A PRELIMINARY INVESTIGATION OF THE SPAWNING HABITS OF SOME FISHES OF THE JAVA SEA

by

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INTRODUCTION.

In 1936 HICKLING and RUTENBERG published a paper in which they developed the hypothesis that the investigation of a nearly ripe ovary may provide information as to the spawning habits of fishes.

"It has occured to us that measurements of the diameters of eggs in ovaries well advanced towards spawning may give evidence of the duration of spawning in a fish of which the spawning habits are unknown. For where the spawning period is short and definite, the batch of transparent yolkless eggs, destined to mature and be spawned, will be withdrawn from the general egg-stock in a single group, sharply distinguishable, at least in the later stages of maturation from the stock of small egss from which it was derived. But when the spawning period is long and indefinite the withdrawal of eggs from the egg-stock, to undergo maturation, will be a continuous process, and there will be no sharp separation between the general egg-stock and the maturing eggs. These will pass continuously one into the other." (HICKLING & RUTENBERG p. 311).

The idea laid down in this publication forms the base of our present investigation. The spawning habits of the fishes of the Java Sea are entirely unknown and by applying HICKLING and RUTENBERG's methods it might be possible to throw some light on this problem.

We must however emphasize that the view, according to which the investigation of a few specimens will reveal to us the spawning habits of the species is very optimistic. It is true that when there is no sharp separation between the young and the maturing eggs, we are allowed to conclude that the spawning of the species is long and indefinite, but on the other hand, if the different batches of maturing eggs are sharply separated from each other, the conclusion that the spawning period of the species is short seems rather premature.

The question clearly involves a double problem. It is obvious that if a species will show a short and definite spawning period, a well defined periodicity in the maturation of the eggs in the single individual is a prime requisite. But at the same time it is evident that still a second condition will be realized when the spawning period of the species is short. This second condition is the more or less synchronous spawning of all the individuals of the same species.

Conditions in tropical seas make it rather probable that specimens which contain ripe ovaries will be found throughout the year, so that a periodicity in the individual may be obliterated in the species as a whole.

Notwithstanding this it is possible that the bulk of the individuals may spawn within a short and definite period, so that, although fishes with a ripe ovary may be found in every season, the species as a whole may show a rather definite periodicity.

Apart from the time factor the problem of the periodicity of the spawning of the single individual may be solved with a little luck by the investigation of one specimen. To investigate the spawning habits of the species, systematic observations for at least 12 months are necessary to enable us to form definite conclusions.

This paper mainly deals with the first part of the problem, but although the observations cover four months only, it it possible to discuss at least for some of the species under observation the second part of our question, the spawning habits of the species as a whole.

MATERIALS AND METHODS.

This investigation includes 13 species viz:

		native name:
1.	*Stromateus niger* BLOCH.	B a w a l.
2.	*Caesio erythrogaster* (K. v. H.) C. V.	E k o r k u n i n g.
3.	*Clupea fimbriata* (C. V.)	T e m b a n g.
4.	*Decapterus russelli* (RÜPP.)	L a j a n g.
5.	*Caranx leptolepis* C. V.	S e l a r k u n i n g.
6.	„ *mate* C. V.	„ t j o m o.
7.	„ *malam* (BL.)	„ m a l a m.
8.	„ *crumenophthalmus* BLKR.	„ b e n t o n g.
9.	*Lactarius lactarius* (BL. SCHN.)	I k a n l e m a h.
10.	*Scomber neglectus* v. KAMPEN	K e m b u n g p e r a m p u a n.
11.	„ *kanagurta* (RUSSELL)	„ l e l a k i.
12.	*Scomberomorus* spec.	T e n g g i r i.
13.	*Euthynnus allitteratus* RAFINESQUE ...	T o n g k o l.

From many of these fishes I was able to gain a good insight into the spawning habits. Of some species the data are incomplete.

In nearly every case the fishes were bought, during the months of February-May 1939, at the fish market, Pasar Ikan, at Batavia. They therefore belonged to the usual commercial catches. Some species were completely fresh, that is to say, the fish had been caught over night and brought to the market as soon as the sea breeze allowed the native prahus to enter the harbour. Other species, on the contrary, were caught higher at sea and had been stored for one or more days on ice. As a rule, with the exception however, of both t e m b a n g and l a j a n g, the preservation was good enough to make a microscopical investigation possible.

The ovaries were in all cases fixed in BOUIN's fluid (picric-acid, saturated aqueous solution 75 parts, formol 25 parts, acetic acid 5 parts) for about 20 hours. Then they were transferred to 70 per cent alcohol. Parts of the ovaries were then treated in the customary way through xylol into paraffin, to be cut into sections. As a rule no serious difficulties were experienced, although in many cases the yolk material was rather hard. In one or two cases where nearly ripe eggs were included it was necessary to cut down the time during which they stayed in xylol and in the hot paraffin.

The ovaries were then cut into sections of 10 μ and stained with EHRLICH's haematoxylin and eosin. The diameters of the eggs were measured by means of a micrometer eyepiece in a compound microscope at a magnification which gave a value of 17.2 μ to each micrometer unit. In the following graphs the diameters of the eggs are given in micrometer units.

To make sure that the eggs had been cut approximately at their maximum diameter, only those eggs were measured in which a nucleus was visible.

In this study ovaries of fish which have never spawned are designated as young. Individuals which have spawned or are approaching their first spawning season are adult. Mature or ripe is the egg which has burst or is ready to burst from the follicle. An ovary containing such eggs is called ripe or mature.

I would here express my thanks to Dr. J. D. F. HARDENBERG, head of the „Laboratorium voor het Onderzoek der Zee", and to Dr. J. REUTER of the „Instituut voor de Zeevisscherij" Pasar Ikan Batavia, for many valuable suggestions and for their help in procuring the material; to Prof. Dr. L. G. M. BAAS BECKING, Director of „'s Lands Plantentuin" Buitenzorg, for reading the manuscript.

GENERAL REMARKS.

In the ovary of the adult fish we find a stock of small yolkless eggs, the cytoplasm of which stains deeply with haematoxylin. From this general egg-stock quota are withdrawn to be matured and finally spawned. The way in which this happens may vary in the different species and forms the subject of the present investigation.

In maturation the eggs undergo some changes, which in the fixed and stained material become evident not only by the increasing size, but more clearly still by the changing of the colour. Gradually the original deep violet-blue becomes lighter and assumes a purple hue due to the developing of yolk.

As this granular yolkmass increases, the cytoplasm retires to the periphery, contracting to a sort of disc. The colour of the stained egg is now orange-red and remains so until the ultimate stages, when the eggs in the fresh ovary change to the naked eye, from opaque to hyaline. In the stained material the colour of these hyaline eggs is pale red while the yolk granules have disappeared and are fused to a homogeneous mass. At this stage the egg follicle bursts and the egg comes free into the lumen of the ovary. Due to the effects of preservation the eggs when measured were seldom perfectly symmetrical. Therefore, to obviate any selection of the longest or shortest diameter the micrometer was placed in a horizontal position and the diameter of the egg was measured parallel to the graduations of the micrometer. This gave measurements of the longest diameters of some eggs, of the shortest of others, or measurements between these two. CLARK (1934, 1925) found this a reliable procedure and very satisfactory for constant use and I fully agree with her. The consequence of this method is however that in the frequency polygon of the diameters of the ova, the differences between two groups of eggs appear less than they are in reality. Indeed in some cases the largest diameter of an egg of the group of the younger eggs exceeded the smallest diameter of an egg of an older group. On considering the different graphs we must thus bear in mind that, if two groups of eggs are connected by a few ova of intermediate size, this connection as a rule does not exist and both groups are very clearly separated during life.

As a matter of fact it was always perfectly easy to discern whether the egg was a large representative of a young or a small one of an older group, as the colour of both groups usually differed considerably.

The group of 2 micrometer divisions contains all the eggs smaller than 2.5 mic. div.

Of each individual fish about 500 eggs were measured. It turned out that this number was sufficient to give an adequate representation of each group of eggs. Thus during this investigation the diameters of more than 60000 eggs were measured. By each species is mentioned how many specimens were used but in composing the figures the frequency polygons of only a few individuals were selected. We might have combined many of our graphs so as to give one figure, with the result that the curve would smooth down considerably, but it was not always easy to select individuals of exactly the same state of maturity. Besides, this procedure tends to obscure or even obliterate some peculiarities of the curves. The following examples taken from Selar bentong and Ikan lemah illustrate this point.

In figure 1 we find the frequency polygons of four different individuals of Selar bentong of almost exactly the same state of maturity. A, B and C belonged to one single catch and were fixed immediately (at sea) in BOUIN's fluid wherein they stayed for about 48 hours. D was bought at the fish market and treated in the accustomed way. Between A, B and C there is hardly any difference at all. C seems to be a trifle younger than A and B. In D the total number of ripening eggs is smaller than in either A, B or C, but the shape of the curve, demonstrating a peak at micr. div. 17 remains materially the same.

If we now compare these four polygons with the one we obtain by combination, we see that, although the curve may be more smooth and thus suggest a greater reliability, we have not only gained nothing by this procedure, but have lost the difference between A, B and C on one side and D on the other.

Although the number of the eggs in the different categories have no absolute value, the lower peak in D, as compared to that of the other curves is, nevertheless, very real. It means, that in specimen D the batch of maturing eggs is smaller than in the other specimens. One look through the microscope at the cross-sections of the ovaries of these specimens is sufficient to confirm this.

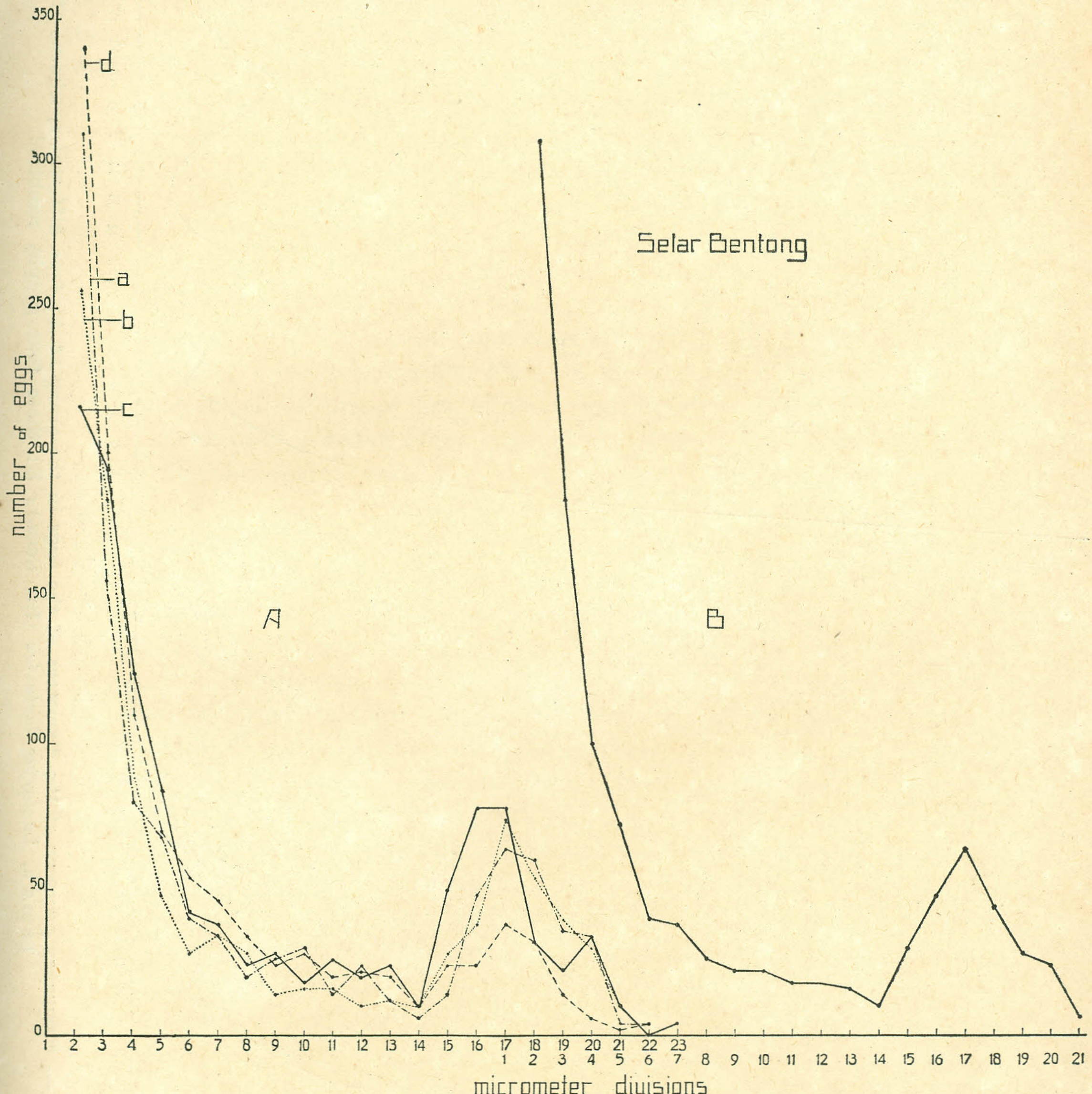

Fig. 1. — Frequency polygons of the diameters of the eggs in the ovary of A: four different specimens of Selar bentong, *Caranx crumenophthalmus* BLKR.; B: these four graphs combined.

As the question of the absolute magnitude of the batch of eggs ripening in each period does not fall within the scope of this investigation, we shall only draw attention to this point. It may be due to differences in the age of

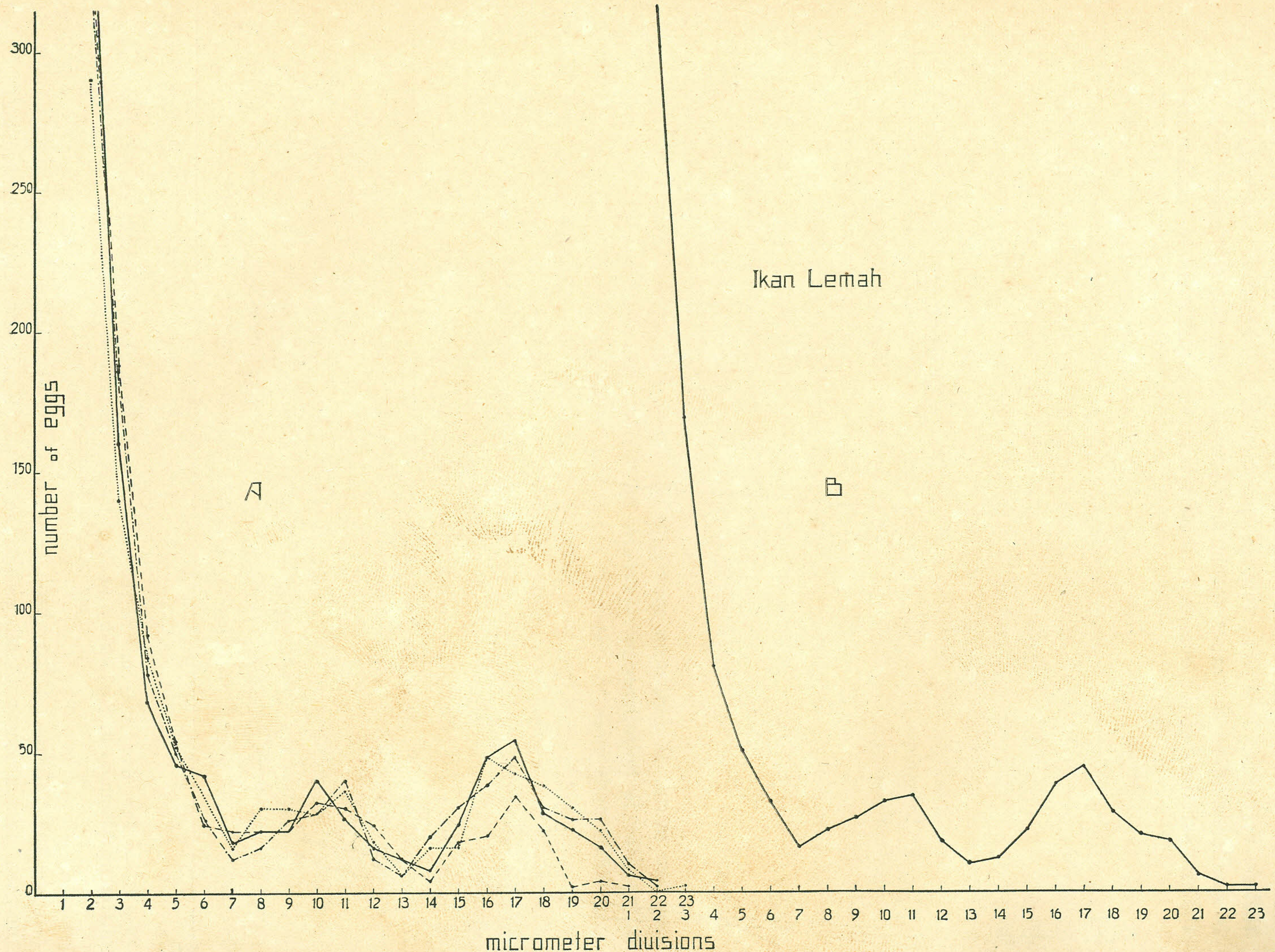

Fig. 2. — Frequency polygons of the diameters of the eggs in the ovary of A: four different specimens of Ikan lemah, *Lactarius lactarius* (BL. SCHN.); B: these four graphs combined.

the fishes, it may also be due to favourable or unfavourable food conditions or other environmental factors during the time that the batch separates from the original egg-stock.

A similar case is shown in figure 2 where the frequency curves of four specimens of Ikan lemah are given. The polygons are more complicated because there are two batches of ripening eggs simultaneously within the ovary, but again we see that every separate polygon shows exactly the same peaks as the combined curve.

These examples, and it is possible to give many more of them, show, that we are allowed to select only a few graphs in order to illustrate, in a composite picture, the growth of the ova to maturity for individual fishes.

MATURATION OF THE EGGS IN THE OVARY.

1. **Stromateus niger** BLOCH. Bawal.

Of this species 12 specimens were examined, which include all stages from very young to completely mature. Figure 3 shows the frequency polygons of the diameters of the ova of five of these specimens.

In A we have a young ovary in which the first batch of developing eggs is beginning to separate from the general egg-stock. We find a low peak at micr. div. 8. Although this peak is statistically not yet reliable, we may attach a definite value to it, when we compare this graph with the following. In B this batch of eggs has developed further. There is now a distinct peak at 11.

This development continues. The eggs increase in size, as shown in C and D. The graph in E is the frequency polygon of the ova in a ripe ovary. The eggs have burst from the follicles, but the fish has not yet spawned. The frequency polygon of a spent ovary would then resemble the left part of this graph. This is much like that of a young ovary as shown in A. There is, however, a marked difference, which makes it possible to discriminate between a young ovary and that of a fish which has just spawned. The difference lies in the presence of larger eggs in the older ovary. It is not easy to find out if these eggs belong to the new developing batch and are only fast growing representatives, or that they are lagging behind and belong to the batch that has already left the ovary. If the latter is the case (and this is the most probable explanation) these eggs will ultimately be resorbed, without coming to maturity. This resorption of eggs could not be observed in the Bawal. It is however a very common phenomenon in many other species and it will be discussed at some length in the description of the development of the eggs of the Kembung species.

Figure 3 thus shows us clearly that in the Bawal one batch of eggs separates from the general egg-stock. These ova increase in size, reach maturity and are ultimately spawned. In the mean time in the general egg-stock hardly any changes take place. The curve E suggests that as soon as the ripe eggs have left the follicles a new batch of eggs begins to develop. However, the low peak at micr. div. 9 in E seems far from being statistically significant.

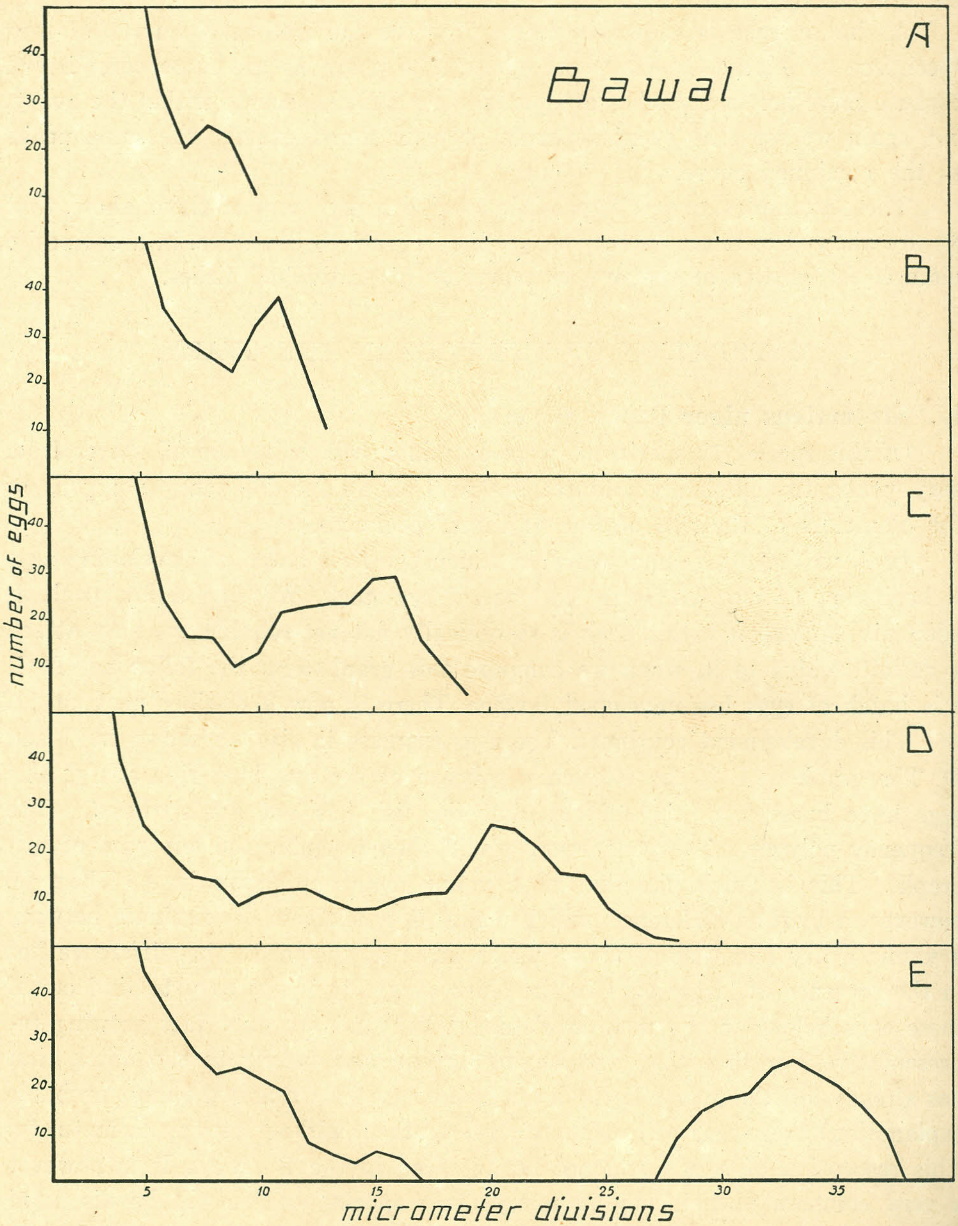

Fig. 3. — Frequency polygons of the diameters of the eggs in the ovary of 5 specimens of B a w a l, *Stromateus niger* BLOCH, in different stages of maturity.

Egg-development in the B a w a l is, therefore, strictly periodic. After spawning the ovary resembles an empty sack, and the new batch of eggs only starts development after the fish has spawned.

Spawning, therefore, is also strictly periodic and the time between two spawning periods is equal to the time, which the egg wants to separate from the egg-stock, grow and mature. Of the absolute duration of this period, this part of the investigation tells us nothing.

2. Caesio erythrogaster (K. v. H.) C.V. Ekor kuning.

18 Specimens of this species were investigated. The material gives a fairly complete life-history of the maturation of the eggs.

Fig. 4. — Frequency polygons of the diameters of the eggs in the ovary of 4 specimens of Ekor kuning, *Caesio erythrogaster* (K. v. H.) C.V.

A (figure 4) shows the frequency polygon of the ova of a very young specimen. A small batch of eggs has separated from the general egg-stock.

This first batch of eggs, however, does not grow to maturity. As soon as the ova have reached a size of about 17 micr. div. they begin to degenerate and are ultimately resorbed. The polygon then shows the shape as in B. The batch of maturing eggs is small and there are at least as many eggs that are degenerating. We see further, that a new batch of eggs has already separated from the egg-stock. This batch of eggs is larger than the first as shown in A. But it remains uncertain whether the eggs will reach maturity. It may be that they will degenerate and be resorbed in the same manner as the first batch. Eventually, however, a third or a fourth batch will grow to maturity. We then may obtain a frequency polygon as shown in C. The maturing batch is clearly separated from the egg-stock, where, though statistically unproved, a new batch seems to start its development (vide the small peak at micr. div. 9). In a later stage of ripeness, just before spawning, the frequency polygon (D) shows two completely separated peaks, indicating that in the nearly ripe ovary there are two batches of maturing eggs, one nearly mature, one half-mature.

The spawning, therefore, is, as in the B a w a l, strictly periodic, but whereas in this species the time between two spawnings is equal to the time necessary for the development the growth and ripening of the eggs, in the E k o r k u n i n g the spawning periods follow each other more quickly. The time between two spawnings being here exactly half the time necessary for the egg to grow to maturity.

Again as in the B a w a l, we cannot say anything as to the actual time elapsing between two spawnings.

3. **Clupea fimbriata** (C. V.). T e m b a n g.

Although the ovaries of many species were preserved, only the one that had been fixed at sea immediately after it had been caught, yielded good results.

The material, therefore, is very scanty, but luckily the ovary of this specimen was well advanced to maturity so that the frequency polygon of the ova gave a fairly good idea of the periodicity of the spawning. Nevertheless, we must not forget, that our conclusions are based on one specimen only.

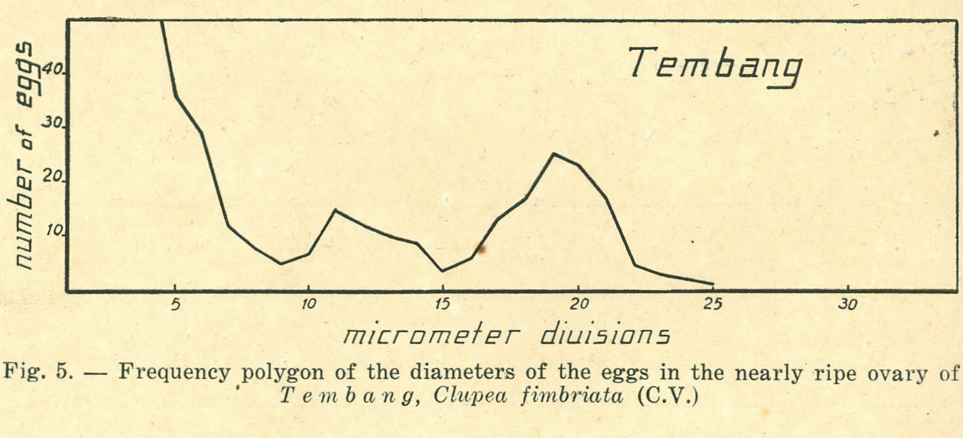

Fig. 5. — Frequency polygon of the diameters of the eggs in the nearly ripe ovary of *T e m b a n g, Clupea fimbriata* (C.V.)

Figure 5 shows this frequency polygon. As in Ekor kuning we find two clearly separated batches of developing eggs, so that we may conclude that the periodicity of the spawning of this species will resemble that of the Ekor kuning, with this restriction however, that the time between two spawnings may be very different in the different species.

4. Decapterus russelli (RÜPP.). Lajang.

The ovaries of 10 specimens were available. Although many more specimens were used in the investigation, only those that were preserved at sea could be used for the microscopical inspection.

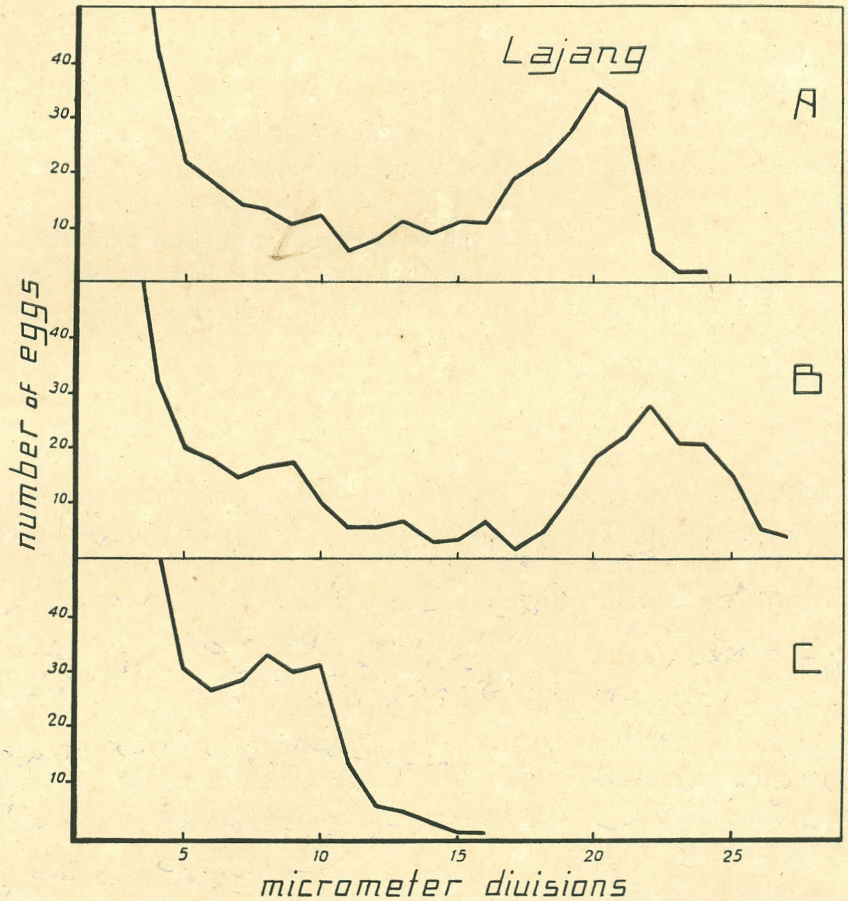

Fig. 6. — Frequency polygons of the diameters of the eggs in the ovary of three Specimens of Lajang, *Decapterus russelli* (RÜPP.).

Figure 6 gives a good idea of the egg-development in this species. In A we have the frequency polygon of the ova in an ovary well advanced to maturity. There is only one batch of developing eggs and this graph resembles in in many respects the one given for the Bawal in figure 3 D.

The ovary, the frequency curve of which is given in B, is very near to maturity. There is not much difference with the preceeding graph, but besides of the fact that the eggs of the maturing batch are larger, we find a low peak at micr. div. 9. Although statistically not yet reliable, we may safely conclude that this is the beginning of the development of a new batch of eggs, if we compare this graph with the following. This is the frequency curve of the ova after spawning. A new batch has separated from the general egg-stock from which it is clearly distinct. This is the end of the foregoing and the beginning of a new cycle.

These graphs show that only one batch of developing eggs is present in the maturing ovary of the Lajang. The type of periodicity resembles thus that of the Bawal. There is however some difference. The withdrawal of the new quota of eggs takes place at a somewhat earlier stage in the Lajang than in the Bawal, for if we compare figure 3 D with figure 6 B (which both represent about the same stage of maturity) we find that in the Lajang the new batch of eggs has started development, whereas in the Bawal there is as yet no trace of it.

If the time necessary for an egg to grow and to mature were the same in both species, this would then imply that the period between two spawnings would be a little shorter in the Lajang than in the Bawal.

5. **Caranx leptolepis** C.V. Selar kuning.

17 specimens of this species were examined, yielding a clear picture of the periodicity of spawning, although the records in the younger stages might have been more complete. In fact it was not possible to obtain an individual with an ovary about halfway to maturity. As will be pointed out in the concluding chapter, this fact is rather important.

Figure 7 gives four different stages of maturity. In A we have the frequency polygon of the ova in a very young ovary. Although there are a few rather large eggs, there is as yet no trace of a quota being withdrawn from the egg-stock. In B we have a much older stage. Two batches of eggs are growing to maturity. The oldest clearly separated from the rest, the youngest batch hardly indicated. It is clear that between A and B one or two stages are missing. One with the first quota of eggs beginning to separate from the general egg-stock and one with this batch clearly distinct from it.

In C the development of the eggs has advanced, the presence of the second batch is more obvious and in D the two batches are distinct. This ovary is nearly ripe.

With restrictions to the time factor, this species shows thus in its individuals the same spawning periodicity as the Ekor kuning.

6. **Caranx mate** C.V. Selar tjomo.
7. **Caranx malam** (BL.) Selar malam.

8. **Caranx crumenophthalmus** BLKR. Selar bentong.

The investigation of these three species includes 5 specimens each of Selar tjomo and Selar malam and 8 specimens of Selar bentong. In

Fig. 7. — Frequency polygons of the diameters of the eggs in the ovary of 4 specimens of Selar kuning, *Caranx leptolepis* C. V.

the development of the eggs in the ovary these species resemble each other so much, that we will discuss them as one species.

Figure 8 shows some frequency polygons of these species. A and B, belonging to S e l a r t j o m o and S e l a r m a l a m respectively are more or less

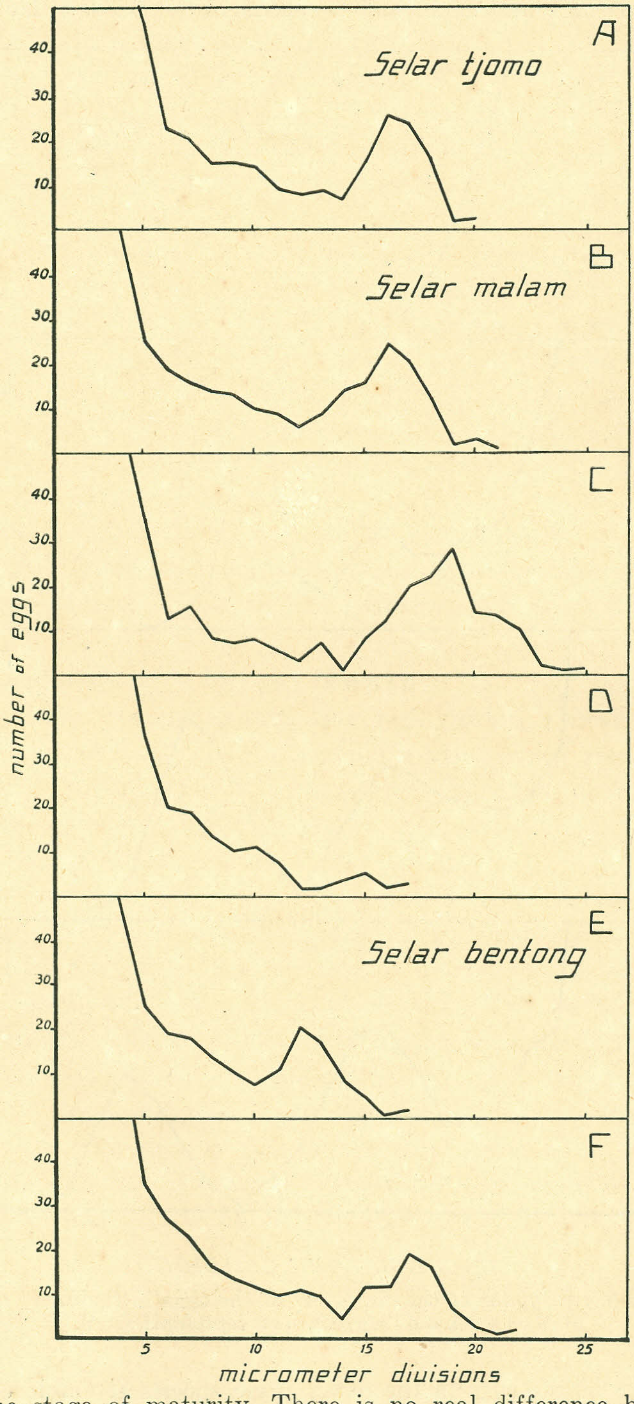

Fig. 8. — Frequency polygons of the diameters of the eggs in the ovary of A: S e l a r t j o m o, *Caranx mate* C. V.; B, C, D: S e l a r m a l a m, *C. malam* (BL.) E. F.; S e l a r b e n t o n g, *C. crumenophthalmus* BLKR.

in the same stage of maturity. There is no real difference between the two graphs. B, C, and D give successive stages of maturity in S e l a r m a l a m.

C is well advanced to maturity, D has just spawned. E and F give two different stages in Selar bentong. The curves show the same features as those of Selar malam and Selar tjomo.

These graphs show that in every species there is only one batch of developing eggs, and as D shows, the new batch does not develop before the fish has spawned. In this point there appears, therefore, a marked difference with Selar kuning, the preceeding species, where a nearly ripe ovary contains two batches of developing eggs. The spawning periodicity of these three *Caranx* species, therefore, resembles closely the type we found in the Bawal and in the Lajang, and the time elapsing between two spawnings must be at least equal to the time necessary for the young eggs to separate from the general egg-stock to grow and to mature.

9. Lactarius lactarius (BL. SCHN.) Ikan lemah.

The 24 specimens of this species that could be examined give a good idea of the periodicity in the development of the eggs in the ovary. Figure 9 gives four frequency polygons, which show the successive stages of ripeness of the ovaries. The development is the same as in Selar kuning or in Ekor kuning, so that we may refer to the descriptions of these species. The graphs give a good illustration of the growth of the two batches of eggs.

The conclusion is again that the individual fishes are definitely periodic in their spawning, and that the time elapsing between two spawnings is equal to one half of the time necessary for the eggs to separate from the egg-stock and to grow to maturity.

10. Scomber neglectus v. KAMPEN Kembung perampuan.

11. Scomber kanagurta (RUSSELL) Kembung lelaki.

Of Kembung perampuan 15, of Kembung lelaki 6 specimens were examined. Both species resemble each other so closely that it is not necessary to discuss them separately. In fact, the microscopical investigation of the ovaries did not reveal a single difference, save perhaps that the mature eggs of Kembung lelaki may be larger than those of Kembung perampuan. But as no spawnripe specimens were caught this point remains unsettled.

Figures 10 and 11 give the frequency polygons of Kembung perampuan and Kembung lelaki respectively. Although the mature eggs are larger and the degree of variability of their diameters is greater than in Ekor kuning or in Selar kuning, it is obvious that the curves belong to the same type. They show two distinct peaks in a nearly ripe ovary and we may therefore conclude that the spawning habits are the same.

There are, however, two features which make a more lengthy discussion necessary. In the first place it turned out that the number of eggs in the second batch was always smaller than that in the first, especially in Kembung perampuan, and secondly, there was, compared with other species, an excessive number of degenerating eggs.

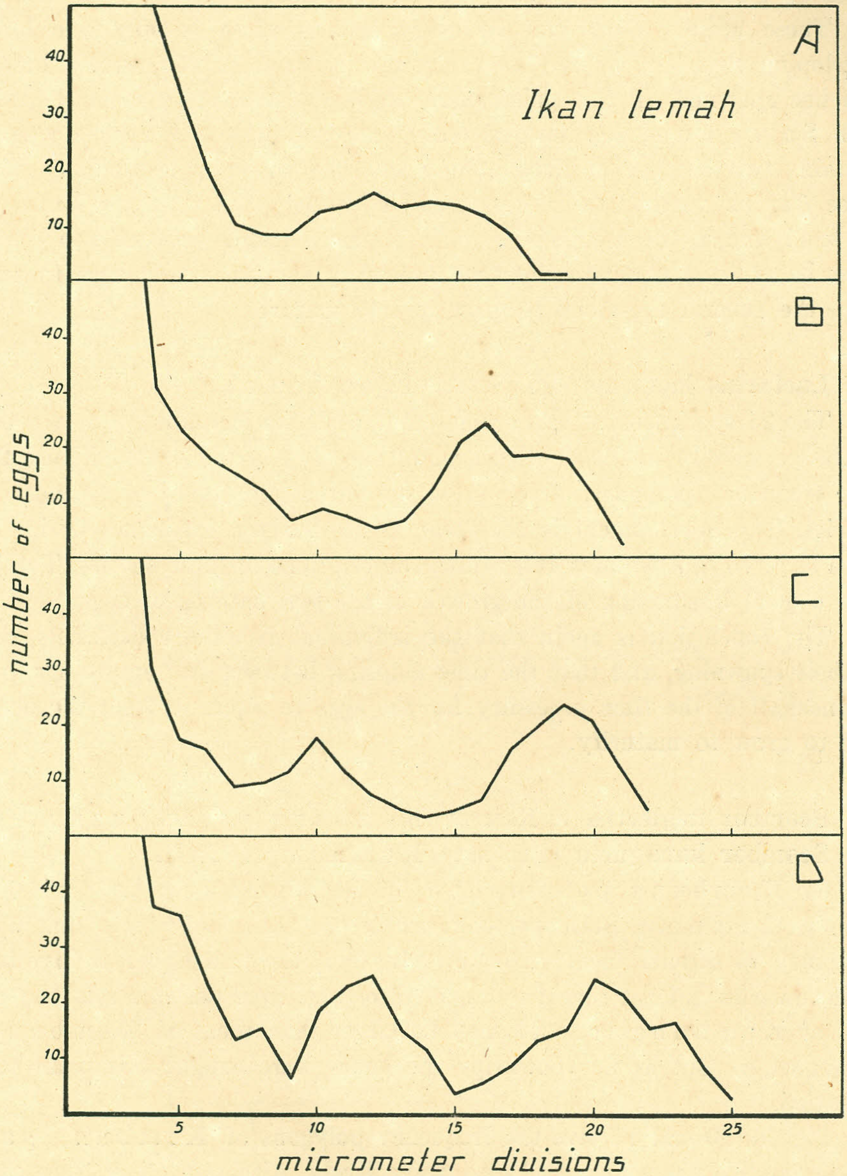

Fig. 9. — Frequency polygons of the diameters of the eggs in the ovary of four specimens of Ikan lemah, *Lactarius lactarius* (BL. SCHN.).

The differences in number of eggs between the first and the second batch are more distinct in Kembung perampuan than in Kembung lelaki. In the more extreme cases these eggs are so few in number that the frequency polygon resembles more or less that of the Bawal or the Lajang. The question, therefore, arises if this species is realy comparable with Ekor kuning or Selar kuning. We need not discuss this any further, because only continuous observations can reveal the fate of this second batch of eggs. As it is we have no certainty that they will ever reach maturity, be-

Fig. 10. — Frequency polygons of the diameters of the eggs in the ovary of four specimens of Kembung perampuan, *Scomber neclectus* VAN KAMPEN.

cause we have to count with the possibility that they are resorbed as soon as they have grown to about the size of 20 micr. divisions.

In nearly every ovary we find a large number of degenerating eggs. It is true that these can be found in the ovaries of many other species, but then their number is never excessive. In both species of Kembung we find them in great numbers, most abundant in the maturity stage which is represented by polygon B in figure 10. This points to the possibility that they belong to an older batch of eggs and their great numbers suggest that the whole batch in this way is resorbed before reaching maturity. If subsequent observations would corroborate this, then the species of Kembung would be intermediate

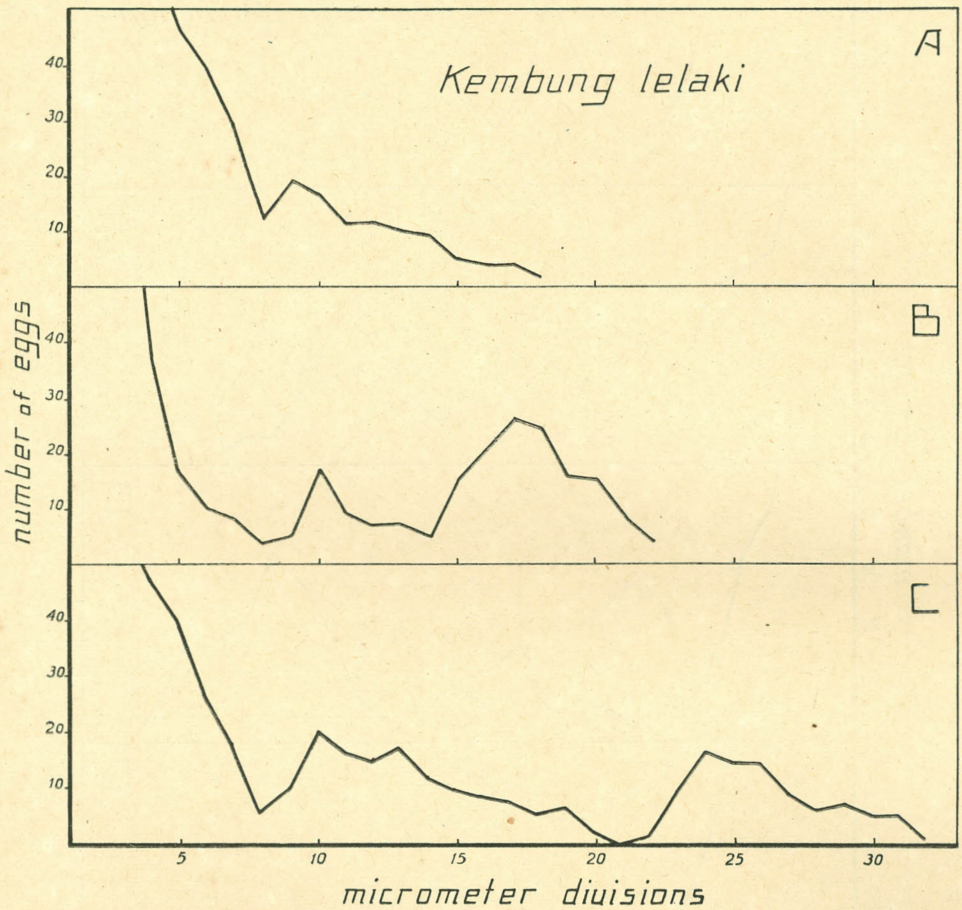

Fig. 11. — Frequency polygons of the diameters of the eggs in the ovary of 3 specimens of Kembung lelaki, *Scomber kanagurta* (RUSSELL).

between the species with one and those with two batches of maturing eggs in the ovary. Eventually the spawning habits would be as those in the species which show only one peak in the frequency polygons of the ova of a mature ovary.

As degenerating eggs can be found in most of the species here studied, I will describe this process in some detail as it can be studied in the fixed and stained material.

In Kembung the egg membrane consists of two distinct layers which in the fixed material become sometimes separated from each other. They stain differently in the eosin. The outer layer takes a distict orange hue, whilst the inner one is more or less rose-coloured. In the stage just before resorption starts the yolk-mass is granular and of a rich orange colour. The beginning of the degeneration of the egg is indicated by the changing of the colour of the outer layer of the egg-membrane. The bright orange becomes dull and gradually this outer layer vanishes. The colour of the inner layer does not change. This layer becomes broken in many places, but remains visible a very long time. At the same time the brilliant orange colour of the yolk changes to a dull reddish brown and the nucleus divides into two, three, or more parts. In the later stages we only find this dull-coloured yolk-mass without any trace of a nucleus and sometimes here and there some last remnant of the inner layer of the egg-membrane.

It is impossible to include these degenerating eggs into the frequency polygon as the diameter cannot be measured with any degree of reliability. Only in some cases, when the nucleus was still intact, measurement was possible. It then appeared that these eggs were larger or at least as large as those belonging to the maturing batch.

12. Scomberomorus spec. Tenggiri.

Four specimens of Tenggiri were examined. In figure 12 is given the frequency polygon of a completely spawnripe individual. The graph shows clearly the type of periodicity in this species. Three batches of maturing eggs are present in a ripe or nearly ripe ovary. The colour of these eggs is different in the

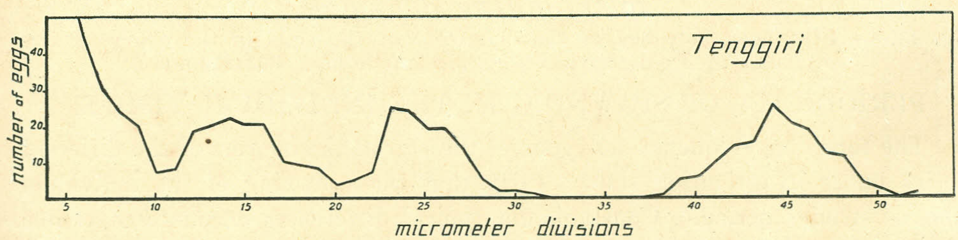

Fig. 12. — Frequency polygon of the diameters of the eggs in the mature ovary of Tenggiri, *Scomberomorus* spec.

separated batches. The oldest, completely ripe, eggs have a light red colour. In the second batch the eggs are brilliantly orange, whilst in the third they display a more violet hue.

It is obvious that the spawning periods in this species must follow each other more rapidly than in one of the preceding species.

13. Euthynnus allitteratus (RAFINESQUE) Tongkol.

Of this species three specimens were examined, which gave two stages of maturity. Figure 13 shows that the type of egg-development is the same as in Ekor kuning or Selar kuning. B is the frequency polygon of the ova of a nearly ripe ovary. Some of the eggs had already burst from the follicles.

The third specimen was in the same stage of maturity, the frequency curve is materially the same as in figure B. This ovary showed the curious phenomenon that a large number of the maturing eggs did not burst from their follicles, but were beginning to degenerate. These eggs showed the same stages of resorption as described for the Kembung species.

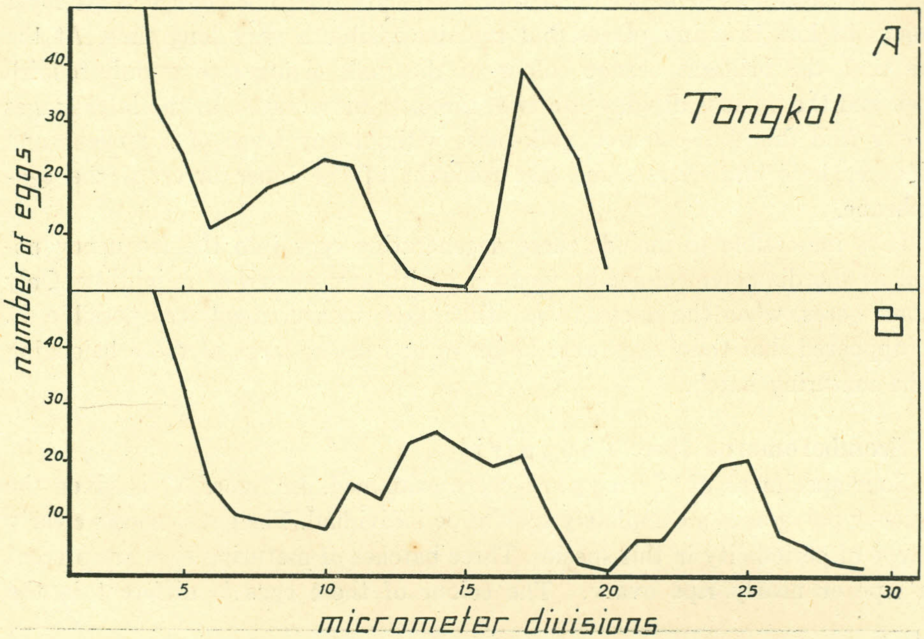

Fig. 13. — Frequency polygons of the diameters of the eggs in the ovary of two specimens of Tongkol, *Euthynnus allitteratus* RAFINESQUE.

PERIODICITY OF SPAWNING IN THE INDIVIDUAL FISHES.

The foregoing frequency polygons of the ova in the ovaries of the different species under investigation show clearly that the spawning of the individual fishes is strictly periodic. Constant and typical differences encountered enable us to distinguish three distinct types. These three types are shown in figure 14.

A gives the type that is represented by the Bawal, the Lajang and the three species of Selar, Selar tjomo, Selar malam and Selar bentong. There is only one batch of maturing eggs and after spawning the ovary resembles an empty sack. The frequency curve of the ova is then as shown in figure 3 E. Only a comparatively small number of larger eggs is present and it is probable that these eggs will degenerate and be resorbed as soon as a new quota of eggs separates from the general stock.

B is the type we found by Tembang, Ikan lemah, Selar kuning, Ekor kuning. Before the first quota of eggs has reached maturity a second batch of eggs separates from the general stock, so that just before spawning the frequency curve shows two well separated peaks. After spawning the ovary contains, beside the small eggs of the general egg-stock, a batch of rather large eggs, halfway to maturity, which will be spawned in due course.

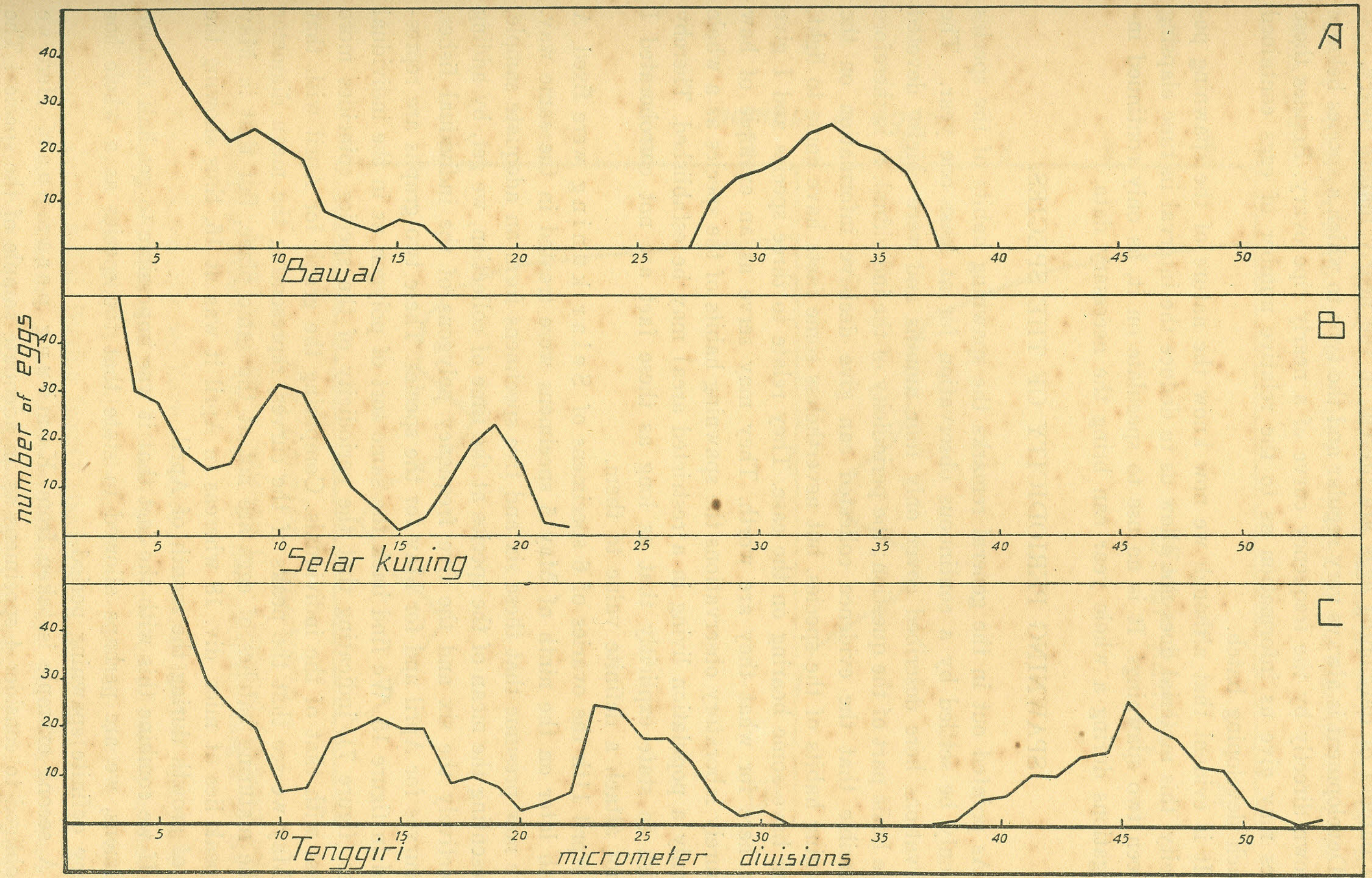

Fig. 14. — Frequency polygons of the diameters of the eggs in the ovary of mature or nearly mature specimens of B a w a l, *Stromateus niger* BLOCH; S e l a r k u n i n g, *Caranx leptolepis* C. V. and T e n g g i r i, *Scomberomorus* spec., showing the three types of egg-development.

The third type C, is represented by the Tenggiri. Here not less than three batches of developing eggs are present in the nearly mature ovary.

Development is always very regular and the type to which a species belongs is shown directly by the frequency curve of a nearly ripe ovary. Besides these curves may give us information as to the relative number of eggs contained in each developing batch.

It is evident that although we now know the nature of the spawning periodicity, this material does not allow us to deduce the interval in time elapsing between two spawnings. It is no use to speculate on it, as only continued investigations during a whole year can bring the necessary data.

SPAWNING PERIODICITY OF THE SPECIES.

As pointed out in the general remarks the spawning habits of the species can only be settled by a continuous observation for at least one year. The observations here described cover only four months and were chiefly devoted to the basic part of the question; the periodicity of the individual. It is therefore impossible that the evidence collected can give decisive information on the spawning habits of the species, but nevertheless some facts have come to light, which have some bearing on the case. They relate to three species and I give them here for what they are worth. They may serve as an example of how by purely laboratory observations the spawning habits of the species as a whole (or only a population living in a restricted area) may be established. Thereby I wish to state explicitly that as long as these fact are not corroborated I cannot attach a definite value to them.

April 11th the ovaries of 6 specimens of Selar kuning were fixed. A month later on the ninth of May 5 specimens were treated in the same way. If we now presume that these six and five specimens form an adequate sample, representing the mean of the species at the time of collection, we get, by adding respectively the six and the five frequency polygons of the individual fishes, the curves for April and for May for the species. These two graphs are represented in figure 15. We find back the same sort of polygon as in the individual fishes (figure 7), indicating that the periodicity of the species coincides more or less with that of the individuals. Comparing the graph for April with that for May we see that the peaks of the curves, representing the mean diameter of the maturing batches of eggs are not at the same place, but that in May the peak lies at micr. div. 18 whereas in April it was at 16, thus showing the rate of growth during the month of April.

If we combine this with the fact that it was impossible to get half mature specimens, we are perhaps allowed to state that the species as a whole has a very definite spawning period.

A second example is taken from Kembung perampuan. Here we are obliged to consider 4 specimens as an adequate sample of the species! The graphs are given in figure 16. We see that in April the peak for the largest eggs lies at 20, in May at 22, suggesting a growth of 2 micrometer divisions during the month of April. The second peak is much lower than the first, a fact to which attention has been drawn already in the description of the individual graphs.

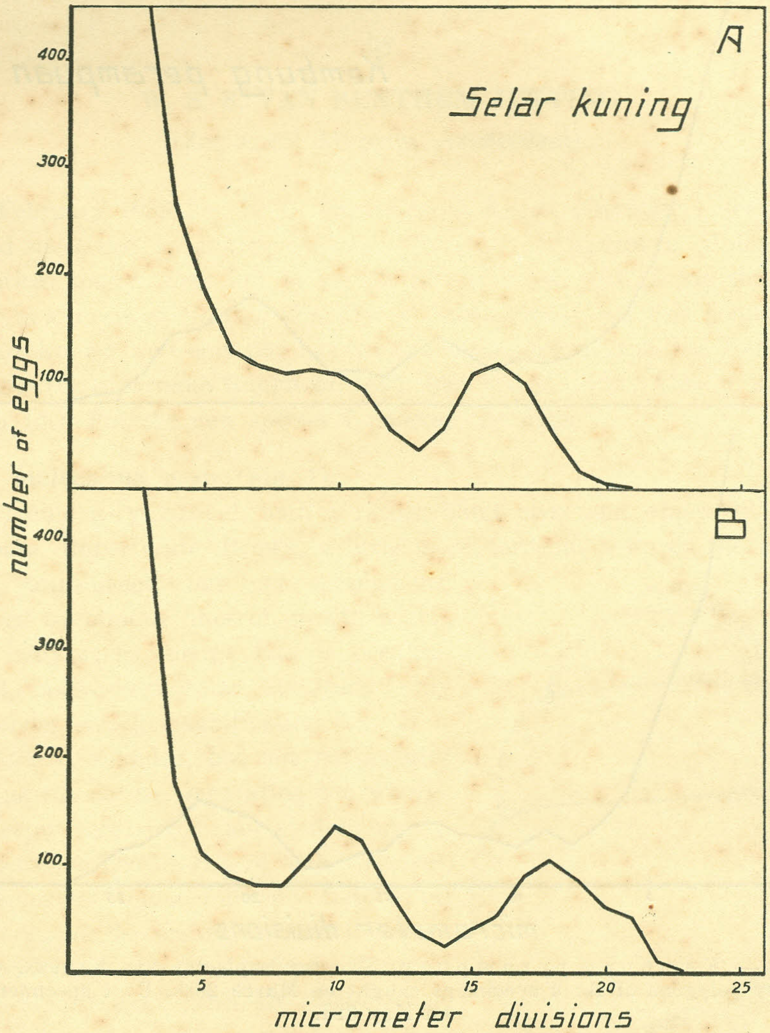

Fig. 15. — Selar kuning, *Caranx leptolepis* C. V. Combined frequency polygons of A: six specimens caught on April 11th; B: five specimens caught on May 9th.

In Ekor kuning we have evidence of another kind of the periodicity of the species. April 11th and 18th I found specimens well advanced to maturity. Six weeks later, May 30th I tried to obtain some specimens with a completely ripe ovary, but I failed. Buying twenty specimens at random I got 10 females which were all immature. Now there are indications, that Ekor kuning leaves its usual haunts to spawn in deeper water, because previous (not published) investigations showed that spawripe individuals are seldom or never found.

If spawning takes place in the months of May and June this would explain why only immature specimens were caught. But here again the total number of the specimens used does not allow us to regard this as an established fact [1]).

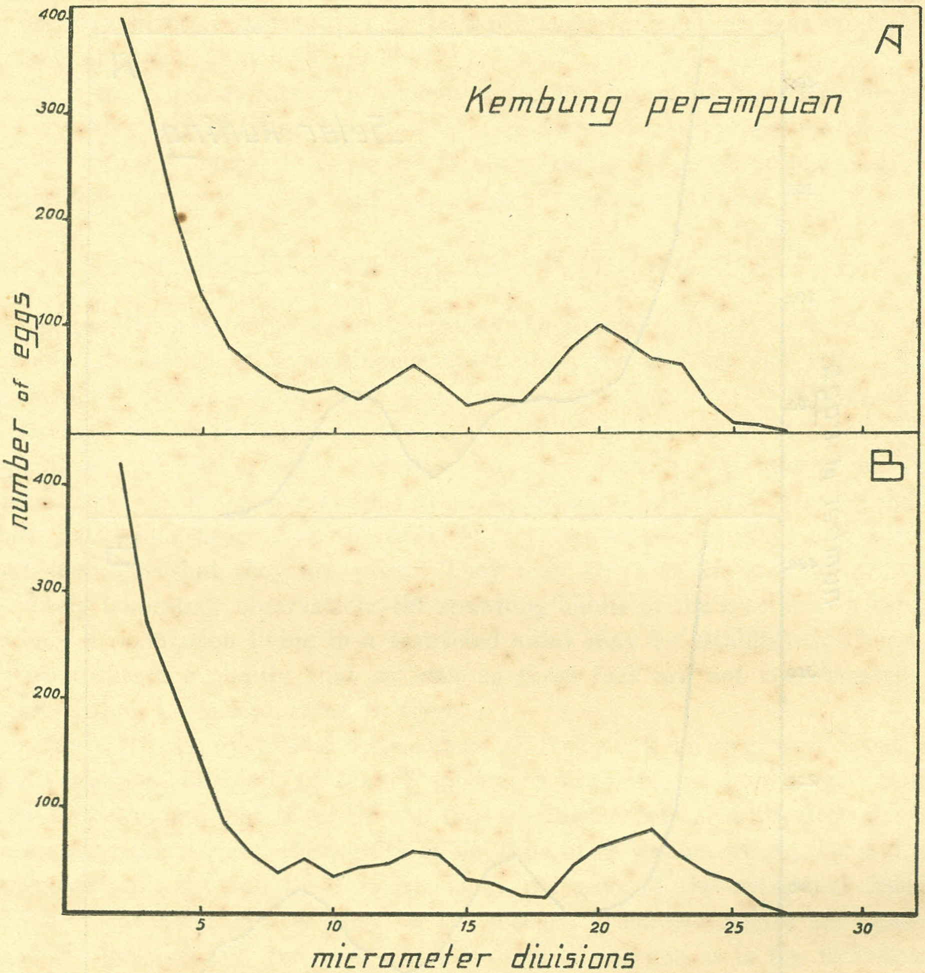

Fig. 16. — Kembung perampuan, *Scomber neglectus* VAN KAMPEN. Combined frequency polygons of A: 4 specimens caught on March 28th, B: 4 specimens caught on May 3rd.

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[1]) In the above we are assuming, that conditions are the same in different parts of the Java Sea. The three samples however were caught at different places.