LIFE HISTORY AND BEHAVIOUR OF INDIAN PRAWNS

B. S. BHIMACHAR

Central Inland Fisheries Research Institute, Barrackpore

Studies on life history and behaviour of prawns form an essential background for the understanding of the disposition of their fisheries and for the formulation of effective methods of exploitation and measures of conservation. Notwithstanding the knowledge that life history and behaviour studies play a significant role in the improvement of these fisheries, very little work, pertinent to problems of management of fisheries, has been done. It is proposed here to outline and examine critically the investigations on various aspects of life history and behaviour that have been made and the results obtained thereof, as well as to indicate the fruitful lines of research that could be taken up with a view to improve the prawn fisheries of this region.

A survey of the published literature on prawns in India reveals that the bulk of information pertains to taxonomical aspects. Second in the order of abundance are publications dealing with geographical distribution and descriptive accounts of prawn fisheries. Life history studies conducted so far pertain to investigations on age and growth, studies on the embryonic and larval development, observations on food habits, investigations on spawning and maturation and certain physiological aspects.

Age and Growth

Studies on age and growth are of paramount importance in fishery biological investigations, since these are required both in assessing the changes in abundance of populations in relation to fluctuations in fishing pressure, as well as in estimation of rates of mortality. Due to the absence of permanent hard parts of the body with periodic markings, it is generally difficult to estimate the age and growth rate in crustaceans with any degree of accuracy. Hence, reliance has, perforce, to be placed on the Petersen's method of analysis of length frequency distributions in age estimations. Tagging, with all the inherent inadequacies, appears to be one of the most reliable techniques in age and growth estimations in prawns. But this method has not yet been effectively utilised by Indian workers. It is a well known fact that growth in arthropods is discontinuous, since they are enclosed in a rigid exoskeleton. All visible growth of these organisms takes place only at the time of or immediately after moulting. Hence, all conclusions on growth presented by various authors represent overall increments in dimensions in a given period of time, which are summations of individual spurts of growth that have taken place at different moultings.

Palaemonids

Among the freshwater prawns, *Macrobrachium rosenbergii* (de Man), the giant freshwater prawn, grows to the largest size. Rajyalakshmi has investigated the age and growth of this species, occurring in the Hooghly estuary, in detail. These studies have indicated that the growth in this species is one of inverse exponential pattern. Males have been estimated to attain lengths of 107 and 149 mm at the end of first and second years of life and females 82.5, 130.5 and 168.5 mm at the end of first, second and third years respectively. Thus, sexual dimorphism in growth is exhibited in this species. Initially, the males grow faster than females, but the rate of growth between the first and second year appears to be slightly faster in females than in males. At given ages, the males are invariably longer than the females. The largest theoretical size (l_∞) estimated to be attained by this species is 396 mm and the largest recorded size is 310 mm.

Macrobrachium malcolmsonii is probably the second largest freshwater species and is recorded to attain maximuum lengths of 230 mm in males and 133 mm in females (Anderson and Mathai). It is (Rajyalakshmi) estimated empirically that the ultimate length (l_∞) this species could attain is 245 mm.

Sexual dimorphism in growth does not appear to be as pronounced as in *M. rosenbergii*, as indicated by studies on the growth of the species in two different rivers, the Hooghly and the Godavari.

While in the Hooghly the males of the species have been estimated to grow by 58, 32.5 and 28 mm during the first, second and third years of life and females, 56 and 37.5 mm in the first and second years, in the Godavari the postulated growths are much faster, the males registering an increase of 80.0, 63.5 and 50 mm in the first, second and third years respectively and females, 74.5, 39 and 35 mm during the corresponding periods. The disparity observed in growth rates of the species in the two rivers could probably be attributed either to environmental factors or to differences in population abundance, if not to inaccuracies in interpretation.

Rajyalakshmi investigating on the age and growth of *Macrobrachium mirabilis* has concluded that males and females of the species attain lengths ranging between 22 and 25 mm in the first twelve months. Subsequently, males grow to 35 to 38 mm in 17 months, while females register lengths of 35 mm in 15 months and 48 mm in 22 months. Females generally grow to bigger sizes than males in this species. The maximum size attained by the species has been recorded to be 62 mm.

Among the marine representatives of *palaemonids*, *Leander tenuipes* and *L. styliferus* have been investigated by Kunju and Rajyalakshmi. *L. styliferus* grows to 55 mm and 85 mm by the end of first and second years of its life. Rajyalakshmi and Kunju arrived at the conclusion that growth is faster during the second year and that monthly increments in length are in the range of 3-4 mm. The recorded maximum length of the species is about 100 mm in *L. tenuipes ;* also no sexual dimorphism in growth has been observed. This species, which attains a recorded maximum length of 74 mm, grows to about 45 mm in the first and 64.5 mm in the second year (Rajyalakshmi). The rate of growth in the species, which is estimated to be 2 to 3 mm per month, is slower than in *L. styliferus.*

Penaeids

One of the most important species of prawns by virtue of its abundance in commercial catches is *P. indicus.* Despite its importance, no investigations have been made on the growth rate of the species. Available information indicates that mature individuals measure about 150 mm in total length, whereas a vast majority of immature prawns available in brackishwaters do not exceed 120 mm (Menon). *Metapenaeus dobsoni,* which is believed to have a life span of about 3 years' (Panikkar and Menon), also exhibits sexual difference in growth, females growing faster and attaining bigger sizes than males. Males grow to 70, 90 to 95 and 110 mm in the first, second and third years respectively, while females grow to 75 to 80, 100 to 105 and 120 mm respectively in identical periods.

Metapenaeus monoceros, which attains recorded maximum lengths of about 180 mm. grows at an average rate of 7.98 mm (George) per month. Individuals measure 106-110 mm in the first year, 131-135 mm in the second year and 156-160 mm in the third year. The males and females of *M. brevicornis* attain lengths of 45.8 and 47.4 mm respectively at the end of the first year of life and to 80.5 and 89.0 mm by the end of the second year respectively. The maximum length attained by the species is about 125 mm (Alcock).

Parapenaeopsis stylifera attains a length of 90 to 100 mm in the first year and grows to its maximum size of 126 to 130 mm by the second year (Menon). *Parapenaeopsis sculptilis* grows at the rate of 12 to 16 mm per month during the first few months after hatching (Rajyalakshmi), but the rate of growth declines thereafter. The lengths attained by males at the end of first and second years are 45.6 and 74 mm, while females grow to 50.6, 79 to 90 and 104 to 118 mm in the first, second and third years respectively. This species attains maximum lengths of about 152 mm.

As mentioned earlier all the conclusions arrived at regarding the growth of these above species were based mainly on analysis of size frequency distributions except probably in the case of *M. monoceros,* where some rearing experiments to substantiate the conclusions were also made. The conventional 'Petersen's method' has several drawbacks and, particularly, in case of most of these species which have prolonged spawning seasons, the interpretation of modes is rendered doubly difficult. Non-representation of certain size groups in the samples or emigration and immigration of stocks from the area of study are some of the other vitiating factors. However, certain improved techniques of dissecting multimodal frequency curves, such as the probability plot method, linear transformation of distributions by plotting differences of logarithms, parabolic transformation of normal curves by conversion into logarithms, etc., have given a wider applicability to this method. Tracing of modal lengths of monthly length frequency distributions has to be done to substantiate the interpretations of the observed modes. Most of these improved methods are being widely used at present in the Central Inland Fisheries Research Institute and their application considerably reduces the inaccuracies in the 'Petersen's method'.

The use of tagging or staining as a method in studies on age and growth should be more widely developed and employed to confirm conclusions arrived at by other methods. Needless to say, these methods have their own limitations and considerable caution is required in accepting the growth rates of tagged individuals as representing those of normal ones. Large-scale rearing experiments will go a long way in throwing more light on the problem of age and growth of prawns, though, obviously, the rates of growth of artificially reared individuals need not be deemed to be identical with those in natural environments.

Certain tentative conclusions that seem to be justified on the basis of information already available are that generally the pattern of growth in prawns can be adequately described by the monomolecular growth function, where the additions to linear dimension decrease in geometric progression with increase in time; that sexual dimorphism in growth is more pronounced in the larger varieties of prawns than in the smaller ones and that generally males at identical ages are larger than females in palaemonids (except in *M. mirabilis*), whereas the reverse situation is observed in penaeids. These conclusions require to be confirmed by further research.

Relative Growth of Length and Weight

As in other animals, in prawns also a definite relation exists between the growth of the two dimensions. The relationship between the two variables can be expressed by the allometric equation $Y = aX^b$, logarithmic co-ordinates of these exponential functions assuming the linear form,

$$\log Y = \log a + b \log X$$

where a and b are constants; b, representing the slope and a, the equilibrium constant. It is known that in instances where the growth is isometric the exponent value does not significantly deviate from the cubic value and that the value of 'a' is an index of the fat content, being higher in fattier individuals. Table II gives the length-weight relationships of various species investigated. It is significant that while the exponent values in freshwater forms are higher than 3, those in marine or brackishwater forms are less than the cubic value. The observed difference may have some bearing on the general body form and more detailed investigations on this aspect may throw some light on the mechanics of environmental control on body form.

Condition Factor

Rajyalakshmi studied the relative condition Kn (W/w) of several species of prawns from the Hooghly estuary. Relative condition is the observed weight divided by the predicted weight for the observed length of the prawn. These values fluctuate around 1, the differences from 1 representing the deviations from regression ($d_{w \cdot 1}$) as proportional parts of a standard $W = 1$. These deviations of K_n from 1 represent all variations in weight not associated with length.

It has been observed that relative condition in prawns generally exhibits abrupt cyclic increases and declines, which have been attributed to the nature of growth pattern in prawns, where sudden spurts of increase in length take place immediately after moulting and these dimensions remain relatively constant during the inter-moult period. In addition to these cyclic changes, declines and recoveries associated with sexual maturity and spawning have also been observed in mature individuals. Studies on seasonal fluctuations in relative condition indicate that condition is generally low in winter months and high in summer and monsoons. These seasonal fluctuations in K_n have been observed to follow an identical pattern to that of growth.

The need for conducting studies on condition factors is so well known to require elaboration here. There is a necessity for such investigations to be conducted on species of commercially exploitable and exploited prawns in the country.

Maturity Fecundity and Spawning

As is well known, palaemonids, with the exception of a few *Leander spp.,* generally mature and spawn in inland waters and penaeids, in the sea, or, possibly, the marine zone of the estuary. It is also known that while palaemonids get berried, carrying their fertilised egg masses on the pleopods, penaeids shed their eggs in the water. Prior to spawning, spermatophores containing numerous spermatozoa may be fixed by the male to the female's body surface or inserted into sperm receptacles.

Very little work has been done on the effects of size and age on maturity and less is known on the influence of environmental factors on attainment of maturity. In fishes, the relationships between sexual maturity, size and age have been examined in some detail and the concensus of opinion is that maturity is correlated to a greater extent with the size than with the age of fish. Unfortunately, sufficiently reliable and adequate data are not available on Indian prawns to permit a critical examination of this point. In the literature, references are found, most frequently, to minimum observed size of mature prawns, which obviously is a very unreliable parameter. Efforts should, therefore, be made to construct maturity curves of various species of prawns, delineating the percentage of individuals that mature first at a given size and express the 50% level of the curve as the mean age at maturity. From the available information, it appears that most of the species of prawns mature in the first year, except *M. rosenbergii* and *M. brevicornis,* which mature in the second year.

Available information on fecundity of Indian prawns is generally based on the counts of eggs spawned on to the pleopods. Barring a few instances, the data are based on insufficient samples and the mathematical relationship between any of the body dimensions and fecundity has not been worked out. Table III summarises the available information on fecundity of some of the species. Assuming that the data are accurate, it can be concluded that *M. mirabilis* is the least fecund species, bearing 550 to 3000 eggs and *M. rosenbergii,* which releases 100 to 160 thousand, the most fecund.

As mentioned earlier, studies on fecundity of Indian prawns have been so superficial that they admit of no general conclusions regarding changes in reproductive capacity with age and size, the relationship between egg number and egg size, egg size and survival of larvae, etc. Available evidence, as observed in *M. rosenbergii* and *M. mirabilis* (Rajyalakshmi), indicates that the relationship between the size (length) of the parent and the fecundity is exponential in the arithmetic form. The value of the exponent in *M. rosenbergii,* which was estimated to be 3.3, indicates that fecundity increases more rapidly than body weight in relation to length ($W = c.\ l.^{3\cdot 2}$). The need for more intensive studies on the problems outlined above is evident, since answers to the problems have a profound importance in formulating proper management measures.

Spawning

Palaemonids, with the exception of *M. roenbergii,* which spawns in waters of low salinity, and *Leander spp.,* which spawn in the sea, generally spawn in freshwaters or freshwater zones of estuaries, where water salinities are in traces; whereas penaeids spawn in the sea or, possibly, marine zone of the estuary. With the possible exception of *M. monoceros* which has a spawning season extending over two months (November — December), the other prawns have prolonged spawning seasons, varying in duration from 4 to 8 months.

M. rosenbergii performs an interesting spawning migration. Generally an inhabitant of freshwaters, this species migrates down to the estuarine regions and spawns in areas where salinity fluctuates between 6 and 17.5‰. The young grow either in tributary or distributary streams of the estuaries and are also possibly drifted to the inshore areas. After they grow to a size of about 2.5 to 3 cm they migrate up the estuary to their freshwater habitats. Though certain authors have mentioned that hatching does not take place in waters of salinity less than 10‰, experiments at the Central Inland Fisheries Research Institute have indicated that eggs do hatch successfully even in freshwaters though the larvae do not survive in waters having salinities of less than 6‰ for more than a few hours. In Kerala, it was recorded that the species migrates into freshwater areas between February and May, where it remains upto August. By the end of August migration towards brackishwaters commences till finally in November the species is found only in brackishwater regions. November to February is reported to be the spawning season of the species in this part of the country. In the Hooghly, on the contrary, outward migration into brackish areas appears to commence in December or January and by March the migration is completed; peak spawning is reported in the months March to May.

An interesting point that emerges from these observations is that while John considers the lowering of salinity in backwaters as a directive factor for the migration of adults into this region, it appears that in the Hooghly actual migration occurs when the salinity is on the increase in the winter and summer months. The return migration of adults into fresh waters is reported to coincide with the increase in salinity in backwaters in Kerala, whereas in the Hooghly the return migration of adults takes place actually during the monsoons and coincides with the decreasing salinity. Similarly, inward migration of young in Kerala backwaters is reported to take place in April and coincide with increasing salinity. In the Hooghly, the young perform upward migration in the months September-October after the virulance of monsoon floods abates a little, though the salinity pattern does not change appreciably. These conflicting reports emphasise the need for more critical and exhaustive studies into the migration and spawning of the species.

Spawning behaviour of *M. rosenbergii* was studied in the laboratory at the Central Inland Fisheries Research Institute. It is observed that courting behaviour in males is released only when a female which had just completed the puberty moult is available in the vicinity. This puberty condition lasts for nearly 24 hours in this species. It is probable, as observed by Burkenroad, that some chemical stimulus might emanate from females in this condition. Sexual fighting between males, for the possession of female, was observed when more than one male were introduced into the arena. The victorious male chases the vanquished and protects the female by arresting it within the range of its long chelipeds. The male mounts the female during copulation and extrusion of eggs on to the pleopods takes place generally eight to twelve hours after mating. Period of incubation was observed to be 19 to 20 days (Rao). John, who made some observations on the same species, recorded the period of incubation as being between 20 to 21 days. As incubation and hatching depend chiefly on temperature, it will be desirable for workers to express the period in number of heat units rather than in days.

John observed that when migration is obstructed, the parent detaches the eggs from the brood pouch and eats them. No such observation was made by Rao. In fact the eggs were retained throughout the period of incubation and even hatched out in cement cisterns. However, detaching of eggs, though not of eating them, were observed when sudden fluctuations in salinity and oxygen take place or when the parent is handled by the observer.

Another palaemonid which is recorded as spawning in the tidal and gradient zones of the Hooghly estuary is *P. mirabilis*.

Metapenaeus dobsoni has been reported to liberate the eggs in the sea at depths of 10 to 12 fathoms. The young of most of the penaeids migrate into coastal and brackish water areas and estuaries and return to the *M. monoceros* were observed to migrate to brackishwaters, where they grow upto brackish waters where they grow upto 10.0 cm before they return to the sea. Similarly, juveniles of *M. dobsoni* (4 to 6 mm), *M. brevicornis* (7 mm), *P. sculptilis* and *L. styliferus* migrate up the esturine and brackishwater areas.

Studies on the ratio of sexes at different lengths and ages have indicated that generally females grow to bigger sizes and greater ages, indicating a higher rate of mortality in males. Support for this observation stems also from the fact that generally the sex ratio in younger individuals is 1 : 1, whereas with advance in age the proportion of males declines rapidly. A single exception recorded, so far, is in the case of *M. malcolmsonii*, where larger numbers of males were observed at higher ages.

Food Habits

Very little work has been done on the nutritional aspects of the food ingested by prawns. Even observations on food habits are seldom quantitative and related to the animal's requirements. Studies on electivity and food preferences are almost non-existent. It may be stated that the entire work on the food and feeding habits of Indian prawns is restricted to a study of the kinds of food eaten by different species as observed from the analysis of gut contents of dead specimens.

Observations on this aspect are so scattered and numerous that it is hardly possible to mention each case individually. Principal items of food found to be consumed by prawns are (a) detritus, (b) dead or disintegrating animals, (c) vegetable matter, (d) plankton, (e) foraminefera, (f) amphipods and (g) nematodes. In addition, sand and debris are often encountered in the guts. Among the dead and disintegrating animals, crustacean remains and polychaete remains formed the bulk. Diatoms and copepods dominate the planktonic constituents of the diet. It may probably be safely concluded that prawns are omnivorous. It was observed that non-crustacean food, which is generally ingested by *P. indicus* during winter months, induces higher percentage of fat formation in the species. Hepatopancreas, ovary and abdominal muscles were observed to be the reservoirs of fat. An important problem that has to be taken up is experimental studies on feeding and growth to ascertain and relate the nutritional requirements of the animal to its growth. Such studies will be of immense value in prawn culture in impoundments.

Embryonic and Larval Development

Studies on this aspect are restricted to palaemonids, possibly because of the difficulty in rearing penaeids under laboratory conditions. Among the more important contributions on this aspect, those of Menon, Nataraj, John, Aiyer and Rajyalakshmi, which deal with embryonic or larval development of *M. idae, M. lamarrei, M. rosenbergii, M. rudis, M. malcolmsonii, M. mirabilis* and *M. scabriculus*, are noteworthy. Barring the contribution of Aiyer which describes the embryology of *M. idae* in considerable detail, all the other accounts are more or less descriptive, with the accent on fixing characters of identity of different species at various stages of development. Aiyer observed that cleavage in *M. idae* does not conform to any of the four types of cleavages in crustacea described by Korscheli and Heider, since, in this species, the first three divisions are not total and cleavage furrows appear dividing the egg into eight distinct blastomeres after the third cleavage. Rest of the development appears to be similar to the types reported for other palaemonids. Important distinguishing features of several palaemonid larvae have been described by Rajyalakshmi and Nataraj. Identification of prawn larvae is very important not only in studies on population dynamics but also in culture fisheries, where the necessity to stock commercially desirable species is recognised. Studies on this aspect have to be intensified to cover other species that have not yet been investigated into. Another important aspect that has to be studied is the distribution and abundance of larvae of prawns of commercially important species, in various areas, in relation to measurable hydrological features. Such studies will be of immediate assistance in the implementation of prawn farming projects, that should and could be taken up on a large scale. Preliminary explorations conducted at the Central Inland Fisheries Research Institute have already yielded very valuable information regarding the availability of larvae, post larvae and juveniles of commercially important species of prawns in the Hooghly estuary.

Physiological Aspects

Contributions on physiological aspects of Indian prawns are scanty. The penaeid prawns on the Indian coast have an osmotic behaviour similar to marine palaemonids and the hyposmotic regulation is associated with powers of regulating the chloride content of the blood when the prawns are in media of different salinities. The homoiosmotic behaviour of marine penaeids is correlated with their ability to migrate into estuaries and the higher salt content of the blood of palaemonids, as compared to other freshwater invertebrates, is considered to be the responsible factor for their ability to migrate into estuaries and brackishwater regions. Sexually mature individuals among both penaeids and palaemonids are observed to be less resistant to salinity changes than juveniles. The migratory movements for spawning may probably be attributed to this factor. The increase in rate of respiration in prawns is found to be inversely proportional to salinity and directly to temperature.

Concluding Remarks

From the above review it is obvious that there is ample scope for reorganising research on the life history and biology of Indian prawns. Ethological studies are almost non-existent with the sole exception of a recent attempt on the understanding of the spawning behaviour of *M. rosenbergii* by Pantulu and others. Other available information on behaviour is in the form of isolated observations or conclusions arrived at on the basis of indirect evidence. Published scientific accounts of life history deal mostly with age and growth, food habits and in a few instances, inconclusive observations on migrations. Even these studies, barring a few, are far from adequate, being based on insufficient material or inadequate methodology, as mentioned in pertinent places in this account. This is unfortunate, since adequate population studies are fundamental to any effective use and management of the resource. Similarly, organised ethological studies, based both on experimental and observational data, will yield information necessary both for the effective improvement and exploitation of our prawn resources. In population studies there is an urgent need for knowledge of abundance of prawns, absolute or relative, their rates of survival, the mortalities caused by natural causes and fishing, their rates of recruitment, effects of measurable environmental factors on larval and juvenile survival and relationship between the number of progeny and the parental stock. Studies on centres and seasons of availability of larvae and juvenile prawns will make available the seed necessary for culture purposes. Studies on food habits should be directed more towards the nutritional aspects of different items of food, the effects of rate of feeding and quality of food on growth of prawns, electivity and food preferences, etc. Effects of different factors, particularly photoperiodism and hormonal control on maturity of prawns, influence of different qualities and quantities of food on fecundity and rate of attresia, effects of parent size on egg numbers and size, effects of egg size on survival of larvae and the optimum sex ratio for successful spawning are some of the more important aspects of maturity and spawning that could be investigated. Spawning migrations and behaviour have to be more fully understood. The preferred optimum and lethal levels of environmental factors like temperature and salinity have to be investigated into. Studies on growth should be directed towards determining rates of growth rather than estimating length or weight at intervals of time and on elucidating the effects of stock density, quality and quantity of food and some of the more important environmental factors on growth. A critical analysis of various aspects of behaviour has to be made with particular emphasis on ascertaining the releasive and directive factors for different patterns of behaviour. These are only a few of the more important factors, the investigation of which will provide a scientific basis for effective management of our prawn fisheries, both culture and capture. Thus there is an immediate need for concerted, organised research activity in various disciplines for fuller and more useful understanding of the life history and behaviour of Indian prawns.

Bibliography

1. AIYER, R. P., *Proc. Zool. Soc. Bengal*, *2*, (2), 101-148, (1949).
2. BALASUBRAMANYAN, C. B., *Curr. Sci.*, *32*, (4), 165-166, (1963).
3. CHOPRA, B. N., *Rec. Indian Mus.*, *25*, (5), 411-550, (1923).
4. ——— *J. Bombay Nat. Hist. Soc.*, *41* (2), 221-234, (1939).
5. ——— *Indian Sci. Congr., 30th Session*, pt. II, 153-173, (1943).
6. ——— *Handbook of Indian Fisheries.* Prepared for the third meeting of Indo-Pacific Fisheries Council, Madras, February, (1951).
7. DAS K. N., *Proc. Indian Sci. Congr., 22nd session, 318, (Abstracts)*, (1935).
8. GEORGE, M. J., *Indian J. Fish.*, *6*, (2), 268-279, (1959).
9. GEORGE, P. C., & GEORGE, M. J., *Curr. Sci.*, *33*, (8), 251-252, (1964).
10. GOPALAKRISHNAN, V., J. *Madras Univ.*, (B) *22*, (1), 69-75, (1952).
11. ——— *J. Madras Univ.*, (B), *23*, 193-202, (1953).
12. ——— *J. Madras Univ*, 111 pp., (1957).
13. GOPINATH, P., *Proc.*, *I. P. F. C.*, *6*, (III), 419-424, (1955).

14. Hora, S. L. & Nair, K. K., *Fishery Dept. Pamphlet* No. 1, Dept. Fish. Govt. of Bengal, Calcutta, (1944).

15. Ibrahim, K. H., *Sci. & Cult., 28,* (5), 232-233, (1962).

16. John, M. C., *Proc. Indian Sci. Congr.,* 34th Session, pt. III, 177, (Abstract); (1947).

17. ——— *Bull. Res. Inst. Univ. Kerala* (C), 5, (1), 93-102, (1957).

18. Kunju, M. M., *Proc. I. P. F. C.,* 6, (III), 404-416, (1955).

19. Menon, M. K., *Proc. Indian Acad. Sci.* (B) *8,* (4), 288-294, (1938).

20. ——— *Proc. I. P. F. C.,* 3, (II & III), 80-93, (1951).

21. ——— *J. Zool. Soc. India, 5,* (1), 153-162, (1953).

22. ——— *Indian J. Fish. 2,* (1), 41-56, (1955).

23. ——— *Ibid. 4,* (1), 62-74 (1957).

24. Nagabhushanam, R. & Sarojini, R., *Indian J. exp. Biol. 1,* (4), 231-232, (1963).

25. Nataraj, S., *Rec. Indian Mus., 45,* (1), 89-96, (1947).

26. Panikkar, N. K., *Nature, Lond., 146,* 366, (1940).

27. ——— *Nature, Lond., 145,* 108, (1940).

28. ——— *J. Mar. biol. Ass. U. K., 25,* (2), 317-359, (1941).

29. ——— *Curr. Sci., 21,* (2), 29-33, (1952).

30. Panikkar, N. K. & Aiyer, R. G., *Proc. Indian Acad. Sci.* (B) *9,* (6), 343-364, (1939).

31. Panikkar, N. K. & Viswanathan, R., *Nature, Lond., 161,* 137, (1948).

32. Panikkar, N. K. & Menon, M. K., *Proc. I. P. F. C., 6,* (III), 328-344, (1955).

33. Patwardhan, S S., *Indian Zool. Mem., No. 6,* 1-120, (1937).

34. Pillai, R. S., *Proc. Indian Sci. Congr., 43rd session,* pt. III, 287-288, (*Abstract*); (1956).

35. ——— *J. Mar. Biol. Ass. India, 4,* (2), 177-182, (1962).

36. Rajyalakshmi, T., *Proc. nat. Inst. Sci. India,* (B), *26,* (6), 395-408, (1960).

37. ——— *J. Zool. Soc. India, 13,* (2), 220-237, (1961).

38. ——— *Indian J. Fish., 8,* (2), 383-403, (1961).

39. ——— *Proc. nat. Inst. Sci. India* (B), *27,* (4), 179-188, (1961).

40. ——— Contributions to the knowledge of the biology and fishery of some estuarine prawns. Thesis submitted for doctorate degree, (1962), (Unpublished).

41. Raman, K., *Curr. Sci. 33,* (11), 21-28, (1964).

42. Shaikhmahmud, F. S., *Indian J. Fish., 7,* (1), 69-81, (1960).

43. Shaikhmahmud, F. S. & Tembe, V. B., *J. Univ. Bombay, 27,* (3), 99-110, (1958).

TABLE I

AGE AND GROWTH OF INDIAN PRAWNS

Species	Sex	Length at Age (in mm) I	II	III	Recorded maximum size (in mm)
Macrobrachium rosenbergii	♂	107	149	...	310 (adove 12″)
	♀	82.5	130.5	168.5	230
		(Rajyalakshmi, 1962)			
M. malcolmsonii	♂	·58	90.5	118.5	230 (Henderson &
	♀	56	93.5	...	133 Mathai 1910)
		(Rajyalakshmi, 1962)			
M. mirabilis	♂	22.25	35.38 (17 months)		41
	♀	22.25	48 (22 months)		62
		(Rajyalakshmi, 1962)			
M. idae	...	...	...	...	115 (Nataraj, 1947)
Leander styliferus	♂ & ♀	55	85	...	100
		(Kunju, 1955 and Rajayalakshmi, 1962)			
L. tenuipes	...	40–49.5	64.5	...	74
		(Rajyalakshmi, 1962)			
Metapenaeus brevicornis	♂	45.8	80.5	...	
	♀	47.4	89 0	...	127
		(Rajyalakshmi, 1962)			
M. monoceros	♂ & ♂ ♀	106–110	131–135	156–160	180
		(George, 1959)			
M. dobsoni	♂	70	90–95	110	118
	♀	75–80	100–105	120	124
		(Panikkar & Menon, 1955)			
Parapenaeopsis sculptilis	♂	45.59	74	...	
	♀	50–65	79–90	104–118	152
		(Rajyalakshmi, 1962)			
P. stylifera		90–100	126–130	...	115
		(Menon, 1953)			
Penaeus indicus		...	...	...	200 (Menon, 1957)
P. carinatus		...	...	...	305

TABLE II

LENGTH — WEIGHT RELATIONSHIPS

Species	L.W relationship	Remarks
Macrobrachium rosenbergii	Log W = — 5.5837 + 3.2276 log L (Rajyalakshmi, 1962)	
M. malcolmsonii	Log W = — 5.4372 + 3.1702 log L (Rajyalakshmi, 1962)	
M. mirabilis	Log W = — 4.9725 + 3.0210 log L (Rajyalakshmi, 1962)	
Leander styliferus	Log W = — 5.02108 + 2.8754 log L (Kunju, 1955)	
L. tenuipes	Log W = — 3 6741 + 2.1433 log L (Rajyalakshmi, 1962)	
Metapenaeus brevicornis	(a) Log W = — 5 0083 + 2.9810 log L	(a) For 21 - 35 mm length group
	(b) Log W = — 4.5407 + 2.6976 log L (Rajyalakshmi, 1962)	(b) For 38 - 120 mm length group
M. monoceros	W = 0.01989 L 2.7603. (George, 1959)	
Parapenaeopsis sculptilis	Log W = — 5 1272 + 2 958 log L (Rajyalakshmi, 1962)	

TABLE III

MATURITY, FECUNDITY AND SPAWNING IN INDIAN PRAWNS

Species	Age at Maturity	Size (mm)	Spawning Season	Fecundity
1	2	3	4	5
Macrobrachium rosenbergii	2 years ♀ (Rajyalakshmi, 1962)	136.0 ♀	Nov.—Feb. (John, 1959) Feb.—July (Rajyalakshmi, 1961)	100,000 to 160,000 (John, 1957) 7000 — 111,400 (Rajyalakshmi, 1961) Log F = 2.7949 + 3 3209 log L
M. malcolmsonii	1 year ♀ (Rajyalakshmi, 1962)	79.0 ♀	May—Aug. (Rajyalakshmi, 1962) May—June (Patwardhan, 1937)	...
M mirabilis	1 year	36 ♀ 26 ♂	Perennial breeder Peak periods Nov., Jan , April and Aug.	550 — 3000 (Rajyalakshmi, 1961)
M. idae		70 ♂ 50 ♀	Sept. — Feb.	2000 — 20,000 (Nataraj, 1947) 6000 — 7000 (Aiyer, 1949)
Leander styliferus	1½ yers.	68	Oct — July (Kunju, 1949)	1600 — 3800
L. tenuipes	1 year	43	Oct. — March (Rajyalakshmi, 1962)	...
Metapenaeus brevicornis	2 years	75	March — April and July — August (Rajyalakshmi, 1962)	—
M. dobsoni	2 years	75 — 80	Sep. — April	(Menon, 1953)
M. affinis	...	120	(Menon, 1957)	
M. monoceros	...	...	Nov. — Dec.	(George, 1959)
Penaeus indicus	...	150	(Menon, 1957)	
Parapenaeopsis stylifera	1 year	60 ♂ 75 ♀	Oct. — May (Menon, 1953)	
P. sculptilis	2 years	75 ♀	Dec. — May	(Rajyalakshmi, 1962)