*J. mar. biol. Ass. India*, 1972, **14** (1): 357-364

# PATTERNS OF BIOLOGY IN THE NEMIPTERIDAE*

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ABSTRACT

The taxonomy of fishes of the family Nemipteridae needs revision. There have been few studies on Nemipterid biology although there are numerous references to the group in reports on Asian fisheries: Isarankura (1970) collates our knowledge of *N. hexodon* and Li K-M. (1954, 1960) and Eggleston (1970) describe *N. virgatus* biology.

The author spent the years 1964-68 in Hong Kong studying the fisheries biology of *N. virgatus*, *N. bathybus* and *N. japonicus*, the three most important species of *Nemipterus* in the fisheries of the northern part of the South China Sea. These species were found to have many similarities in general biology and the purpose of this paper is to outline these patterns in general. It is felt that such an outline may be useful to future workers on this valuable and interesting group of fishes.

## INTRODUCTION

THERE are numerous species of Nemipteridae but as the taxonomy of the group needs clarification it is not possible to say just how many species there are. The family occurs in the Indo-Pacific region from south Japan to East Africa. Recently *Nemipterus japonicus* has extended the range of the group into the Mediterranean by way of the Suez Canal system. The most widely distributed species is *N. japonicus* but many other species are also of local fisheries importance. *N. virgatus* landings in Hong Kong outweigh those of any other single species and this Nemipterid was selected for special international study during the CSK project. *N. hexodon* is an important commercial species in Thailand.

There have been few studies on Nemipterid biology although there are numerous references to the group in reports on Asian fisheries. Isarankura (1970) collates our knowledge of *N. hexodon* and Li K-M. (1954, 1960) and Eggleston (1970) describe *N. virgatus* biology.

The author spent the years 1964-1968 in Hong Kong studying the fisheries biology of *N. virgatus*, *N. bathybus* and *N. japonicus*, the three most important species of *Nemipterus* in the fisheries of the northern part of the South China Sea. These species were found to have many similarities in general biology and the purpose of this paper is to outline these patterns in general. It is felt that such an outline may be useful to future workers on this valuable and interesting group of fishes.

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* Presented at the 'Symposium on Indian Ocean and Adjacent Seas—Their Origin, Science and Resources' held by the Marine Biological Association of India held at Cochin from January 12 to 18, 1971.

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## Taxonomy

There is a very real need for clarification of the taxonomy of the Nemipteridae. The species can be very readily separated by their colour patterns. Even juvenile fish of 5 cm long bear the characteristic colour pattern of their species. However, most of the taxonomic works on the Nemipteridae are based on preserved specimens and inadequately describe the colour patterns. An essential requirement for fisheries workers in the Indo-Pacific area is the development of a key to species based on colour pattern so that fresh specimens can be quickly and accurately identified.

A questionnaire sent to fisheries scientists in many South-East Asian countries provided material on colour patterns of *Nemipterus* of several species and showed that fish with two differing colour patterns are both known as *Nemipterus* (*Odontoglyphus*) *tolu*; in addition fisheries biologists in several countries know fish having the same colour patterns by differing names.

Work on Hong Kong species has shown that male and female fish have identical colour patterns and that in *N. virgatus* and *N. japonicus* the length of the elongated filament of the dorsal lobe of the tail is not related to sex.

## Growth Rates and Age Determination

These two matters are of great concern to fisheries biologists. The growth rates of *N. virgatus*, *N. bathybus* and *N. japonicus* were established from length frequency histograms and from otoliths. All three species have a short breeding season in Hong Kong waters and as a result of this length frequency histograms can be used to determine growth rates. It is, however, essential to plot the data for males and females separately as the growth rates of the two sexes are very different.

In *N. virgatus* three year groups can be seen on the male histogram but older fish cannot be separated into year groups; in females only the 'O' group fish can be seen in relation to the main group of fish. In *N. bathybus* and *N. japonicus* length frequency histograms allow the growth rates of male fish to be established but are of less usefulness with female fish.

It was therefore necessary to find another age-determination method for female fish and large male fish. It was found that both scales and otoliths could be used. The scales are ctenoid and large. Critical oblique lighting along the axis of the scale was essential to reveal the scale-marks. Scales were either mounted on a slide or placed in water in a glass dish over a black background for examination under low-power magnification. Many replacement scales were present. The easiest scales to read were those from just behind the operculum and below the lateral line. Male fish laid down only one scale-ring annually but some female fish put down a spawning mark as well as a 'winter-ring'. It has been shown, however, that the readability of *N. japonicus* scales deteriorates towards the Equator. Scales of *N. japonicus* from S. Vietnam and Thailand were not readable. This is presumably due to the more equable conditions nearer the Equator. Hong Kong has seasonal changes in day-length, water temperature and rainfall all of which might affect the biology of its fishes (Williamson, 1970).

Otoliths were found to be much easier than scales to use in age-determination. They do have the disadvantage that their collection mutilates the fish and lowers its market value. Rings were clearly visible in most otoliths when they were placed unground (but dehydrated in absolute alcohol) in creosote in a black excavated dish. The central area of the otolith has a variable number of narrow rings but when the fish is one year old a broad clearly demarcated translucent ring is laid down each year. A count of translucent rings including the 'one year ring' gives the age of the fish. The otoliths of male and female fish older than one year old differ in appearance. In females the rings of opaque and translucent material are very narrow indicating slow growth. The otoliths of large females are much thicker than those of males of the same size.

In most *N. virgatus* translucent material is laid down in February-May and opaque material for the rest of the year (Eggleston 1970). For male fish there is a clear correlation between the number of rings and the modes on the length-frequency curve. A few of the large males over 30 cm had 4 or 5 rings, one 36 cm fork length had 6 rings. Females with 6 rings were rarely seen but several with 4 or 5 were noted. These females were much smaller than males with the same number of rings. Thus it is apparent that female fish reach the same age as male fish but do not reach the same size. Examination of otoliths and length frequency histograms from *N. bathybus* and *N. japonicus* showed that in these species also the males grow larger and quicker than the females.

The mean size at various ages for *N. virgatus* and *N. bathybus* is shown below :

| Age (years) | 1 | 2 | 3 | 4 | 5 | 6 | Max. |
|---|---|---|---|---|---|---|---|
| *N. virgatus* Male | | | | | | | |
| Length (cm) | 14 | 23 | 28 | 31 | 34 | 36 | 37 |
| Weight (gm) | 38 | 183 | 355 | 456 | 565 | 660 | 660 |
| Female | | | | | | | |
| Length | 14 | 20 | 23 | 25 | 27 | 29 | 29 |
| Weight | 38 | 130 | 205 | 265 | 325 | 365 | 365 |
| *N. bathybus* Male | | | | | | | |
| Length | 12 | 15 | 19 | 21 | | | 25 |
| Weight | 30 | 60 | 140 | 185 | | | 250 |
| Female | | | | | | | |
| Length | 12 | 14 | 16 | 16 | | | 19 |
| Weight | 30 | 54 | 75 | 75 | | | 130 |

In *N. virgatus* males over 30 cm and females over 26 cm fork length are not common. In *N. bathybus* there are few females over 16 cm taken. The largest *N. japonicus* seen was a 29 cm male. The major part of the Hong Kong trawler catch of *Nemipterus* is *N. virgatus* measuring 16-28 cm, *N. bathybus* from 12-18 cm and *N. japonicus* from 12-20 cm. Long-liners catch *N. virgatus* over 20 cm long and *N. bathybus* from 12 cm. Gill-netters catch *N. japonicus* from 12-20 cm.

## DISTRIBUTION

All three of the species studied are open-water rather than reef fishes and all three are most abundant on sandy-mud and muddy-sand bottoms and least common on sand bottoms.

The depth distributions of the three species differ.

*N. japonicus* occurs from very shallow water to maximum depths of 30 fathoms. The small fish are generally most abundant in water shallower than 15 fathoms and only large fish occur in depths greater than 25 fathoms.

*N. virgatus* occurs from 10 to 80 fathoms : trawlers catch this species mostly between 20 and 45 fathoms. Young fish were only taken (by shrimp beam-trawlers) in water between 10 and 18 fathoms. Although occurring on suitable bottoms all along the Continental Shelf a tongue of sandy bottom off the mouth of the Pearl River may, at least partially, separate two separate groups of fish, although there may be some interchange between the groups of young fish by means of the muddy bottomed, shallow coastal waters. Each year to the southwest of the Pearl River estuary in depths of 20 to 30 fathoms large catches of ripe fish are trawled in March, April and May. How far this is due to migration into the area and how far to behavioural changes increasing the vulnerability of the fish to fishing is not known but *N. virgatus* are caught in other areas during this period although there is some indication of declines in catch rates in these areas during the spawning season. Ripe fish are taken in areas away from the area of good catches. It is possible that other areas of apparent ' aggregation ' also occur. There is some evidence that such areas exist to the southeast of Hong Kong and to the southeast of Hai-nan Island. After May, the catch rates become more uniform over the whole Shelf.

*N. bathybus* occurs from about 20-25 fathoms to depths of 150 fathoms with its main centre of abundance in the depth range 25-50 fathoms. There is some evidence from research vessel catch rates that catch rates for this species increased during the spawning season in depths between 25-35 fathoms. As *N. bathybus* is not a high price fish it is not sought by the fishermen as is *N. virgatus* and therefore commercial fishing patterns are not geared to take advantage of seasonal changes in vulnerability of this fish. Juvenile *N. bathybus* less than 12 centimetres long occur over much of the Shelf but are most abundant in the 25-40 fathom range. Deeper than 60 fathoms only large fish were taken.

Thus each species has its own defined depth range within which the fish of differing size groups occur. In the shallower parts of this range small and average size fish occur, sexually mature fish appear to aggregate in the shallower part of the depth range during the spawning season, only large (and generally only large male) fish occur in the deeper parts of the depth range.

## Reproduction

So far as the author is aware nothing is known of mating behaviour in the Nemipteridae. The identical colour patterns of the male and female and the slight but marked differences in colour pattern between species would indicate that some species-recognition behaviour pattern is probably involved in mating. The small size of the testes and the small amount of milt produced would further indicate that close apposition of the male and female must be necessary for successful fertilisation.

The testes in all species of *Nemipterus* examined (*N. virgatus*, *N. bathybus*, *N. japonicus*, *N. tolu*, *N. hexodon*, *N. furcosus*) are small. Very young fish can be sexed as the testis is visible as a short, fine thread lying on the inner surface of the peritoneum. In young females the ovary—a thin thread soon developing into a small solid cylinder—lies beneath the peritoneum.

During development the testes grows into a flat flap of tissue and with the onset of sexual maturity this becomes thicker and often triangular in section. The testes are usually pink in colour and even when fully ripe in large fish only extend about one-sixth or one-seventh of the way along the body cavity and their diameter is about a sixth to a fourth of their length. In large fish the testes may become lobulated. The maturity stage of the testes is difficult to assess by eye as its appearance changes little throughout the year. In young immature female fish the ovary soon develops from a narrow thread into a short solid cylinder. This gradually increases in size with the approach of sexual maturity until just before spawning the cylindrical ovaries lie along the dorsal surface of the body cavity for about a third to a half of its length. At spawning the ovary diameter is about one-fourth of its total length.

The development and condition of the ovary was described in eight stages from immature (1) through developing (2-3), ripening (4-5), ripe (6), half-spent (7) and spent (8). Ovaries were easy to classify (unlike testes) and therefore in analysing the results only females were used. The results showed clearly that all the three species first spawn when one year old (milt could be expressed from one-year-old males). When the percentage frequency of stages 6 and 7 in each month are plotted they show that in *N. virgatus* spawning takes place from March to May, in *N. bathybus* from June to October and in *N. japonicus* from May to October.

No wholly ripe gonads in which all eggs were translucent were seen. At most about 50% of the ovary would be blotched with clusters of transparent eggs. Teasing out ripe ovaries showed that while about one-quarter of the volume of the gonad was taken up by ripe eggs the remainder was of developing eggs of a range of sizes. Examination of spent gonads showed the presence of only very small eggs. It was therefore reasoned that *Nemipterus* are probably fractional spawners releasing eggs at several spawnings through the breeding season. The small amount of milt produced by the male also argues for this. In order therefore to obtain fecundity estimates it was decided to collect ovaries from ripening females at the start of the spawning season. Fecundity was calculated by weighing the ovaries, taking a weighed sample and counting the number of large eggs present then raising the number of eggs in proportion to the total ovary weight. Time only allowed this to be done for *N. virgatus* and in this species fecundity ranged from about 2,000 to almost 50,000 depending on the size of the fish. There was considerable variation in this figure. Fecundity was related to size as would be expected and larger fish contained more eggs than smaller fish. A nematode parasite in the ovary also affected the number of eggs present. Fish heavily parasitised contained up to 15% less eggs than unparasitised fish. Thus fecundity is relatively low in *N. virgatus* and subjective assessment of ovary size in relation to egg size indicated that it is also low in *N. japonicus*, *N. bathybus* and other *Nemipterus* species.

## Food and Feeding

All three species studied are active predators. The diet of larger fish consists mainly of crustacea, fish and cephalopods, although *N. japonicus* takes a greater proportion of lamellibranch molluscs than the other two species. Stomach content studies indicated that feeding is by day and that as only motile animals are taken that hunting is by sight. Large fish eat mainly animals living on or very close to the bottom, for example, prawns, crabs, bottom dwelling fish, isopods, etc., but occasionally large quantities of mysids were eaten—these presumably would be swimming just above the bottom. Young fish (12 centimetres and under and particularly young *N. bathybus*) eat considerable quantities of copepods, ostracods and amphipods. However, in general as the size of the fish increases a narrower range of foods are eaten and the food organisms in the stomach are fewer in number but larger. Cephalopods play a larger part in *N. virgatus* diet than in that of other species, small crustacea are important in *N. bathybus* diet and *N. japonicus* eats more polychaetes and lamellibranchs than the other two species. Examination of a few *N. tolu*, *N. hexodon* and *N. furcosus* stomachs indicated that they also eat motile benthic animals.

## Behaviour

Little is known of the behaviour of Nemipteridae (*see* reproduction section) but it is possible to infer from fishing catches that the fish do not school. Rarely do adjacent hooks on long lines bear fish of the same species. Fish of each species often occur singly in trawl catches except in the breeding season. Stomach content examination and state of fullness of the stomachs indicate that the Nemipterids are daylight feeders. Long line catches are best in early morning and evening. Catches of Nemipterids in otter trawls are greater at night probably indicating that the fish are somnolent and less able to escape the net at night. Thus the Nemipteridae appear to be active by day, dependant mainly on sight in their hunting which is usually at dawn and dusk and inactive at night.

## Biological Patterns and Generalisations

In the northern part of the South China sea, the *Nemipterus* species have differing biologies but all follow a similar biological pattern. As it is likely that other Nemipterids have similar patterns of biology it may be helpful to students of Nemipterid biology in other localities or on other species if these patterns are summarised.

In Hong Kong species, the male and female colour patterns are identical and the sexes cannot easily be distinguished externally. All species are least common on sandy bottoms. Each species has its own depth distribution and the size of fish increases with depth. All have well defined reproductive seasons but spawning is fractional through a three to five months season. Fecundity is low and testes are small. Male fish grow quicker and reach a larger size than females but there is no evidence for any difference in longevity. Both sexes mature at one year old. Fish can be aged from otoliths. Scales can also be used but these are more difficult to read. All Hong Kong species are diurnal, sight feeding predators eating motile benthic animals. There is no evidence for migratory movements of the total stock but some spawning aggregations do occur.

## Fisheries Implication

*Nemipterus* species occur on muddy sand bottoms and around Hong Kong they are taken by long lines, bottom trawls and gill nets. The Hong Kong long liners use Saran main lines with nylon monofilament snoods at short intervals, 72 snoods to the line. Bait generally used is salted anchovy or fresh squid or mackerel scad when these are available cheaply. Studies of stomach contents on line caught fish showed that when anchovy bait is used several of the soft baits are taken before the fish is hooked. Only rarely was more than one squid bait found in the stomachs of lined fish. Catch rates with squid bait were generally good. However, squid is generally more expensive than anchovy and must be kept in cold storage to retain its fresh condition and attractiveness as a bait. However, investigations into the two baits might well show that the profitability of squid bait is higher than that of the cheaper anchovy. Hooking rates could possibly also be improved by using a short snood of say 6 to 8 inches long and by incorporating into the snood or the hook shank a flotation device so that the bait is presented to the fish a few inches above the sea-bed.

In all tropical multi-species trawl fisheries it is difficult to develop regulations which will maintain the yield of each species at its optimum. Mesh size regulations affect the different fishes in different ways and these are most directly related to their body shape and behaviour. With any given mesh size each species would be affected in different ways. For example, the yield of flattened high bodied fish such as breams, snappers, flounders, trevally, etc., will be affected sooner at a given effort level than will that of round bodied fish such as the lizard fish, nemipterids, mackerel scads, etc., which are recruited at a larger size. On the theoretical grounds, assuming that other biological factors such as fecundity, age and size at first maturity, etc., have no general overriding effect, then it can be expected that the proportion of flattened fishes in the catches will fall as fishing effort increases. Nemipterids generally grow quickly in their first year but as yet little is known of their mortality rates in relation to their growth rate and it is not possible to calculate at which size the weight of a year group is at its highest—this size would be the size at which the yield could be greatest. It is, however, known that once sexual maturity is reached growth slows in the female. However, in male fish growth continues at a rapid rate after sexual maturity. Until more is known of the parameters affecting the production of a wide range of species it will not be possible to draw up regulations or recommendations to improve profitability of these tropical trawl fisheries other than by improving efficiency.

Shrimp trawlers using beam trawls in 10 to 20 fathoms catch large quantities of juvenile nemipterids, namely *N. japonicus* and *N. virgatus* in Hong Kong and adjacent waters. The significance of the loss of these young fish and its effect on nemipterid recruitment is not known but when this is considered the economic importance of the shrimp fishery must be borne in mind.

Line fishing and gill net fishing are more selective than trawl or shrimp net fishing. Line fishing normally takes place in depths greater than 30 fathoms and therefore takes place outside the range of juvenile *N. virgatus* and *N. japonicus*; young *N. bathybus* are first taken at about 12 to 13 centimetres. Line fishing in itself is selective as the size of hooks and baits as well as the area fished tends to limit the catches to fish of more than one year old. Gill net fishing is the most selective of all fishing methods used in the area when fishing for *N. japonicus* catches are frequently almost mono-specific. In these cases the mesh size can be adjusted to take the fish at the size when the yield per year group would be highest. However, the necessary biological investigation to establish this size has not yet been carried out. Such biological investigations would then have to be followed by gear studies to determine which mesh size would catch the fish at the size selected.

## CONCLUSION

In conclusion I would like to thank the organisers of the symposium for having given me the opportunity to present this paper and to say that the paper in itself deliberately generalises in order that this may stimulate discussion and increase interest in this particular group of fishes. Some of the data used in the papers have already been published (Eggleston 1970), the remaining data will be published fairly shortly through the Hong Kong Fisheries Research Bulletin.

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