fucata, Rhabdamia gracilis, R. cypselurus, Apogon sangiensis, A. leptacanthus, Ostorhynchus quadrifasciatus* and *O. apogonides*. The most abundant among these were *R. gracilis, A. fucata, A. sangiensis* and *O. quadrifasciatus*. Apogonids were distributed in all the lagoons surveyed except at Chetlat.

Caesionidae : Fishes with fusifor, compressed body, often brightly striped with blue, yellow and grey and juveniles in large numbers appear inside the lagoons as well as at adjacent reef areas during certain seasons. They are used as live bait at present only in Minicoy Island. Only juveniles are employed as bait and are reported to be excellent bait fish. They are very hardy and the rate of survival is very high in the bait tanks. They are migrant forms and are temporarily associated with branched or massive coral colonies. Seven species were collected during the present investigations *viz. Caesio caerulaureus, C. striatus, C. xanthonotus, Gymnocaesio gymnopterus, Pterocaesio pisang, P. tile* and *P. chrysozona* ; the most abundant were *Caesio caerulaureus* and *P. chrysozona*. Caesionids were collected from all the lagoons except at Chetlat and Bangaram-Tinnakara-Parali group.

Pomacentridae : They are small, brightly coloured with a flattened deep to oblong body associated with ramose arborescent corals. Most of the species are resident forms. Pomacentrids are employed as bait only at Minicoy. They are hardy and some species are reported to be excellent baits. Four species were collected in good numbers during the present survey *viz. Chromis caeruleus, C. nigrurus, Pomacentrus pavo* and *Lepidozygus tapeinosoma*, the former three are resident forms and the latter a migrant form. *C. caeruleus* is the most widely distributed live bait fish of Lakshadweep which was collected from all the lagoons surveyed.

Atherinidae : They are slender, silvery fishes distributed at nearshore areas of the lagoon often associated with algae. Atherinids are very hardy which can be kept in captivity for prolonged periods. They are caught by the encircling net. Atherinids are used as bait only at Minicoy and they are preferred only when the other baits are not available. Eventhough four species are recorded from Lakshadweep only one species *viz. Pranesus pinguis* was collected in good quantities. Atherinids are available in significant quantities only at Bitra, Chetlat, Kalpeni and Minicoy.

DISTRIBUTION

The lagoons and shallow adjacent reef areas of Lakshadweep provide ideal habitat for the live bait fishes. The distribution of live baits in the ten lagoons of Lakshadweep *viz.* Minicoy, Suheli Par, Kalpeni-Cheriyam, Kavaratti, Agatti Bangaram-Tinnakara, Parali group, Perumul Par, Kadamat, Bitra and Chetlat are given in Fig. 1 to 10. It is seen that the vast shallow coral sand areas of the lagoons of Suheli Par, Kalpeni-Cheriyam, Bangaram, Perumul Par and Bitra hold good potential of *S. delicatulus*. At Minicoy, Kalpeni-Cheriyam, Agatti and Kadamat lagoons, apogonids were distributed over wide areas. Large areas of pomacentrid distribution were seen at Bangaram-Tinnakara-Parali group, Suheli Par, Bitra, Kadamat, Perumul Par and Kalpeni. The distribution of atherinids is of a lower magnitude. Eventhough the areas of availability of caesionids were also mapped, it is reasonably assumed that since the caesionids are migratory, their distribution and abundance in the lagoon may vary from time to time.

A basic pattern in the spatial distribution of the various groups of live baits is discernible from the distribution pattern observed at various lagoons. *S. delicatulus* is distributed in the nearshore areas of the lagoon where there is sand flat formation. Pomacentrids are abundantly distributed in the regions next to the sand flat areas in the slightly deeper parts of the lagoons and are associated with ramose, arborescent and flabellate corals. Apogonids and the silver sprat *S. gracilis* are distributed in the still deeper parts of the lagoon associated with massive corals. Atherinids are distributed in areas very close to the lagoon beach. The distribution pattern of the migratory caesionids cannot be ascertained.

CATCH AND CATCH RATE

The total catch of the different live bait species collected during the exploratory survey from the lagoons of the different islands of Lakshadweep is presented as percentage of total catch in Table 1. Sparts constituted the major group at Suheli Par, Bitra and Kalpeni ; apogonids were present in good concentration at Kavaratti, Perumul Par and Kadamat ; caesionids contributed in relatively high proportion at Agatti, Kalpeni and Minicoy ; pomacentrids especially *Chromis caeruleus* formed the bulk of the catch at most of the islands namely, Agatti, Bangaram, Suheli Par, Chetlat and Minicoy ; and atherinids at Bitra.

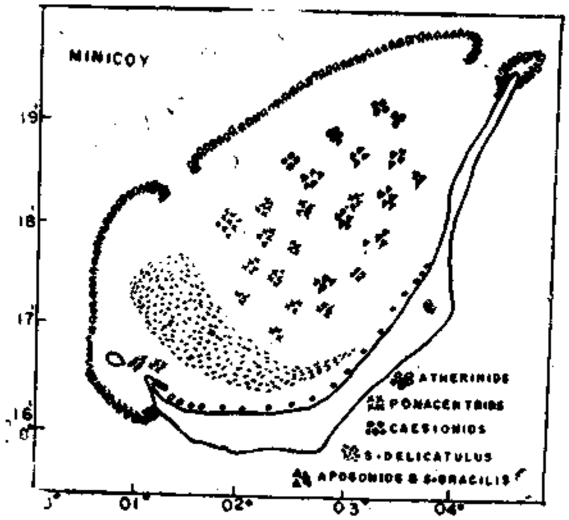

Fig. 1. Distribution of live baits in the lagoon of Minicoy.

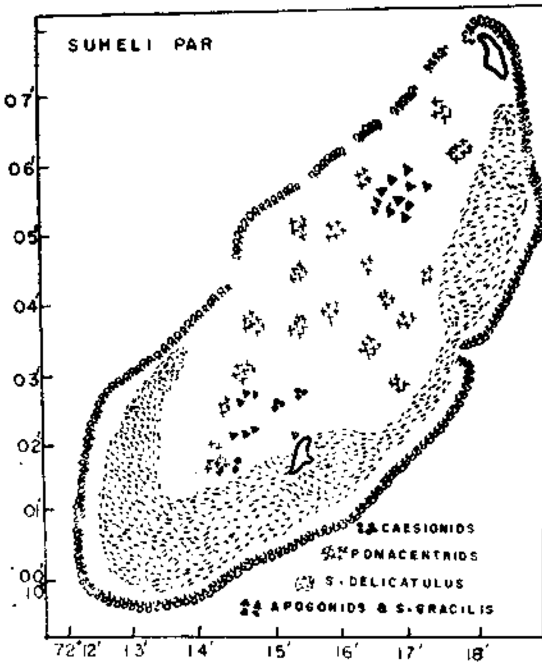

Fig. 2. Distribution of live baits in the lagoon of Suheli Par.

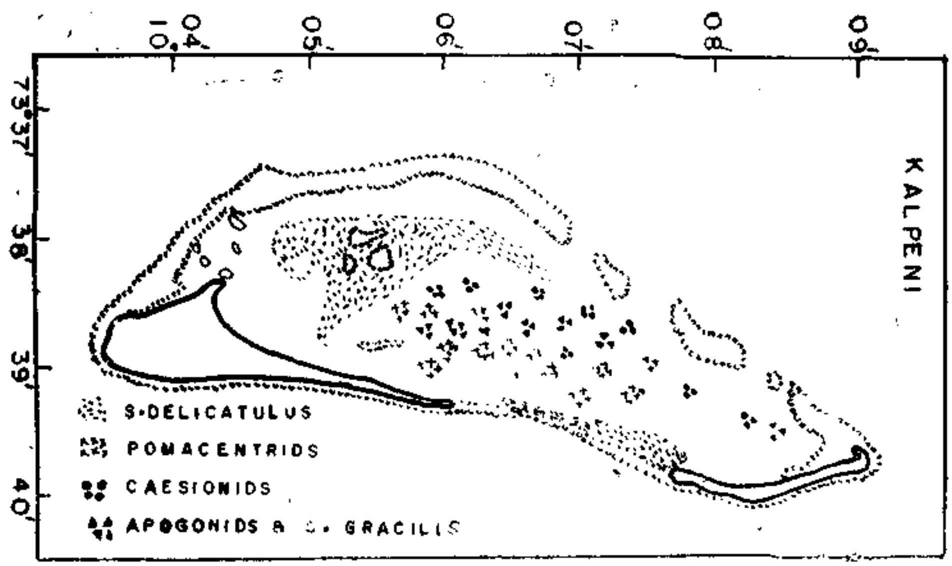

Fig. 3. Distribution of live baits in the lagoon of Kalpeni.

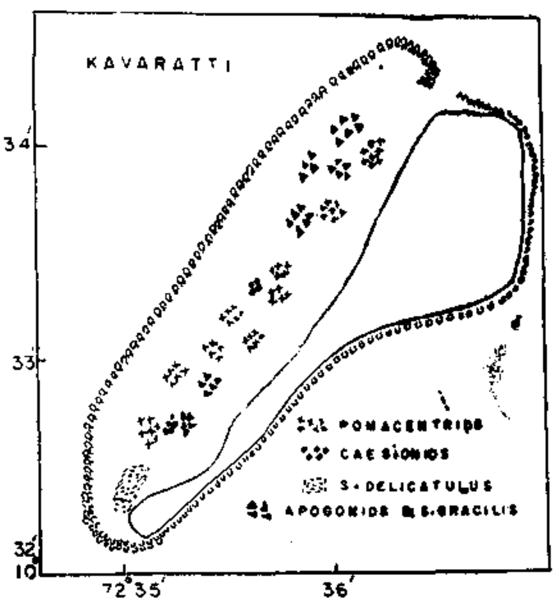

Fig. 4. Distribution of live baits in the lagoon of Kavaratti.

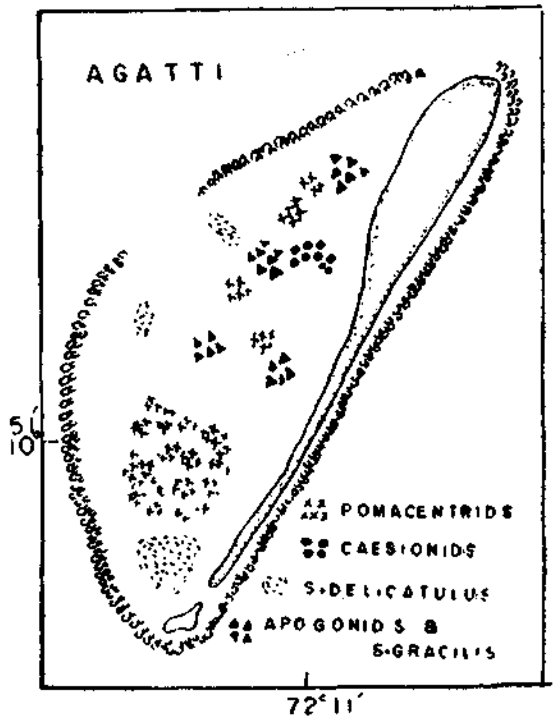

Fig. 5. Distribution of live baits in the lagoon of Agatti.

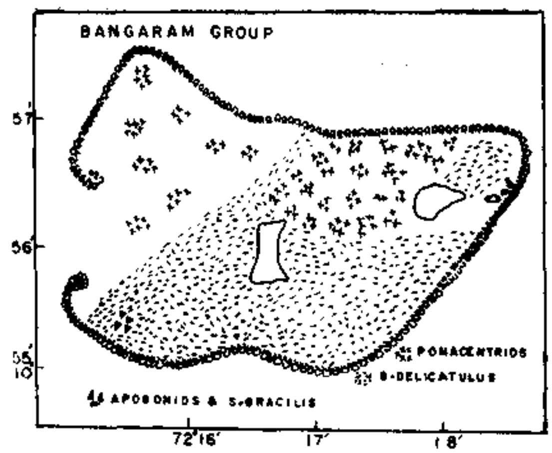

Fig. 6. Distribution of live baits in the lagoon of Bangaram Group.

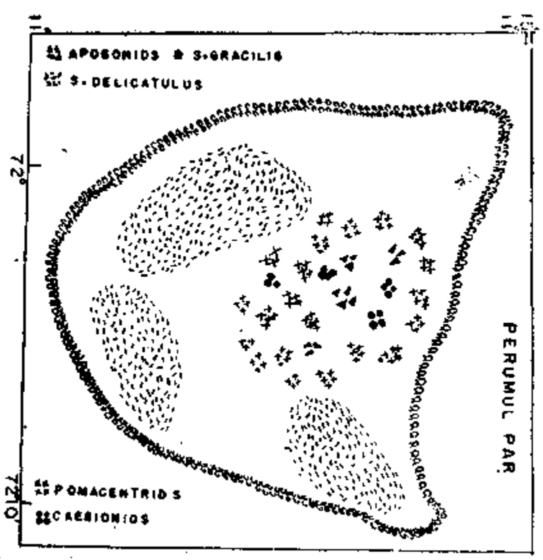

Fig. 7. Distribution of live baits in the lagoon of Perumul Par.

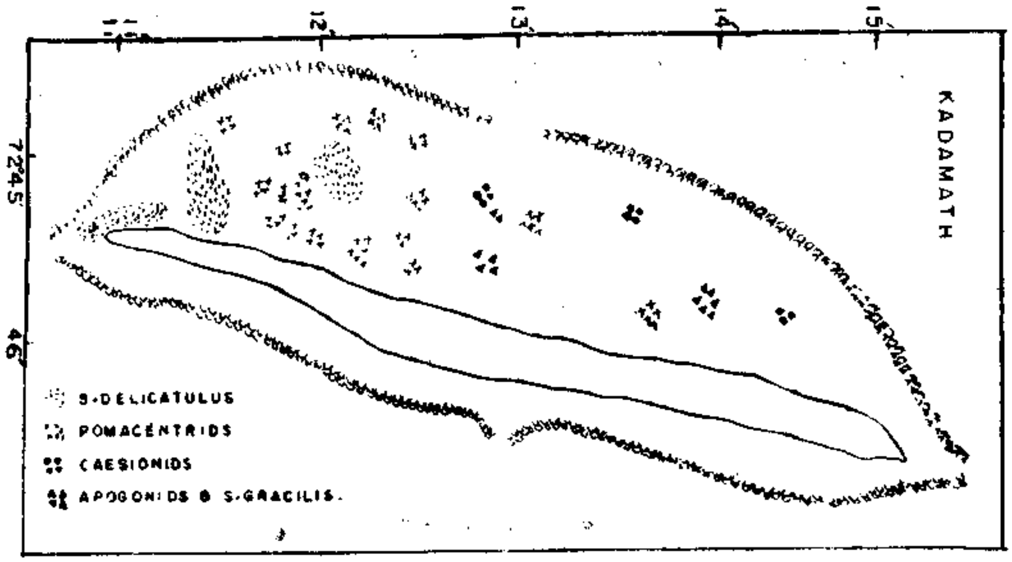

Fig. 8. Distribution of live baits in the lagoon of Kadamath.

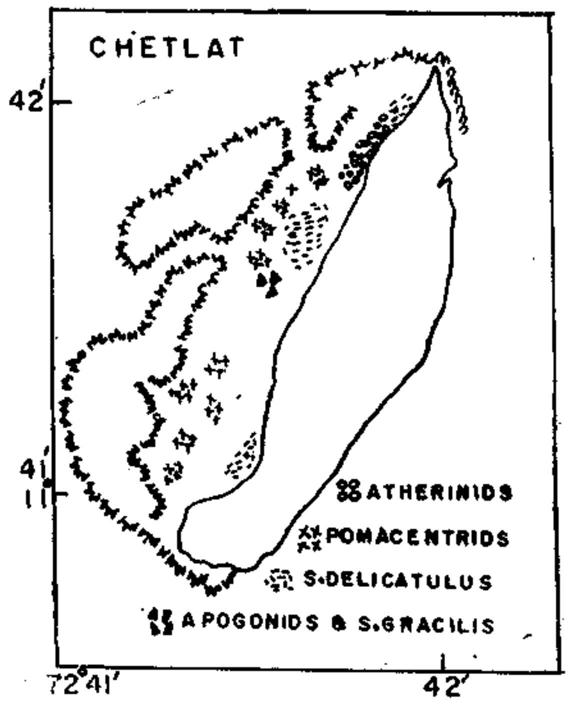

Fig. 9. Distribution of live baits in the lagoon of Chetlat,

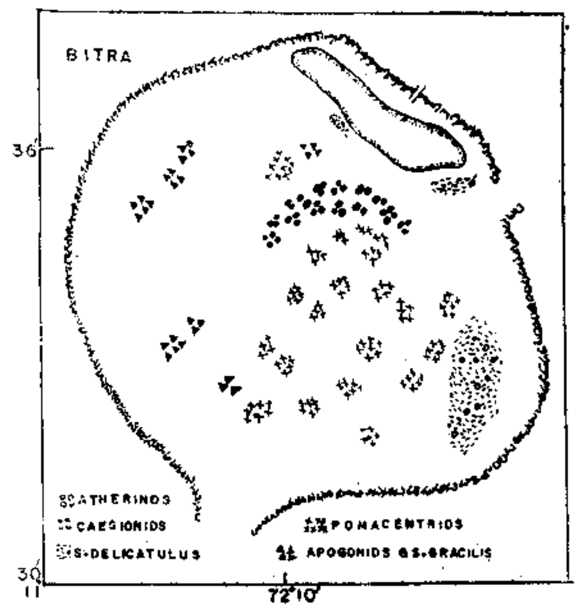

Fig. 10. Distribution of live baits in the lagoon of Bitra,

TABLE 1. *Percentage distribution of different groups of live baits in Lakshadweep*

Islands		Sprats	Apogonids	Pomacentrids	Caesionids	Atherinids	Total weight (gm)
Kavaratti	..	12.4	63.2	23.0	1.4	—	1,740
Agatti	..	12.2	38.3	34.0	15.4	—	6,535
Bangaram	..	22.4	1.0	75.6	1.0	—	4,900
Perumul Par	..	28.8	40.2	26.2	4.8	—	3,125
Suheli Par	..	34.6	9.8	52.0	3.6	—	3,945
Kadamat	..	13.1	42.4	42.5	2.0	—	4,955
Bitra	..	37.5	16.3	32.7	1.0	12.5	5,200
Chetlat	..	—	—	91.2	—	8.8	570
Kalpeni	..	29.6	25.6	33.2	9.7	2.0	7,590
Minicoy	..	22.5	28.4	38.8	10.1	0.3	6,165

TABLE 2. *Catch composition of baitfishes (in gm) collected during the survey*

Species		Kava-ratti	Agatti	Banga-ram	Perumul par	Suheli par	Kada-mat	Bitra	Chet-lat	Kalpeni	Mini-coy
Dussumieridae											
S. delicatulus	..	215	400	1,100	750	490	650	1,250	—	1,600	1,218
S. gracilis	..	—	400	—	150	875	—	700	—	650	168
Apogonidae											
A. fucata	..	50	250	—	—	60	1,850	—	—	—	650
A. sangiensis	..	—	50	—	—	125	200	—	—	—	153
A. leptacanthus	..	—	250	—	—	125	—	—	—	—	—
R. cypselurus	..	—	450	5	—	—	—	—	—	—	—
R. gracilis	..	—	1,450	—	1,250	77	—	850	—	1,595	845
O. apogonides	..	1,050	5	—	—	—	—	—	—	350	100
O. quadrifasciatus	..	—	50	50	—	—	50	—	—	—	—
Caesionidae											
C. caerulaureus	..	—	650	40	150	140	—	50	—	385	410
P. pisang	..	—	55	—	—	3	—	—	—	—	—
P. tile	..	—	—	—	—	—	—	—	—	—	106
P. chrysozona	..	—	300	—	—	—	100	—	—	335	105
C. xanthonotus	..	25	—	—	—	—	—	—	—	—	—
Pomacentridae											
C. caeruleus	..	250	2,005	3,660	800	2,050	2,050	1,650	520	2,500	2,316
C. nigrurus	..	—	20	—	20	—	—	—	—	10	—
P. pavo	..	150	200	50	—	—	50	50	—	—	—
L. tapeinosoma	..	—	—	—	—	—	5	—	—	—	74
Atherinidae											
P. pinguis	..	—	—	—	—	—	—	650	50	510	20

Species-wise occurrence of different baitfishes in the lagoons of the islands surveyed is presented in Table 2. It is evident from the Table that the common species represented in most of the islands were *S. delicatulus*, *S. gracilis*, *R. gracilis*, *C. caerulaureus* and *Chromis caeruleus*.

is presented in Fig. 11 a. Throughout the period of study, a bimodal distribution of abundance of live baits was noted, the primary peak during October-November and the secondary peak during March-April. Tertiary peak of less magnitude was also noted during January in 1985 and 1987.

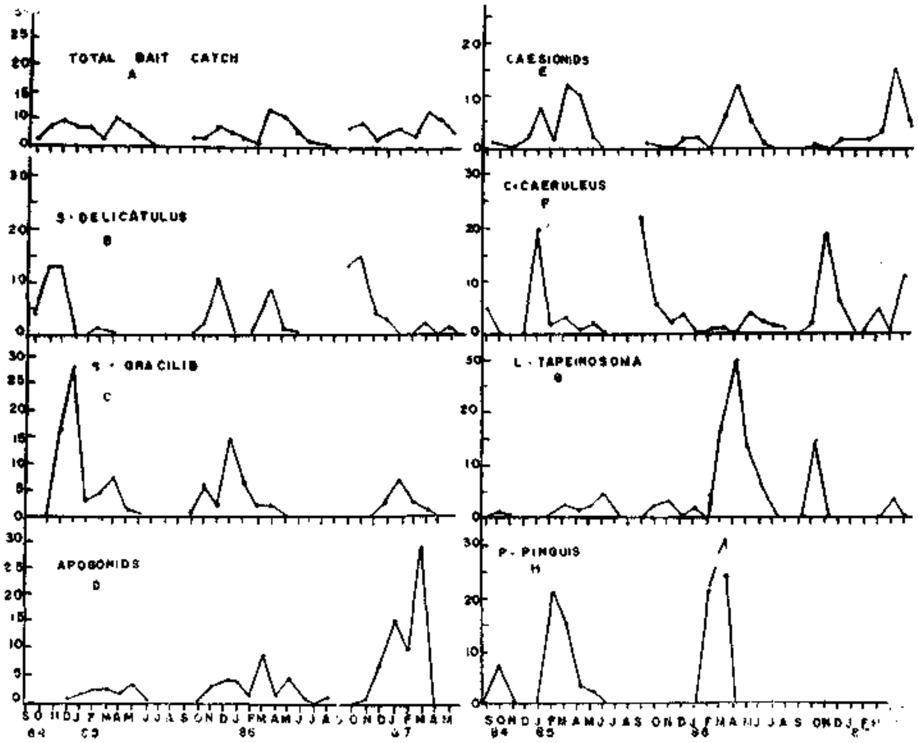

Fig. 11. a. Trend of catch of tuna livebaits at Minicoy during September '84 to May '87 and Seasonal trend of different groups of livebaits at Minicoy, b. *S. delicatulus*, c. *S. gracilis*, d. *Apogonids*, e. *Caesionids*, f. *C. caeruleus*, g. *L. tapeinosoma*, and h. *P. pinguis*.

Catch rate expressed as catch per operation (gms) during the survey indicate that it was maximum at Kadamat (1.24 kg) followed by Agatti (0.82 kg), Bitra (0.81 kg), Suheli Par (0.79 kg), Bangaram (0.70 kg), Perumul Par (0.63 kg) and Minicoy (0.47 kg). Low catch rates were observed at Kavaratti and Chetlat.

The seasonal trend of the catch of tuna live baits during September 1984 to May 1987

The occurrence and abundance of important live baits such as *S. delicatulus*, *S. gracilis*, apogonids, caesionids, *C. caeruleus*, *Lepidozygus tapeinosoma* and *Pranesus pinguis* at Minicoy during the same period are shown in Fig. 11 b to h. For migratory forms such as caesionids March-May period was found to be more productive, whereas the resident species such as apogonids evinced erratic abundance pattern during most of the months.

The catch rate of tuna live baits at Minicoy during the period mentioned above indicated that the monthly catch per effort varied between 0.7 kg and 3.1 kg with the mean of 2.1 kg.

in Fig. 12 to 14. It is seen that the common size range noted for them ranged from 25 to 79 mm.

Length-weight relationship : Length-weight relationships were calculated for males, females

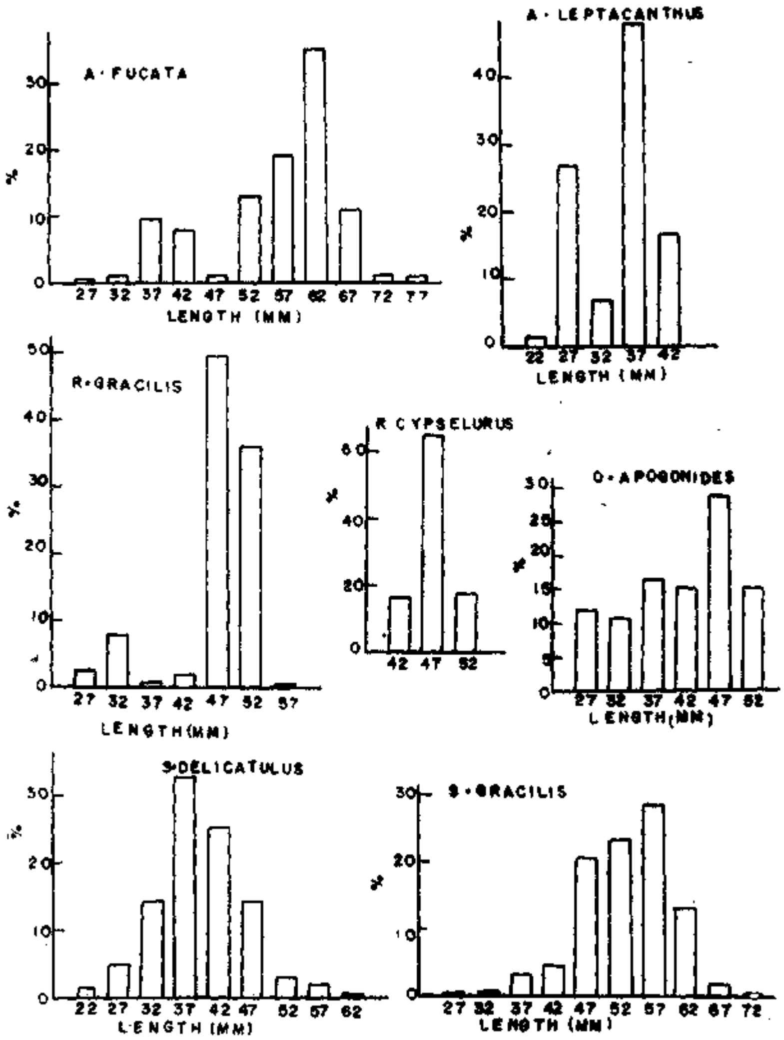

Fig. 12. Size composition of *A. fucata, R. gracilis, S. delicatulus, A. leptacanthus, R. cypselurus, O. apogonides* and *S. gracilis*.

Biological Characteristics

Size composition : The size composition of seventeen species of live baits collected from the various lagoons of Lakshadweep is given

and juveniles separately for ten species for which adults and juveniles are employed as live bait and for juveniles only, for seven species for which only juveniles are used for live bait purpose. The number of fish used for the estimation (n), the 'r' value and the length-weight relationship formulae are given in Table 3. The length-weight relationship plotting is given in Fig. 15 to 17.

Size at first maturity: To determine the size at first maturity, the percentages of mature and immature specimens at 2 mm interval were determined. Maturity stages I and II were treated as immature and III to VII as mature. Size at first maturity at 50% level was calculated for ten species for which adults were also used as live baits (Fig. 18). The smallest size of mature fish obtained and the size at first maturity of the ten species are given in Table 4.

Sex ratio: The sex ratio was calculated for ten species which showed that in most cases males and females were represented in 1 : 1 ratio. However, the Male : Female ratio for *Pomacentrus pavo* was 1 : 1.24, for *R. gracilis* 1 : 2 and for *P. pinguis* 1 : 1.5. The sex ratio of different species is given in Table 5. Incubating eggs in the mouth were noted for the apogonids *viz. A. sangiensis, A. fucata* and *O. quadrifasciatus.*

Fecundity: Mature ovaries in stages IV to VI were used for estimating fecundity. Only yolked eggs were enumerated. Fecundity estimates were made for ten species and the results are presented in Table 6.

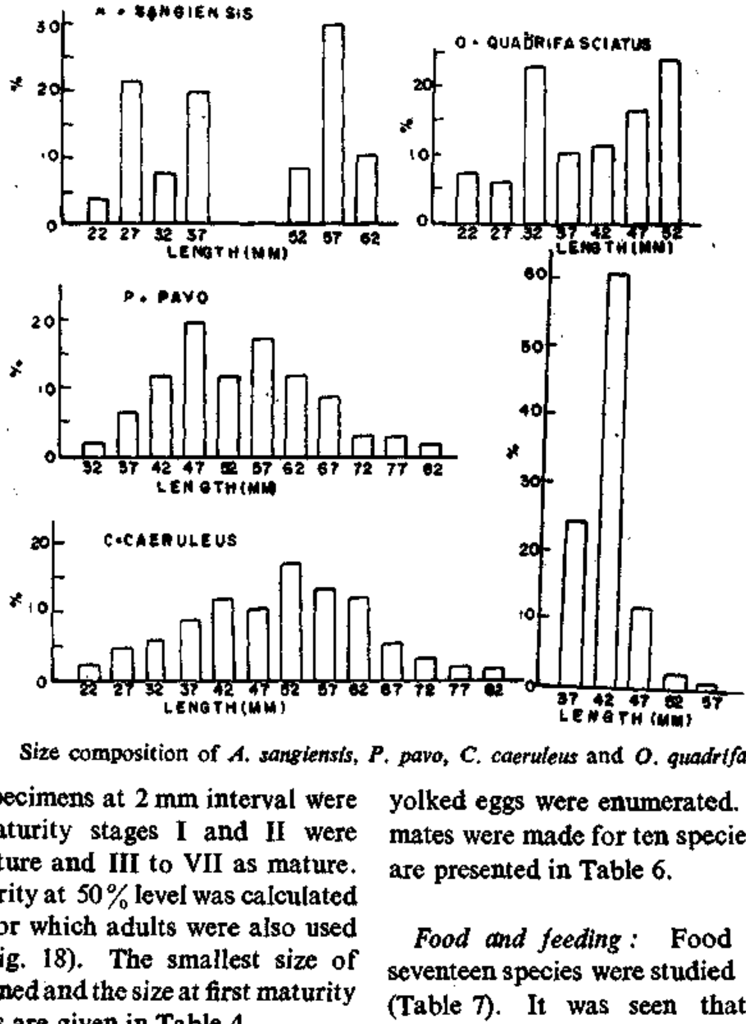

Fig. 13. Size composition of *A. sangiensis, P. pavo, C. caeruleus* and *O. quadrifasciatus.*

Food and feeding: Food and feeding of seventeen species were studied by gross analysis (Table 7). It was seen that all the species except *P. pavo* were zooplankton feeders and *P. pavo* was an algal browser. Apogonids are nocturnal feeders and the rest diurnal feeders with peak feeding during early morning and evening hours.

TABLE 3. *Length-weight relationships of live bait fishes*

Species	Male	Female	Juvenile
S. delicatulus ..	$W=0.015010\ L^{2.7771}$ r=0.9416 n=348	$W=0.00431\ L^{[illegible]}$ r 0.9616 n=317	$W=0.00157\ L^{[illegible]}$ r=0.9871 n=49
S. gracilis ..	$W=0.0018403\ L^{[illegible]}$ r=0.9398 n=317	$W=0.002084\ L^{[illegible]}$ r=0.9159 n=355	$W=0.015754\ L^{[illegible]}$ r=0.9898 n=11
C. caeruleus ..	$W=0.011237\ L^{[illegible]}$ r=0.8859 n=135	$W=0.113579\ L^{2.5613}$ r=0.9146 n=109	$W=0.04515\ L^{[illegible]}$ r=0.9532 n=115
A. fucata ..	$W=0.004748\ L^{3.2641}$ r=0.9104 n=76	$W=0.004422\ L^{[illegible]}$ r=0.9105 n=64	$W=0.00933\ L^{[illegible]}$ r=0.9845 n=37
R. gracilis ..	$W=0.03963\ L^{[illegible]}$ r=0.7724 n=89	$W=0.00161\ L^{[illegible]}$ r=0.8793 n=89	$W=0.04005\ L^{2.5441}$ r=0.8779 n=25
R. cypselurus ..	$W=0.00620\ L^{[illegible]}$ r=0.8554 n=18	$W=0.1023\ L^{[illegible]}$ r=0.7537 n=36	—
A. sangiensis ..	$W=0.1265\ L^{[illegible]}$ r=0.7995 n=25	$W=0.02181\ L^{[illegible]}$ r=0.7357 n=27	$W=0.00253\ L^{[illegible]}$ r=0.9742 n=55
A. leptacanthus ..	—	—	$W=0.000568\ L^{[illegible]}$ r=0.9763 n 70
O. quadrifasciatus ..	$W=0.003522\ L^{[illegible]}$ r=0.9767 n=22	$W=0.01376\ L^{[illegible]}$ r=0.9867 n=29	$W=0.0043\ L^{[illegible]}$ r=0.9710 n=45
O. apogonides ..	—	—	$W=0.020352\ L^{[illegible]}$ r=0.9715 n=90
P. pavo ..	$W=0.03413\ L^{[illegible]}$ r=0.9901 n=21	$W=0.05076\ L^{2.7209}$ r=0.9300 n=50	$W=0.0675\ L^{[illegible]}$ r=0.9635 n=20
L. tapeinosoma ..	—	—	$W=0.608835\ L^{[illegible]}$ r=0.5383 n=128

TABLE 3 (*Contd.*)

Species	Male	Female	Juvenile
C. caerulaureus ..	—	—	$W=0.008967\ L^{3.0880}$ $r=0.7881$ $n=231$
P. chrysozona ..	—	—	$W=0.004261\ L^{3.1618}$ $r=0.9606$ $n=203$
G. gymnopterus ..	—	—	$W=0.4988\ L^{2.5353}$ $r=0.7586$ $n=31$
C. striatus ..	—	—	$W=0.005094\ L^{3.1811}$ $r=0.9672$ $n=50$
P. pinguis ..	$W=0.002162\ L^{3.3043}$ $r=0.9843$ $n=71$	$W=0.001018\ L^{3.4741}$ $r=0.9793$ $n=108$	—

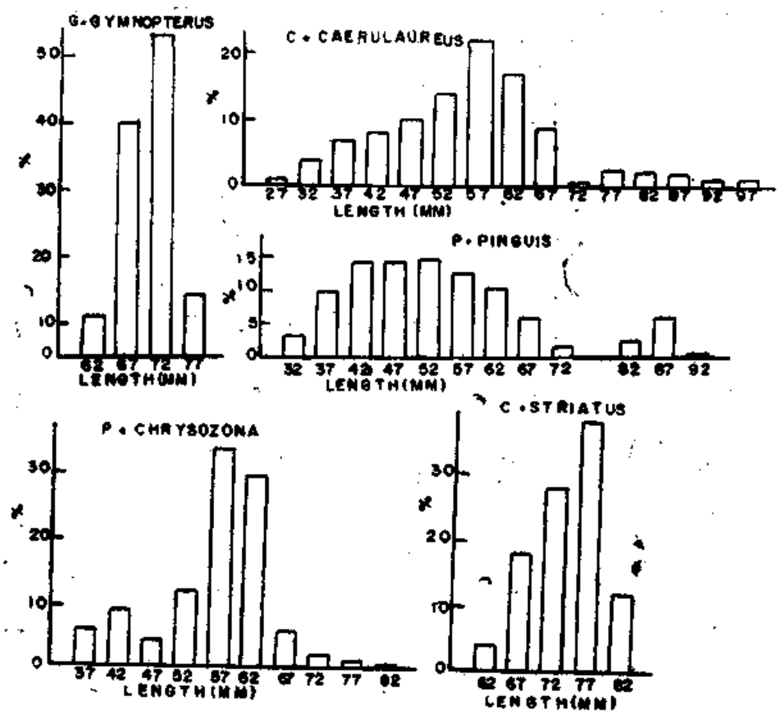

Fig. 14. Size composition of *G. gymnopterus*, *P. chrysozona*, *C. caerulaureus*, *P. pinguis* and *C. striatus*.

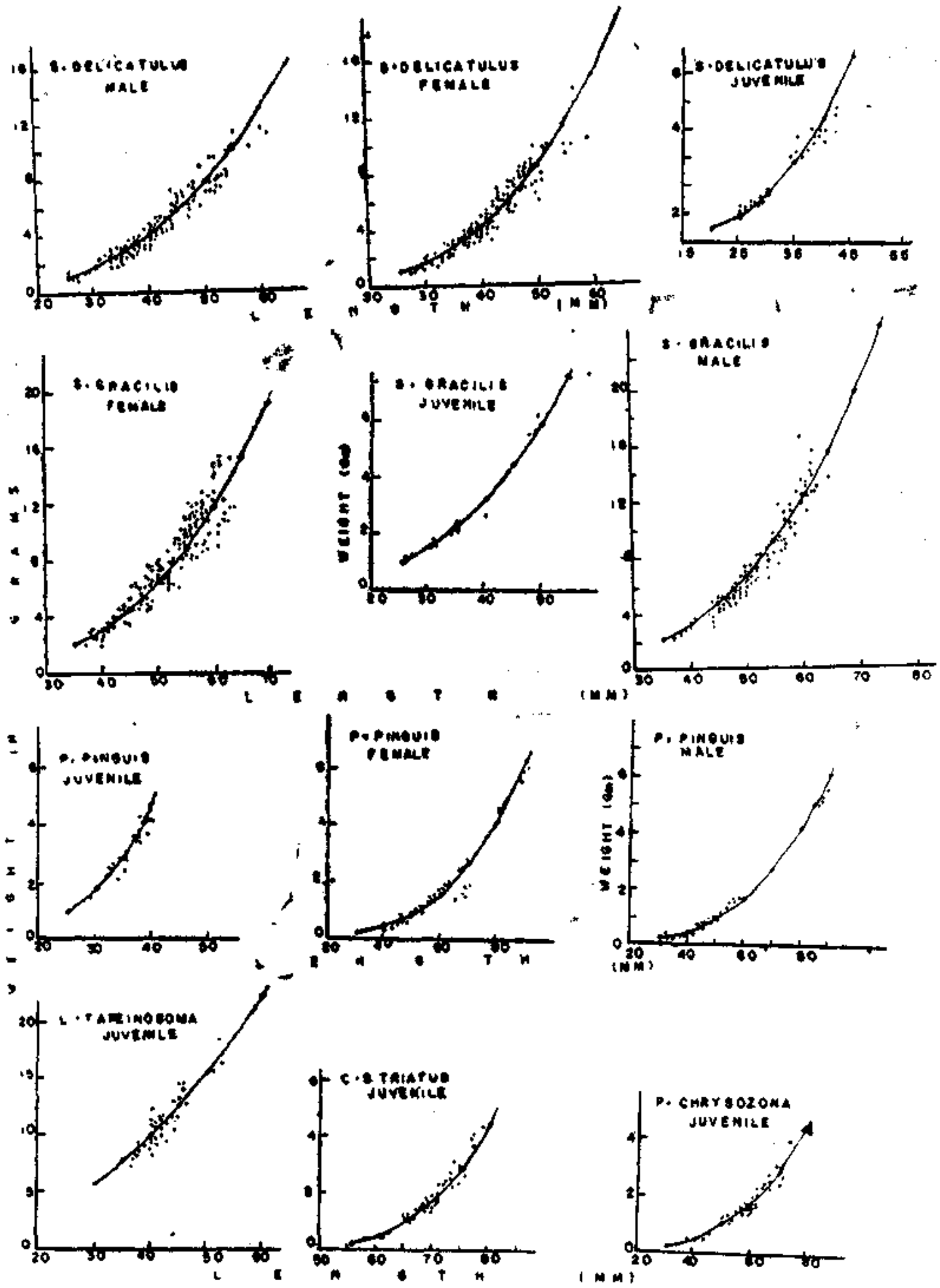

Fig. 15. Length-weight relationships of *S. delicatulus*, *S. gracilis*, *P. pinguis*, *L. tapeinosoma*, *C. striatus* and *P. chrysozona*.

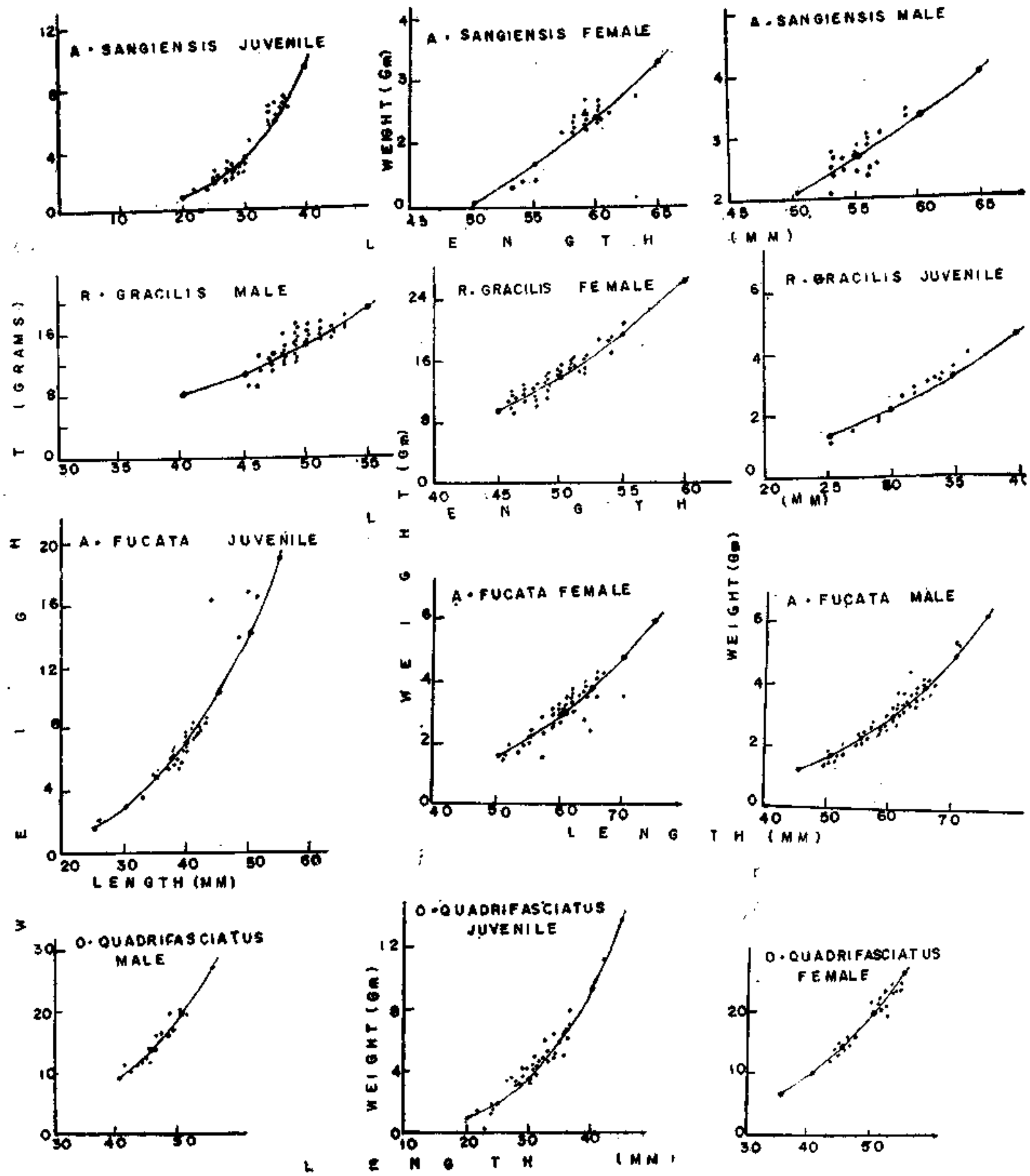

Fig. 16. Length-weight relationships of *A. sangiensis*, *R. gracilis*, *A. fucata* and *O. quadrifasciatus*.

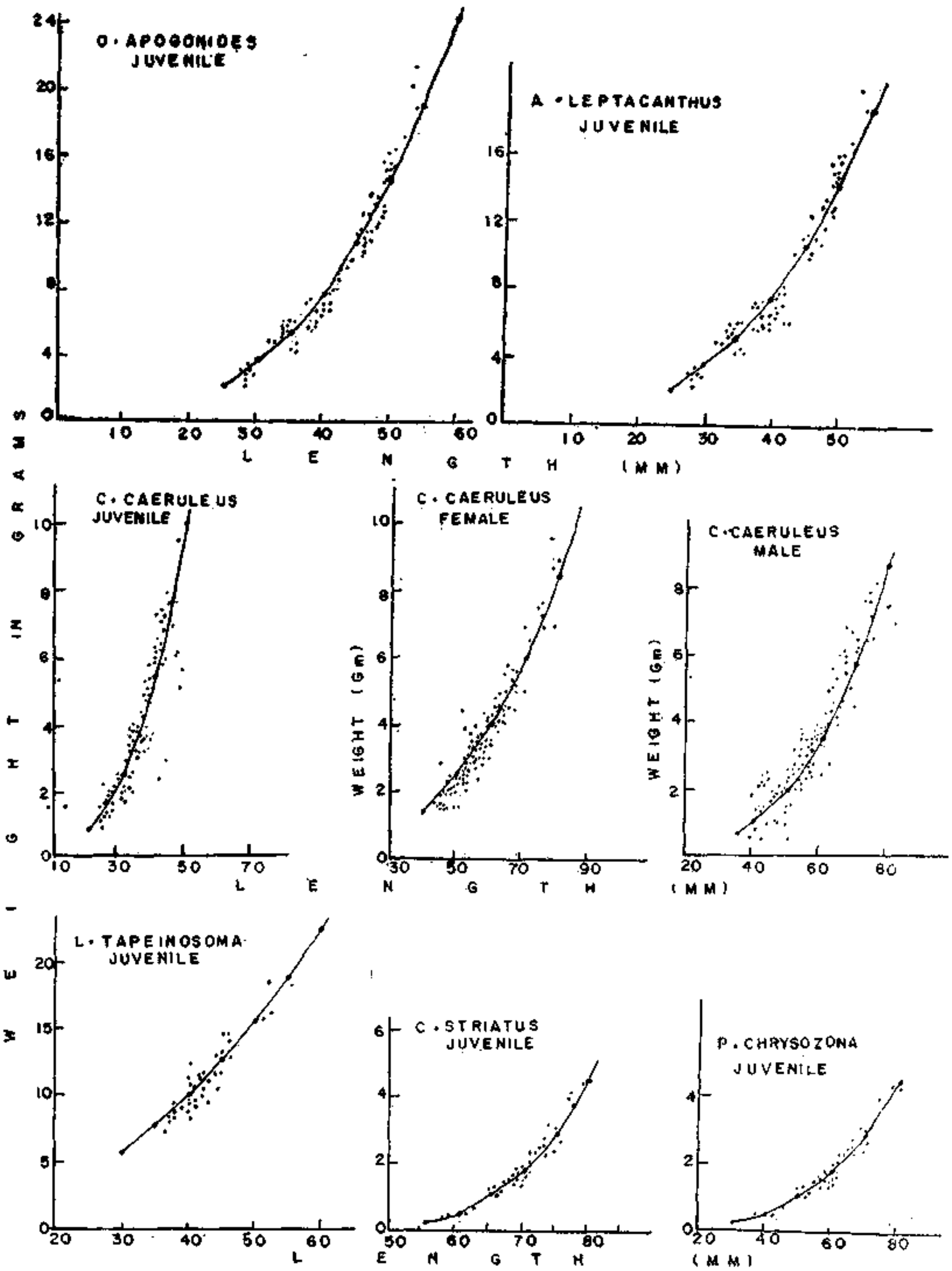

Fig. 17. Length-weight relationships of *O. apogonides, C. caeruleus, L. tapeinosoma, A. leptacanthus, C. striatus* and *P. chrysozona*.

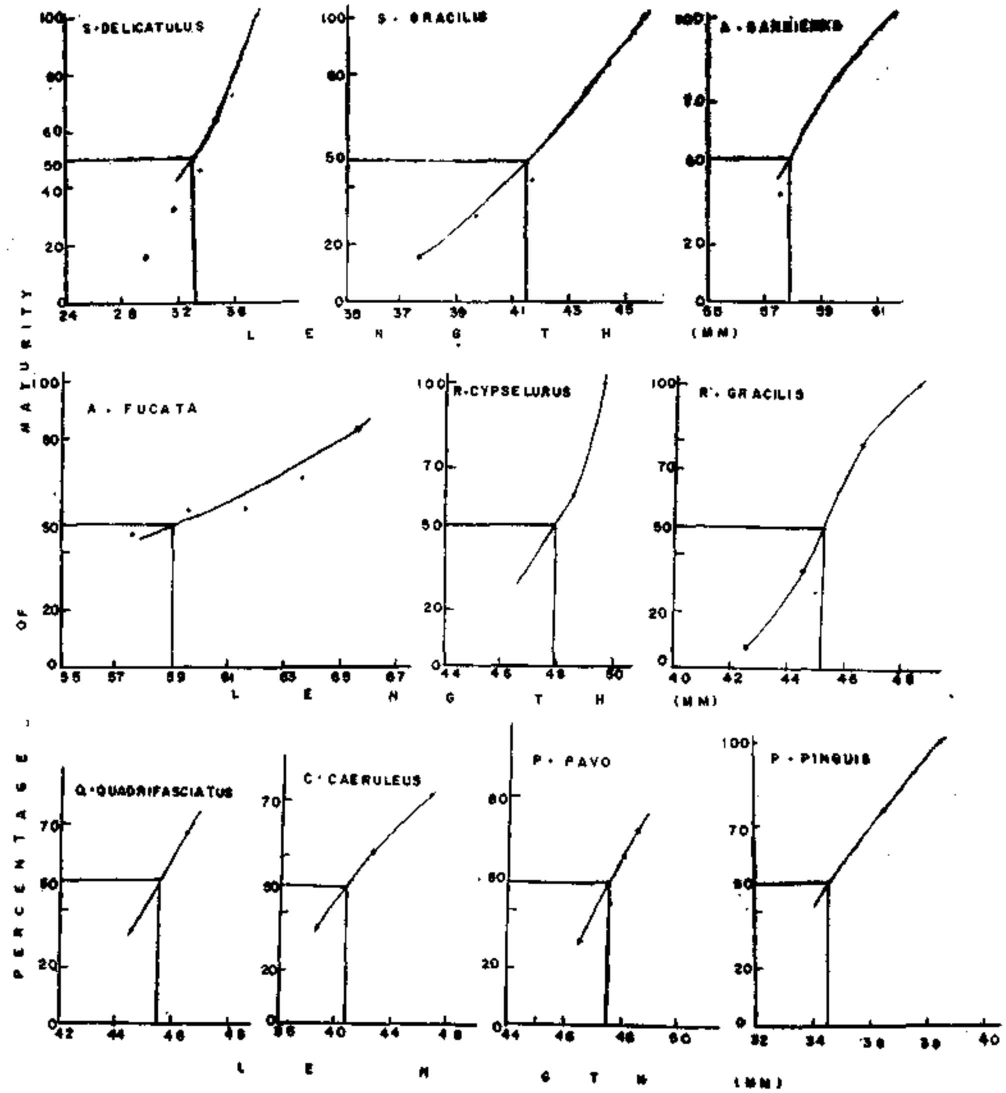

Fig. 18. Size at first maturity of *S. delicatulus*, *A. fucata*, *O. quadrifasciatus*, *S. gracilis*, *R. cypselurus*, *C. caeruleus*, *A. sangiensis*, *R. gracilis*, *P. pavo* and *P. pinguis*.

TABLE 4. *Size at first maturity of live bait fishes*

Species		Smallest mature fish observed (mm)	Size at first maturity (mm)
Spratelloides delicatulus	..	29	33
S. gracilis	..	37	41
Archamia fucata	..	55	59
Rhabdamia gracilis	..	44	45
R. cypselurus	..	46	48
Apogon sanglensis	..	57	58
Ostorhynchus quadrifasciatus		44	46
Pomacentrus pavo	..	46	48
Chromis caeruleus	..	40	41
Pranesus pinguis	..	34	34

TABLE 5. *Sex ratios of live bait fishes*

Species		No. of males	No. of females	Female Male :
S. delicatulus	..	348	317	1.1 : 1.0
S. gracilis	..	317	355	1.0 : 1.1
A. fucata	..	76	64	1.2 : 1.0
R. gracilis	..	89	89	1.0 : 1.0
R. cypselurus	..	18	36	1.0 : 2.0
A. sangiensis	..	25	27	1.0 : 1.1
O. quadrifasciatus	..	22	29	1.0 : 1.3
P. pavo	..	21	50	1.0 : 2.4
C. caeruleus	..	135	133	1.0 : 1.0
P. pinguis	..	71	108	1.0 : 1.5

TABLE 6. *The total length (TL) range, total weight (TW) range, fecundity (total number of yolked eggs) range and the mean relative fecundity (eggs per gm body weight) of live bait fishes*

Species		No. of fish studied	TL range (mm)	TW range (gms)	Fecundity range	Mean relative fecundity
S. delicatulus	..	17	38-49	0.40-0.93	235-1,087	818
S. gracilis	..	42	47-61	0.68-1.52	541-2,393	1,067
A. fucata	..	13	57-66	1.52-4.12	1,146-2,558	540
R. gracilis	..	15	49-54	1.30-1.74	1,509-3,225	1525
R. cypselurus	..	17	46-52	0.88-1.88	1,270-3,310	1,660
A. sangiensis	..	20	57-61	2.34-3.78	1,320-5,770	1,077
O. quadrifasciatus	..	16	46-54	1.45-2.52	930-2,960	1,058
P. pavo	..	17	47-67	2.07-6.48	1,526-6,023	909
C. caeruleus	..	30	48-77	2.49-9.65	1,715-22,765	1,343
P. pinguis	..	14	42-63	0.42-1.91	90-330	239

TABLE 7. *Food and feeding habits of live bait fishes (All are zooplankton feeders except* P. pavo *which is an algal browser)*

Species	Major food items
S. delicatulus	Copepods, decapod larvae, mysids, polychaetes, *Lucifer*, cladocerans, amphipods.
S. gracilis	Copepods, cladocerans, decapod larvae, amphipods, crustacean remains.
C. caeruleus	Decapod larvae, copepods.
P. pavo	Algal filaments.
R. gracilis	Copepods, amphipods, decapod larvae, cladocerans, mysids, fish eggs, zoea of crab, polyp of siphonophores.
R. cypselurus	Cladocerans, crustacean remains.
A. fucata	Amphipods, mysids.
A. sangiensis	Copepods, amphipods.
O. quadrifasciatus	Decapod larvae, euphausids, amphipods.
O. apogonides	Decapod larvae copepods, crab larvae, crustacean remains.
A. leptacanthus	Mysids, cumacea, copepods, amphipods.
C. caerulaureus	Copepods, decapod larvae, crustacean eggs, cladocerans, ostracods, polychaetes.
P. chrysozona	Copepods, crustacean remains, apogonid eggs, ostracods, decapod larvae, cladocerans.
P. pisang	Decapod larvae, ostracods, crustacean remains.
C. xanthonotus	Ostracods, decapod larvae, crustacean remains.
L. tapeinosoma	Copepods, crustacean eggs.
P. pinguis	Copepods, *Lucifer*, postlarvae of molluscs.

BAITFISH EVALUATION

The desired characteristics of a good live bait fish are (i) length below 15 cm. preferably between 6-8 cm, (ii) highly reflective lateral surface, (iii) a tendency to flee towards the surface, (iv) hardiness and survival for prolonged periods in captivity, (v) a tendency to return to the boat when broadcast and (vi) relative abundance and availability to the fishery. An evaluation of the above characteristics of the tuna live baits of Lakshadweep was made based on the review of literature and field and laboratory observations, and the results are as follows :

A. Body length	1. 2.5 to 7.5 cm.
	2. 7.5 to 15.2 cm.
B. Body form	1. Elongate.
	2. Oblong.
	3. Deep bodied.
	4. Notably compressed.
C. Body colouration	1. Silvery.
	2. Light, dusky.
	3. Medium dark to dark.
	4. Dark and light.
	5. Bright colours.

D. Baitfish behaviour	1. Response to predator.
	2. No response to predator.
	3. Schooling or balling around vessel.
	4. Disperses, dives, sounds or leaves the vessel.
E. Schooling behaviour	1. Schools at or near surface.
	2. Schools at or near bottom.
	3. Aggregates on or adjacent to reefs.
	4. Disperses or solitary.
F. Survival in captivity	1. Good.
	2. Fair.
	3. Poor.
G. Baitfish evaluation	1. Excellent (High attraction rate).
	2. Good (Effective, suitable, successful etc.).
	3. Poor (Low attraction rate).

	A	B	C	D	E	F	G
Dussumieridae							
S. delicatulus ..	1	1	1	3	1	2, 3	1, 2
S. gracilis ..	1	1	1	3	1	2	1
Apogonidae							
A. fucata ..	1	2	5	2	3	1	2
R. gracilis ..	1	2	5	2	3	1	1
R. cypselurus ..	1	2	5	2	3	1	2
A. sangiensis ..	1	2	5	2	3	1	2
A. leptacanthus ..	1	2	5	2	3	1	2
O. quadrifasciatus ..	1	2	5	2	3	1	2
O. apogonides ..	1	2	5	2	3	1	2
Caesionidae							
C. caerulaureus ..	1, 2	2	5	1	2	1	1
C. striatus ..	1, 2	2	5	1	2	1	1
P. pisang ..	1, 2	2	5	1	2	1	1
P. chrysozona ..	1, 2	2	2	1	2	1	1
G. gymnopterus ..	1, 2	5	2	1	2	1	1
Pomacentridae							
C. caeruleus ..	1, 2	3	3	4	3	1	2
P. Pavo ..	1, 2	3	3	4	3	1	2, 3
L. tapeinosoma ..	1	2	3	1	3	1	1
Atherinidae							
P. pinguis ..	1, 2	1	1	—	1	1	2, 3

DISCUSSION

Shomura (1977) opined that none of the species used in the pole and line fishery as live bait could be described as 'perfect' baitfish, since some species may be good for initially attracting tunas, but may not be too effective in holding the fish at the boat. However, based on the desirable characteristics some of the species can be categorised into 'good' baitfish. From the overall picture of the evaluation of the characteristics of baitfish, it could be seen that *S. delicatulus*, *S. gracilis*, *R. gracilis*, *C. caerulaureus*, *C. striatus*, *P. chrysozona*, *G. gymnopterus* and *L. tapeinosoma* can be categorised as the best species of live baits. The high initial mortality of the sprats, especially of *S. delicatulus* at the time of capture and handling is a negative aspect of its suitability. The apogonid *R. gracilis* eventhough is an excellent bait, the availability of it all through the fishing season in the islands has to be ascertained. The juveniles of caesionids and the pomacentrid, *L. tapeinosoma* even. though are excellent baits, their migratory nature causes wide fluctuation in their availability from year to year which make them undependable species for the pole and line fishery. The sprats, apogonids and the pomacentrid *Chromis caeruleus* are the major resident species which can sustain the pole and line fishery.

The scarcity of live bait at Lakshadweep, often reported in recent years can be attributed mainly to three reasons *viz.* (i) tampering the lagoon ecosystem (ii) the wide fluctuation in the availability, of migrant bait species in certain years and (iii) the exploitation pressure due to the increased demand. With the increase in effort of pole and line fishery to northern islands the demand for live baits has increased considerably. The data collected by CMFRI indicate that the utilisation of live baits at Minicoy has increased from 2799 kg in 1981-82 to 6,457 kg in 1986-87. In the islands other than Minicoy, only *S. delicatulus* is being exploited at present as live bait, whereas the live bait resource survey has proved that vast resources of live bait species, both migrant and resident forms belonging to pomacentridae, apogonidae and caesionidae are available around Agatti, Bangaram, Perumul Par, Suheli Par, Kadamat and Bitra. Hence as recommended by James *et al.* (1987) steps should be taken to encourage exploitation of live bait species other than *S. delicatulus* also. This can avoid the dependence of tuna fishery on this single species, the scarcity of which suspends the tuna fishing as well as depletion of the stock of the species due to over exploitation.

An aspect worth considering for the better utilization of available resources is to evolve better methods of handling, holding and transportation of baits especially those which are prone to large scale mortality during capture and handling such as *S. delicatulus.* Gopakumar and Mathew (1986) reported that initial mortality of *S. delicatulus* following capture ranges from 30-80% depending on the mode of capture, size of fish and density stocked in the tank. They found that the shock mortality due to osmoregulatory stress was greatly reduced by introducing the fish to 50% sea water immediately after capture. Strusaker *et al.* (1975) studied environmental factors affecting stress and mortality of *Stolephorus purpureus* and reported a variety of factors such as capturing the fish during night time, transferring the bait by allowing the fish to swim, introducing the fish in 50% sea water immediately after capture, keeping oxygen concentration to saturation level, using green coloured tanks with rounded corners for storing bait, etc. could reduce the mortality of the bait. Smith (1977) observed that daylight loading of the bait catch, avoiding overcrowding in the bait net and use of buckets with blue colour for transferring bait substantially reduced initial mortality.

An alternative to supplement the natural baitfish resources is to culture live baits.

Shomura (1977) opined that problems faced in culturing baitfish differ markedly from place to place, especially as to the availability of land and fresh water for developing the culture facilities. Herrick *et al.* (1975) investigated the feasibility of rearing the topminnow *Poecilia vittata*, a viviparous fish by using high density cultural techniques. They reported that the cost of producing topminnows are substantially lower than the costs of capturing live bait and hence the production of topminnows on a commercial level using the techniques developed at Hawaii Institute of Marine Biology appeared to be economically feasible. Baldwin (1977) also opined that intensive culture of a suitable live bait fish appears to offer a reasonable solution in areas known to have little or no natural stocks of baitfish. However, it is felt that a substantial capital investment is required for the construction of brood ponds, rearing ponds, wells, water storage tanks, the land for locating these facilities and the costs of equipments such as pumps, compressors, generators etc. Recurring expenditures such as maintenance of equipments, electricity, food, labour, etc. are also involved. According to Collette and Nauen (1983) and Sakagawa (1986) the bait rearing is hardly feasible on large enough scale to support a major fishery for skipjack tuna. At Lakshadweep, due to the costs involved in the operations to capture natural live baits for culture practices and capital intensive culture systems, the economic feasibility of utilising the cultured baits to sustain the present small scale fishery and envisaged expansion in this sector should be carefully ascertained. Eventhough the breeding biology of only few species are known, the candidate species for holding and rearing appears to be *Chromis caeruleus*, *Rhabdamia gracilis* and *Archaemia fucata*. The mouth breeding habit of some of the apogonids is a positive aspect in their being reared in captivity.

Another aspect for solving the baitfish scarcity problem is the introduction of substitute baits. Baldwin (1977) stated that throughout the Pacific, anchovies rank first in terms of quantity used, value and general desirability as baitfishes. Based on the live bait investigations done at Vizhinjam, Luther *et al.* (1984) reported that for *Stolephorus buccaneeri* and *S. devisi* hardiness could be increased by holding them in pens and it was possible to keep the former species for about three months and the latter two months in captivity. No information is available on the *Stolephorus* resources around Lakshadweep. The feasibility of capturing and utilising whitebaits as live bait for tuna in the Lakshadweep sea needs to be explored. Since the environmental degradation deprives the live bait species of the specific microhabitat requirements to settle at the end of their postlarval pelagic life, the protection of the reef ecosystem while implementing developmental programmes in the islands is of paramount significance. In short, employment of all the species of available live baits, better utilization of captured live bait, development of economically viable confinement and transportation methods, artificial production of live baits, introduction of substitute baits and conservation of the delicate coral reef ecosystem seem to be the major options for the development and management of tuna live bait fishery in the Lakshadweep.

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