

SEXUALITY IN *POLYDACTYLUS INDICUS* (SHAW)

P. V. KAGWADE

Central Marine Fisheries Research Institute Substation, Bombay.

ABSTRACT

Sexuality and the apparent segregation of sexes of *Polydactylus indicus* are discussed. This species is a hermaphrodite throughout its life with gonochoristic ovotestis. Visual differentiation of sexes could be misleading; only microsections of gonads reveal the true identity of sexes. When the ovary is active, the testis in the same individual lies dormant and rudimentary and vice versa, leading to an erroneous identification of sexes. The spawning is inshore with one of the sexes dominant and hence are the earlier reports of concentration of one sex in the commercial landings. Gametes retain potency long after exposure, signifying the possibility of artificial fertilization.

INTRODUCTION

The information available on the sex-ratio in *Polydactylus indicus* is somewhat conflicting, necessitating a detailed study of the sexuality and the sexual behaviour of the fish. Mohamed (1955) and Nayak (1959), for example, noticed that maturing specimens in the trawler landings from the Cambay region comprised mostly of females. Mohamed also mentioned that some of the catches from Satpati, a fishing village north of Bombay, were composed mostly of males. Bhatt *et al* (1964) recorded mostly males in the landing from the Gulf of Kutch. A detailed investigation now carried out following the finding of hermaphroditism in *P. indicus* (Kagwade 1968) has made it possible to understand in some detail the reasons for the so-called segregation of sexes.

MATERIAL AND METHODS

During the period from February 1969 to April 1971, 204 specimens were sexed. Gonads were collected from the specimens landed by the Government of India Trawlers, 'Kalyani IV' and 'Kalyani V' and from the New India Fisheries bull trawlers, 'Akashi-Maru 23' and 'Akashi-Maru 25' from Bombay and Saurashtra waters. Dahanu, a fishing village 180 km north of Bombay, was periodically visited during the season for this fish. *P. indicus* landed here were adults and almost all of them were gutted. Therefore, only those specimens wherein a small bit of the gonad by chance was left behind were chosen, and such bits of gonads were preserved in 10% formalin. Every specimen was

sexed microscopically by teasing out a small bit of the gonad on a microslide. In doubtful cases, and sometimes to ascertain the position of the ovarian and testicular components of the ovotestis, sections 8μ in thickness were taken and stained with Delefield haematoxylin-eosin.

Individuals with gonads that showed only testicular tissue were regarded as apparent males and those that showed only ovarian tissue as apparent females, while the rest showing both the testicular and ovarian tissues together as distinct hermaphrodites. In respect of the condition of the ovarian part of the ovotestis, five maturity groups viz., immature (stages I and II), maturing (stages III, IV and V), mature (stage VI), spent (stage VII) and spent-recovering were adopted.

OBSERVATIONS

The sex composition of *P. indicus* based on the present study is given in Table 1. Of the 204 gonads examined, 4.41% appeared to be males and 30.39% to be females under the microscope, the remaining 65.20% were distinctly hermaphrodites. Hermaphrodites were recognised either by the naked eye or under the microscope. Sometimes, depending upon the stages of development of the two sex elements, they could be noticed only after sectioning.

The males, given in Table 1, were below 80 cm in furcal length. Since the size at first sexual maturity for this species was found to be 80 cm in standard length (Karekar and Bal, 1960), all these specimens were deemed immature. The stage was confirmed so also cytologically. In females, immature stages were scarce. They were mostly in the maturing stage IV or in the semispent stage which is almost similar to stage IV. A few individuals were in oozing and spent stages.

Among the hermaphrodites, the greatest number (55.64%) were the spent-recovering ones, the immature stages I and II together constituting next (39.85%). The maturing hermaphrodites, which were few in number (4.51%), were recognised only in stage III. The testicular part of the ovotestis in the maturing stages IV and V and the mature stage VI in oozing condition were not recognisable externally.

The following observations based on the histological and cytological studies of a number of gonads at various stages give a clear picture of sex in *P. indicus* (Plate I and II):

The micro-sections of the gonads of immature *P. indicus* at various lengths, ranging between 34 and 81 cm in furcal length, were taken. The gonads of fish measuring 58 cm, 75 cm and 81 cm were distinctly ovotestis with well formed ovarian and testicular parts placed side by side. The transparent ova in these were immature, measuring not more than 0.04 mm in diameter (Figs. 2 and 3). The seminiferous tubules in the testicular part were

TABLE 1. Percentage sex composition, distribution at different lengths and maturing stages of hermaphrodites of *Polydactylus indicus*.

Apparent Males	Apparent females	Distinct hermaphrodites								
9 (4.41%)	62 (30.39%)	133 (65.20%)								
No.	No.	Mid-point of size groups in cm.	Maturity stages of the hermaphrodites (in Nos.)							
			I	II	III	IV	V	VI	VIII	Spent recovering
1	—	35	2	—	—	—	—	—	—	
3	—	45	4	—	—	—	—	—	—	
—	1	55	2	—	—	—	—	—	—	
2	1	65	5	1	—	—	—	—	—	
3	6	75	10	3	3	—	—	—	—	
	5	85	4	12	2	—	—	—	—	2
	31	95	—	10	1	—	—	—	—	54
	18	105	—	—	—	—	—	—	—	18
			27	26	6					74
			Immature	Maturing		Mature	Spent	Spent recovering		
			39.85%	4.51%				55.64%		

mostly filled with developing spermatogonia. The primary and secondary spermatocytes were larger in size and contained deeply stained chromatin. In some tubules the development progressed still further and spermatids of relatively smaller spherical cells with small spherical nuclei were noticed. The picture of ovotestis was not distinct in the gonadal sections of fish measuring 34 cm, 41 cm and 66 cm. The germinal layers were very prominent (Fig. 1) and the process of spermatogenesis has started in these gonads. The ovarian part in these gonads, however, was not seen.

Figure 4 shows the onset of maturation in the ovarian part of the ovotestis of a fish measuring 82 cm. In some of the ova, deposition of yolk in the cytoplasm has begun. At this stage, the seminiferous tubules in the testicular part are packed with spermatids (Fig. 5).

When a small bit of gonad from oozers was teased out on a slide, a number of small immature ova were noticed. The testicular part was not recognised. But sections of such gonads (Fig. 6) showed testicular part which was full of deeply stained primary and secondary spermatocytes. Scattered here and there were some seminiferous tubules with not very densely packed spermatids and probably with a few sperm also along with them.

The section of hermaphrodite of 92 cm (Fig. 7) presented was probably a step next to the shedding of ova of a hermaphrodite. The section revealed a number of seminiferous tubules filled with well developed sperm having a small darkly stained head and a long fragile tail. At this stage, the ovarian part showed ova in the immature condition.

Hermaphrodites in the spent-recovering stage in such gonads, formed the highest percentage in the samples. Immature ova were observed in the ovarian part and developing primary and secondary spermatocytes were observed in the testicular part. There were also seminiferous tubules filled with not very dense spermatozoa. Probably the development and shedding of spermatozoa were in batches as was apparently the case with ova.

Some of the gonads of apparent females in the maturing stages IV and V, when sectioned, showed deeply stained bodies close to the ova (Fig. 9). Under higher magnification some of these bodies showed a number of dark dots. It is probable that these bodies were the reduced seminiferous tubules and the dark dots, spermatids or sperm heads. All the formalin-preserved maturing so-called female gonads were, therefore, examined once again thoroughly. A gonad of a semispent fish measuring 103 cm showed a small white speck of the size of a pin-head, more towards the periphery rather than the centre of the cut surface of its piece taken from the anterior end. When examined microscopically, it was found to be the testicular part of the gonad proving thereby that the maturing individuals were not females but hermaphrodites.

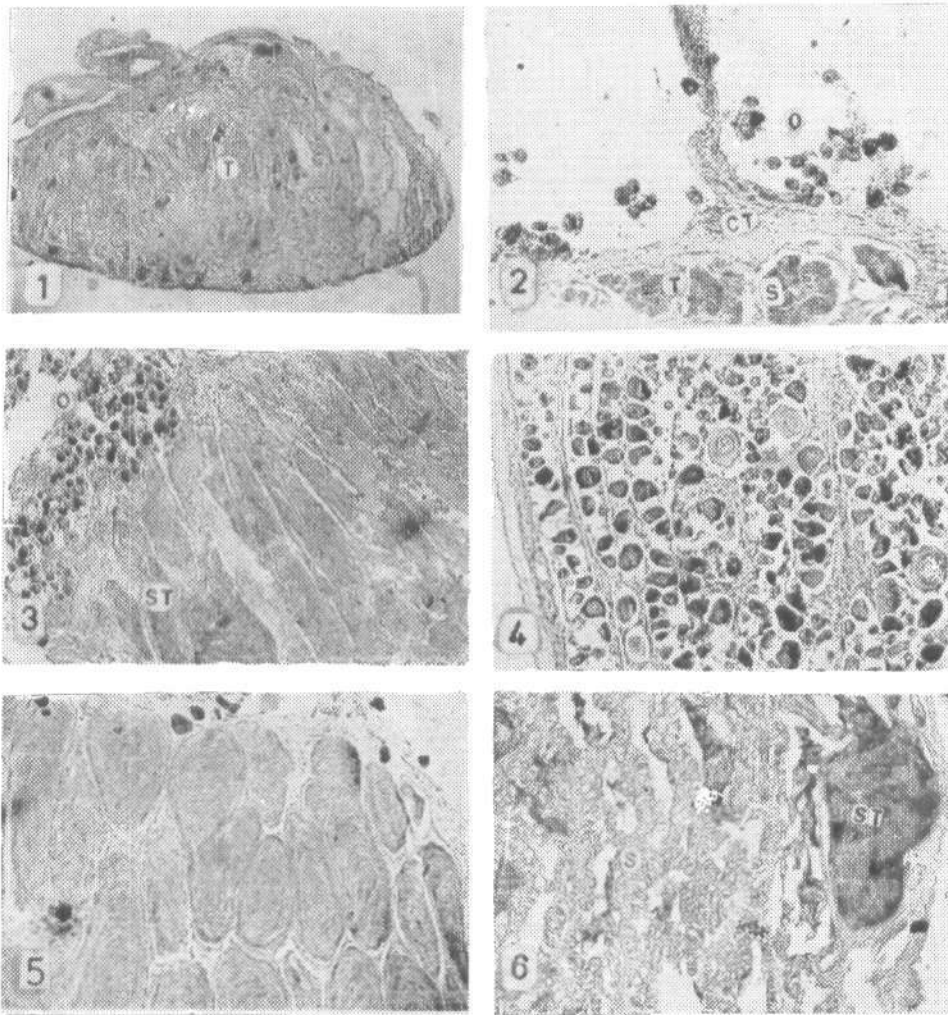


FIG. 1. T.S. of ovotestis of immature *P. indicus* measuring 41 cm. X78.
FIG. 2. T.S. of ovotestis of immature fish measuring 75 cm. X85.
FIG. 3. T.S. of ovotestis of immature fish measuring 82 cm. X85.
FIG. 4. L.S. of ovotestis of maturing fish measuring 82 cm. X70.
FIG. 5. T.S. of ovotestis of maturing fish measuring 82 cm. X85.
FIG. 6. T.S. of ovotestis of oozing fish measuring 91 cm. X68.
(CT: connective tissue; O: ovary; OMY: ovum with yolk;
S: spermatogonia; ST: seminiferous tubules; T: testis.)

(Facing P. 326)

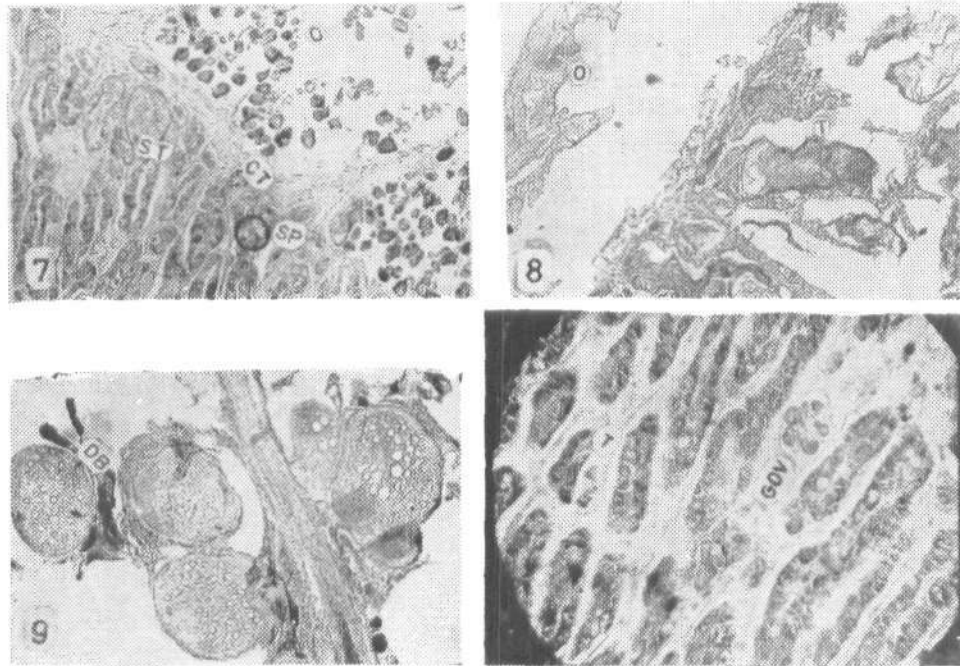


FIG. 7. T.S. of ovotestis of *P. indicus* measuring 92 cm, after shedding of ova X88.

FIG. 8. T.S. of ovotestis of spent-recovering fish measuring 99 cm. X73.

FIG. 9. T.S. of ovotestis of semi-spent fish measuring 108 cm showing deeply stained bodies near the ova. X66

FIG. 10. T.S. of ovotestis of fish measuring 92 cm showing a small group of ova within the testicular tissue. X140.

(CT: connective tissue; DB: darkly stained bodies; GOB: group of ova; O: ovary; OM: ovum; S: spermatogonia; ST: seminiferous tubules; T: testis.)

(Facing P. 327)

Further, the gonadal sections presented earlier (Fig. 7) of the specimen measuring 92 cm in which seminiferous tubules were filled with well developed sperm and also of the oozing specimen measuring 91 cm (Fig. 6) in addition to the regular ovarian part of the ovotestis showed also groups of small immature ova numbering 7-8 in the midst of the testicular tissue (Fig. 10). These isolated groups of ova were distinctly separated from the surrounding testicular tissue by a well formed connective tissue layer around them.

CONCLUSION

From the above studies it may be concluded clearly that *P. indicus* is a hermaphrodite throughout its life. In the juvenile stage a number of cases of ovotestis have been met with. At the same time there is also a very small percentage of specimens where the ovarian tissue is not noticed along with the testis. This may be because the development and differentiation of the two sex elements in these cases are still not complete. Possibly the delayed ovarian part in this small percentage of individuals may develop soon before the maturation size. In the beginning of the maturing stage of the gonad, the testicular part itself is very evident externally but, as the maturation advances, it is not recognisable and hence these specimens are mistaken as females. But instances of existence of testicular part in some of the maturing gonads have come to light in the above studies. It is the great reduction in size of the testicular part of the ovotestis against the comparatively very well developed and large size of the ovarian part of it in *P. indicus* that puzzles the nature of the sex at this stage. It is also very difficult to describe the location of testicular part at this stage. It may be said that it is not noticeable anywhere on the outer surface of the gonad. It appears that the proliferation of the ovarian lamellae extends so much over the greatly reduced testicular part that the latter which remains concealed inside the former cannot be taken notice of.

The oozing gonad, even when teased out on a slide, does not show any testicular part, but the same when sectioned shows testicular part with a number of primary and secondary spermatocytes. This suggests that the greatly reduced testicular part now begins to develop and function after the liberation of the ova. For this reason, fully spent gonads are rarely met with in the samples. The next step to this is the spent-recovering one. These spent-recovering gonads have the testicular part very much developed than the ovarian part. Often the size of the testicular part is so big and the milt in it so full that it is mistaken for true male gonads. The ovarian part, being immature, is not recognisable without a very close examination.

There are also instances when some small isolated groups of ova are found within the testicular part of the ovotestis in addition to the regular ovarian part. It is felt that these isolated groups may be part of the ovarian lamellae which invade the testicular part at the time when the ovarian part is active

and then left behind in the testicular tissue. The same may explain the presence of reduced seminiferous tubules in the ovarian part of the maturing ovotestis.

P. indicus entering the Cambay inshore waters and taken by trawlers have been observed to be maturing females while the inshore (local) landings as at Satpati were composed of mostly males. It has already been reported that the spawning grounds of *P. indicus* are in the inshore waters of Dahanu about 30 km. north of Satpati (Kagwade, 1972). Hence, it may be postulated that this species enters the inshore waters as maturing female and spawns as female and subsequently the testicular part matures and it spawns again, but as male—all these processes take place in the inshore waters.

Thus it appears certain that *P. indicus* is a hermaphrodite throughout its life. The ovotestis is gonochoristic as only one of its sex components functions at a given time.

Experiments have been conducted by Forester (1965) on the viability of ova and spermatozoa of *Oncorhynchus nerka* by considerable exposure to water and air before fertilization. He has noted fertilization taking place after the spermatozoa are held in water for 8 h and in air for 72 h and similarly after the ova are held in water for 28 m and in air for 96 h. Such data regarding the viability of gametes in water and air would be every useful in determining the duration between spawning and fertilization in nature and thereby help solve the problem of speed of transportation of ova and spermatozoa in artificial fertilization. Parkes (1960) states that fertilizing capacity of fish spermatozoa is retained longer in lower and refrigerated temperatures and also in dry condition in the salmonid fishes.

The specimens used from trawlers in the present study were from the refrigerated holds whereas those from Dahanu fishing village were from the open deck left dry without any ice. Generally, the trawler specimens were 2-9 days old after the capture and Dahanu specimens 1-2 days old. The sections of all specimens taken show that the sex elements were alive at the time of fixing because the staining was very uniform. If the spermatozoa were dead, they would have taken more of eosin due to changes in permeability of cell membranes caused by death. Similarly, ova too were in a healthy condition.

From these observations it can be said that the gametes in *P. indicus* are viable for a considerable length of time after spawning and as such hold promise in future studies on artificial fertilization. Further, the endocrinological basis of these sex-changes offers an interesting study.

ACKNOWLEDGEMENTS

I wish to express my gratitude to Dr. S. Z. Qasim, Director and to Dr. R. V. Nair, Deputy Director of Central Marine Fisheries Research

Institute, Cochin, for their encouragement and guidance shown in this study. I am thankful to Dr. P. V. Rangnekar, Head of the Zoology Department, Institute of Science, Bombay, for kindly extending the facilities for micro-photographs of the slides presented here. My thanks are due to Shri P. Dandapani and my other colleagues who were of immense help to me at the various stages of this investigation.

REFERENCES

- BHATT, Y. M., M. N. KUTTY, K. V. SUBBA RAO AND D. M. PUNWANI. 1964. "Ghol-Dara" fishery off Bedi Port in the Gulf of Kutch. *Indian J. Fish.*, 11 (A) (1): 135-156.
- FORESTER, R. E. 1965. Effect of retention of spermatozoa and ova of sockeye salmon *Oncorhynchus nerka*, in water and without addition of water, on fertility. *J. Fish. Res. Bd. Canada*, 22 (6): 1503-1521.
- KAGWADE, P. V. 1968. Hermaphroditism in *Polydactylus indicus* (Shaw) *J. mar. biol. Ass. India*, 10 (2): 399-400.
- KAGWADE, P. V. 1972. The spawning grounds of *Polydactylus indicus* (Shaw) (MSS).
- KAREKAR, P. S. AND D. V. BAL. 1960. A study on maturity and spawning of *Polydactylus indicus* (Shaw). *Indian J. Fish.* 7 (1): 147-164.
- MOHAMED, K. H. 1955. Preliminary observations on the biology and fisheries of the thread-fin, *Polydactylus indicus* Shaw in the Bombay and Saurashtra waters. *Indian J. Fish.*, 2 164-179.
- NAYAK, P. D. 1959. Some aspects of the fishery and biology of *Polydactylus indicus*. Shaw. *Indian J. Fish.* 6 (2): 280-297.
- PARKES, A. S. 1960. The biology of spermatozoa and artificial insemination. *Marshall's Physiology of Reproduction*. 1, Part 2, Chap. 9: 161-263. Parkes, A. S. Ed., Longmans Green, London.