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THE EGGS AND EARLY LARVAL STAGES OF THE AUSTRALIAN PILCHARD—*SARDINIA NEOPILCHARDUS* (STEIND.).

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(Plate xvi, and Figures 1–4.)

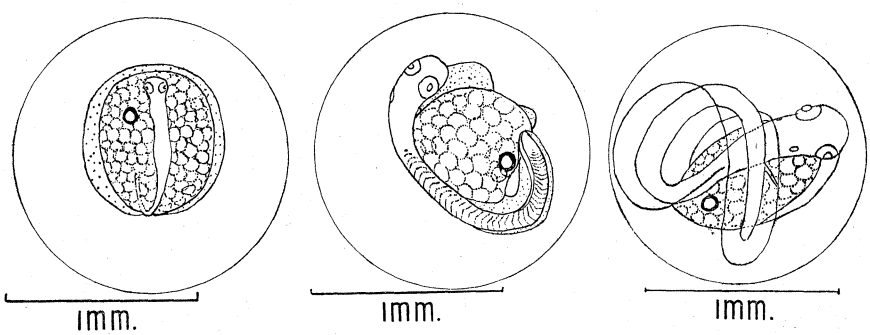
ONE of the most important of the scientific fishery problems to be undertaken in Australian waters is the recognition of the pelagic fish eggs and larvæ (more especially those of commercially important fish) and their seasonal and geographical distribution. It has taken many years to achieve a working knowledge of the fish eggs and larvæ of the North Sea, yet that is a well-defined and almost closed area, which is inhabited by large numbers of a reasonably small list of fish species. In comparison the work to be carried out in the coastal waters of New South Wales alone may prove much more difficult. With a fish hatchery in working order it would be possible to make certain of the characters of the eggs and early larvæ of at least some of our important fish species. Unfortunately, so far as this is concerned, fish hatcheries for marine fish species are not particularly favoured by experts to-day, but marine laboratories would make it worth while to attempt the hatching and rearing on a small scale. Eggs can also be pressed from ripe fish on board a trawler and sperm obtained in the same way. That fertilization can be achieved with the simplest apparatus in this manner in Australian waters has already been proved by the authors.

Another method of determining the species of fish eggs and one of wide application, although necessitating time and patience, is that of collecting both eggs and larvæ by the utilization of coarse meshed plankton nets at sea. These eggs and larvæ are sorted out and the different stages fitted together until examples are obtained possessing characters sufficiently marked to indicate the identity of the mother fish. The present paper is concerned with the discovery of the eggs of the pilchard by this means.

Plankton nets suitable for the capture of fish eggs have been used regularly during the past two years at a spot about four-six miles east of Sydney Heads. Many different kinds of eggs have been captured during this period. Amongst these the type of egg figured (Figures 1–3) was found to be particularly abundant in three successive years during the months of June, July and August. The egg averages 1·4 millimetres in diameter and is marked by a segmented yolk and a wide perivitelline space. The general appearance of the egg at once suggested that it was one belonging to some species of the herring group (family Clupeidæ). But although we were struck at the outset by a resemblance to the egg of the European pilchard, we hesitated to accept it as a pilchard egg in view of the presence of several clupeid species, to which it might have belonged, in our waters.

Delsman at Batavia[1] found no less than six different kinds of eggs of Clupeids all of the same type as the Sardine or Pilchard egg of Europe—that is, possessing a segmented yolk and a wide vitelline membrane. It was obvious that with several unknown clupeoid possibilities in these waters it would be rash to claim the mere general resemblance to the European pilchard egg as sufficient evidence of identity.[2]

During the year 1933 the eggs first turned up in our catches late in the month of May, and as they were present in considerable numbers a special effort was made by weekly expeditions to obtain later and later larval stages. We were very successful in this, and for five or six weeks the larvæ were collected, larger ones being present in the later hauls until, at the beginning of August, they



Figures 1-3.

Egg of *Sardinia neopilchardus*, Steindachner, diameter 1·4 mm.

Figure 1.—Early stage of development. Figure 2.—Later stage of development. Figure 3.—Ready for hatching.

disappeared. The largest specimen obtained measured 28 mm. in length. This specimen set aside our doubts about the species, for whilst counts of the myotomes had shown an equally possible diagnosis as pilchard, sandy sprat, or blue sprat, the character of the dorsal fin settled the question. The eggs and larvæ were accounted definitely to be those of the Australian pilchard (*Sardinia neopilchardus* Steind.).

The Egg.

The eggs are slightly smaller than those of the European pilchard—*Clupea pilchardus*,[3] and the Japanese sardine—*Clupea melanosticta* Schlegel. The diameter of the eggs of the former is 1·5 to 1·8 mm. and of the latter 1·5 mm. The mode for the eggs of the Australian pilchard in New South Wales waters is 1·44 mm., but they range from 1·27 to 1·5 mm. in diameter. The diameter of the yolk is only ·75 to ·8 mm. There is a distinct bluish tinge to the vitelline membrane which in some cases approaches a red tint. The effect is, however, purely optical

[1] Delsman.—" Fish Eggs and Larvæ from the Java Sea," No. 7, p. 218. Treubia, viii, 3-4, July, 1926.

[2] Regan obtained three specimens of Clupeid larvæ taken by the British Antarctic (Terra Nova) Expedition, 1910, off the coast of New Zealand. These were designated larvæ of the pilchard on the basis of their resemblance to the larval stages of the European species.
See Regan—" Larval and Post-Larval Fishes." British Antarctic (Terra Nova) Expedition, 1910. Natural History Report, Zoology, i, 4, 1916, p. 136.

[3] Ehrenbaum—" Eier und Larven von Fischen " in Brandt und Apstein, Nordisches Plankton, i, 2, 1909.

and not due to the presence of pigment. It disappears when the membrane is dissected away from the egg. A single small oil globule is present as in the European and Japanese pilchard eggs.

The segmentation of the yolk is that characteristic of clupeids and is probably due to the intermixture of cytoplasm and yolk. There seems to be some indication that the separate spherules become larger as the egg develops. Usually all stages of development are found in one catch of eggs and, although no indication of the exact duration of development has been obtained, it may be suggested as not more than two days in the New South Wales coastal waters at 17°C. since the European pilchard egg hatches in four-five days at 9°–12° and the Indian clupeid egg takes less than 24 hours. Already before hatching one other clupeid character can be noted—the anus of the tiny embryo is far posterior in position (see Figure 4).

No pigment is present in the eyes or elsewhere at hatching time.

The newly hatched larva is 2·5 mm. in length. Large numbers of individuals were captured at this stage each year—it was the later stages that were more difficult to obtain.

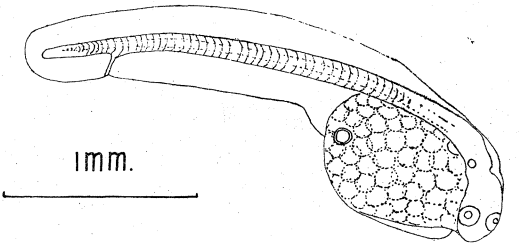


Figure 4.

Newly hatched larva of *Sardinia neopilchardus*, Steindachner, 2·5 mm. Note yolk sac and oil globule, also anal aperture near posterior end.

The remains of the yolk are to be seen appended to the larva (Figure 4); the oil globule is still present and posterior in position. As yet no pigment is present anywhere. A characteristic criss-crossing of the muscle fibres of the myotomes may be noted at this stage; it is figured for the much larger larva of 15·5 mm. (Pl. xvi, fig. 3). At the 2·5 mm. stage the anus lies under about the 42nd myotome.

The yolk sac is still visible when the length of 4·5 mm. is attained (probably $2\frac{1}{2}$–3 days after hatching) but the yolk has now disappeared. The most difficult or crucial period for the young larva has arrived and further development will depend not only on its luck in surviving enemies but on the presence of a suitable supply of microplanktonic plants and animals on which to feed.[4]

The rudiments of the fins may be noted at the stage just mentioned—the first to appear being the pectorals. The intestine also begins to show a characteristic folding (very distinctive of the larvæ of Clupeid fishes) at the length of 4·5 mm.

The embryonic condition of the tail is still a feature of the embryo, but signs of the ventral lobe of the caudal fin are to be seen at the 4·5 mm. stage. The dorsal

[4] One larva of the length of 11·5 mm. (Pl. xvi, fig. 2) contained a newly captured copepod in its stomach. This turned out to be *Paracalanus parvus*, one of the most common species in New South Wales coastal waters.

fin is first visible in our larvæ when the length of 7·5 mm. is reached (Pl. xvi, fig. 1). It is probably present before this, but we had no stage corresponding to a 6 mm. length. The anal fin appears when a length of 12·7 mm. is attained. The pelvic fins do not appear until later when the length of 18 mm. is reached.

Pigment has made its appearance when the larva is about 8 mm. in length. It develops first in the eyes, although at this stage a few chromatophores may also be seen along the ventral margin of the larva.

At a length of 8 mm. the tail shows a distinctly heterocercal character, but the hypural region is developing, and in the subsequent stages the ventral lobe becomes longer and the dorsal reduced, although at 15·5 mm. the dorsal lobe is still present (Pl. xvi, fig. 3).

At an early stage, say 3 mm., it is possible to count 40–42 myotomes in front of the anus, and whilst the number behind is not so distinct it is at least 10. Actual counts of the vertebræ in adult specimens of the Sandy Sprat (*Hyperlophus vittatus* Castelnau), Blue Sprat (*Stolephorus robustus* Ogilby) and Pilchard (*Sardinia neopilchardus* Steind.) give 46 for the first named and 45 for the last two. There is little diagnostic information, therefore, to be gained from those counts in the larva, except to exclude some other possible species. (The number of the vertebræ in the Australian Herring, *Harengula castelnaui* (Ogilby) is 39.)

The 15·5 mm. larva (Pl. xvi, fig. 3) presents well developed hypurals and the caudal fin is approaching the homocercal type, although a distinct separate dorsal portion is to be noted as already mentioned. The dorsal fin is now considerably developed and shows upwards of 16 fin rays—an important point as will be noted below. The anal fin is also well developed, but there is still no trace of the pelvic fins. There is now a series of chromatophores along the body next to the ventral edge, extending from the operculum to the point where the folding of the intestine is to be noted. From this point deeper lying chromatophores can be seen, presumably in the wall of the abominal cavity.

The latest stage captured is that of 28 mm. (Pl. xvi, fig. 4). At this stage the pelvic fins are easily seen, and there are eighteen or nineteen fin rays in the dorsal fin. This in itself cuts out the other possible clupeoid species of our shores. It is a noteworthy fact that the dorsal fin is far posterior and well behind the pelvics, although in the adult the position of the dorsal fin is more nearly midway between head and tail. It is evident that during later development the position of the dorsal fin must move forward. Exactly similar conditions are met with in the development of the European pilchard.

At the 28 mm. stage there are about 38 myotomes in front of the anus (the number is less than at the 8 mm. stage). The tail fin has lost the dorsal lobe and is already homocercal in type with incut middle part giving a bifid appearance. The chromatophores are, as before, a series at the base of the body especially between the head and pelvic fins and between the anus and caudal fin, and in addition there are the abdominal pigment spots associated with the alimentary canal region.

The number of eggs and larvæ captured has at times been considerable. Thus, in a net of cheese cloth with a circular mouth 3 feet in diameter and towed for only 10 minutes near the surface, 406 eggs of *Sardinia neopilchardus* were obtained on 18 July, 1931, and over a thousand in a similar haul on 21 June of that year.

It is fair to assume from the facts now set forth that very considerable numbers of Australian pilchards must be present off the coast of New South Wales during

the months of May or June to August, and indeed this fits in with the statements of fishery inspectors and of men on board trawlers, who have seen them from the deck. It has now been definitely established that the fish are breeding during these months. The characters of the eggs and larvæ have been set out and figured.

These facts should be of the utmost importance in view of the demand for some scientific data regarding the occurrence and migration of our pelagic fish and the possibilities of their exploitation.

EXPLANATION OF PLATE XVI.

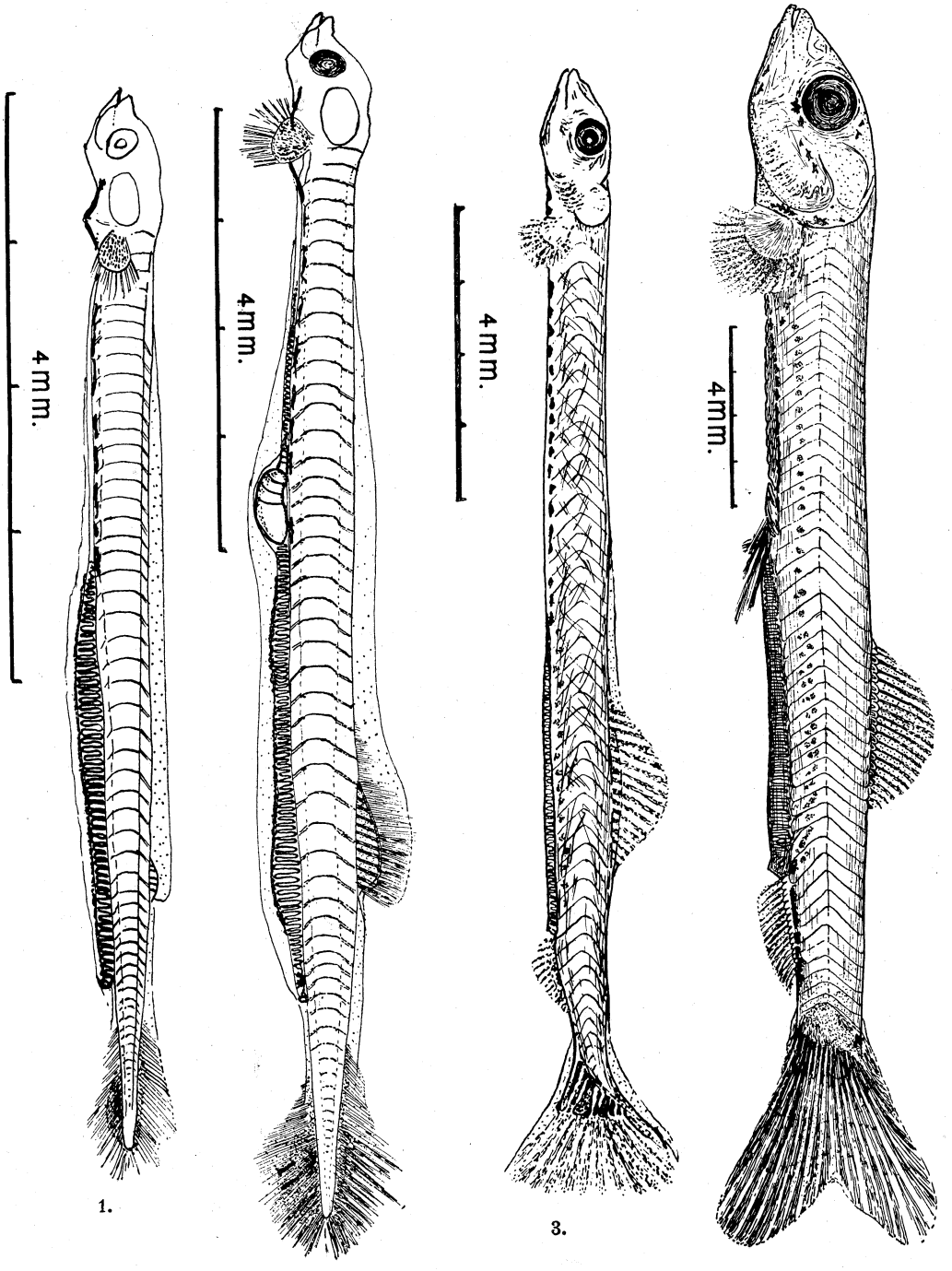
Sardinia neopilchardus, Steindachner.

Figure 1.—Larva 7·5 mm. in length. Dorsal fin just beginning to appear.

Figure 2.—Larva 11·5 mm. in length. Note copepod in alimentary canal.

Figure 3.—Larva 15·5 mm. in length.

Figure 4.—Larva 28 mm. in length. Dorsal fin with 19 rays. Pelvic fins well developed.



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