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Gonad Maturation and Fecundity of a Fish with Partial Spawning (*Tilapia nilotica* L.)

Kh.A. Hussein

Institute of Oceanography and Fisheries, Alexandria, Egypt

ABSTRACT. Samples of ovaries of *Tilapia nilotica* collected monthly from Lake Manzalah (Egypt) confirm that the female laye eggs in batches, hence is partial spawner. The number of such batches varies from 4 to 5. The nearly ripe eggs are pearshaped, surrounded by a thick layer of cytoplasm directly beneath the outer covering layer (oolema).

A peculiarity of oogenesis of *T. nilotica* is the continuous resorption of oocytes in different stages of maturation, even up to the time of ripening. Resorption occurs not only during trophoplasmic growth but also during the period of protoplasmic growth. Reduction in egg number by consecutive resorption greatly affects the calculation of final fecundity. Percentages of resorption and consequently the decrease in the number of oocytes in each stage are correlated primarily with the size of oocytes and also with the size of the ovary itself and finally with the size of each batch ready to shed.

Egyptian lake fisheries depend mainly on *Tilapia*. These are very productive fishes, ovulate ripe eggs in batches during the extended spawning season (April-September), and hence are considered as polycyclic fishes. These fisheries depend on the production of young throughout the spawning season and throughout life, taking into consideration the characteristic short life span of *Tilapia nilotica* in the Egyptian northern lakes.

Fecundity of *Tilapia* spp. is mostly calculated on the basis of the total number of yolked eggs, regardless of their vastly different sizes and the extensive changes that take place during maturation.

Eggs in the ovaries of polycyclic as well as monocyclic species pass through many changes as they become ripe. Such changes occur throughout both periods of growth; protoplasmic and trophoplasmic.

The final fecundity is correctly calculated only when ovaries are nearly ripe (stage IV-V of maturation), having thus adjusted for the considerable loss of oocytes.

El-Zarka (1962) determined the maturity stages of *Tilapia zillii* Gerv. in Lake Quarun according to the external feature of the ovaries. Persov (1963) and Grachev (1971), working on salmon (*Oncorhynchus gorbuscha* Walbaum), correctly interpreted the potential and final fecundity. Investigations of Hardisty (1964) on fecundity of lampreys are similarly valid. Latif and Rashid (1972) and Latif and Saady (1973) described the oogenesis and macroscopic peculiarities of the gonads of *T. nilotica* and the number of egg groups formed throughout the spawning season. The purpose of the present study is to calculate on legitimate bases the final fecundity of that most economically important fish of Egypt, and thereby to provide the first proper estimate for a polycyclic cichlid species.

Material and Methods

A total of 1570 fresh specimen of *T. nilotica* were collected monthly in the period from May 1974 to June 1975 from the commercial catch in Lake Manzalah. Ovaries of 264 females were separated and fixed immediately in Bouin solution. Small parts taken from the central regions of the ovaries were passed through an ascending series of alcohol and embedded in paraffin. Sections at 6-10 μ were stained with Heidenhain's iron haematoxylin.

Stages of maturation were determined according to the scale given by Sakun and Butskaya (1968). Both macro and microscopic studies were carried out using the dead specimens from which generalizations were extrapolated concerning the species as a whole.

Egg number and egg diameter were calculated on gonads of different stages of maturation, beginning with stage II and up to stage IV-V. Small parts of gonads taken from the same central regions, were weighed on a sensitive balance of 1 mg accuracy. Ovaries were weighed on a balance of 10 mg accuracy. Average diameter of oocytes in each stage of maturation was determined from the slides. Samples of oocytes with different measurements in each weighed sample were divided into groups having the same average diameter and then counted under a binocular microscope, using a dissecting needle. The average number of oocytes in every stage was estimated for different length groups with the same degree of maturation. Unyolked oocytes with little protoplasmic growth were designated as IIa, whereas those with considerable protoplasmic growth were designated as IIb.

Results

1. Gonad Maturation

Histological examination of the ovaries of *T. nilotica* in different seasons reveals that gonadal maturation can be divided into five distinct stages according to the scale of Sakun and Butskaya (1968).

Stage 1

In this stage, the ovary is usually an immature, translucent and ribbonlike structure, although oogonia and young oocytes beginning protoplasmic growth are present throughout the year. Each oogonium contains very little cytoplasm. The nucleus is prominent, with 1-2 nucleoli, and occupies a central position (Fig. 1). On further growth, the oogonia increase in size with an increase in the protoplasmic mass.

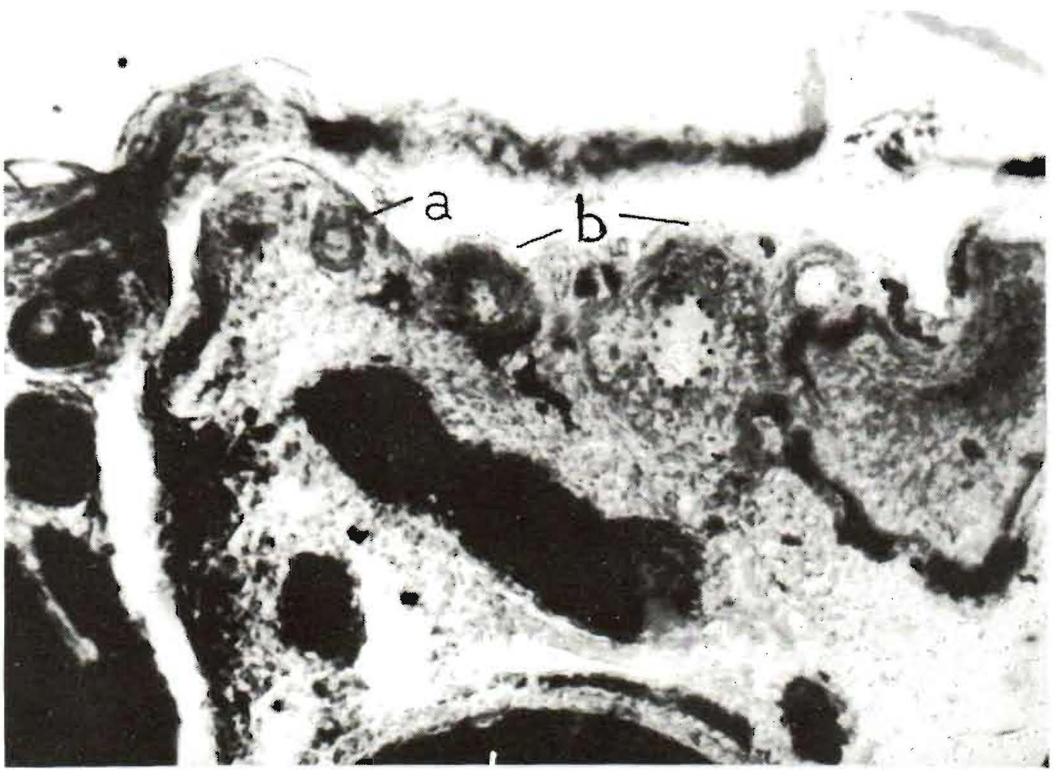

Fig. 1. Part of the ovary in stage I of maturation (×630). a · oogonium in synapsis, b · oocytes with little protoplasmic growth.

Stage II

Oocytes in stage II are characterized by rapid protoplasmic growth (Fig. 2). The cytoplasm in early parts of the stage stains faintly with Heidenhain iron haematoxylin. The oocytes are ovoid or spherical, their nucleus is small and centrally positioned. This stage is also characterized by the appearance of small vacuoles in the cytoplasm and a yolk nucleus which stains dark (Fig. 3). On further growth of ooplasm, the yolk nucleus disintegrates and forms a network. The outer layer of the epithelial follicle thickens throughout this stage.

Stage III

A dense deposition of trophic elements (yolk and fat) characterizes this stage, and growth is trophic rather than protoplasmic as in earlier stages. It is mainly seasonal. Oocytes in stage III reach a size of about 0.3 mm. Nucleoli are scattered

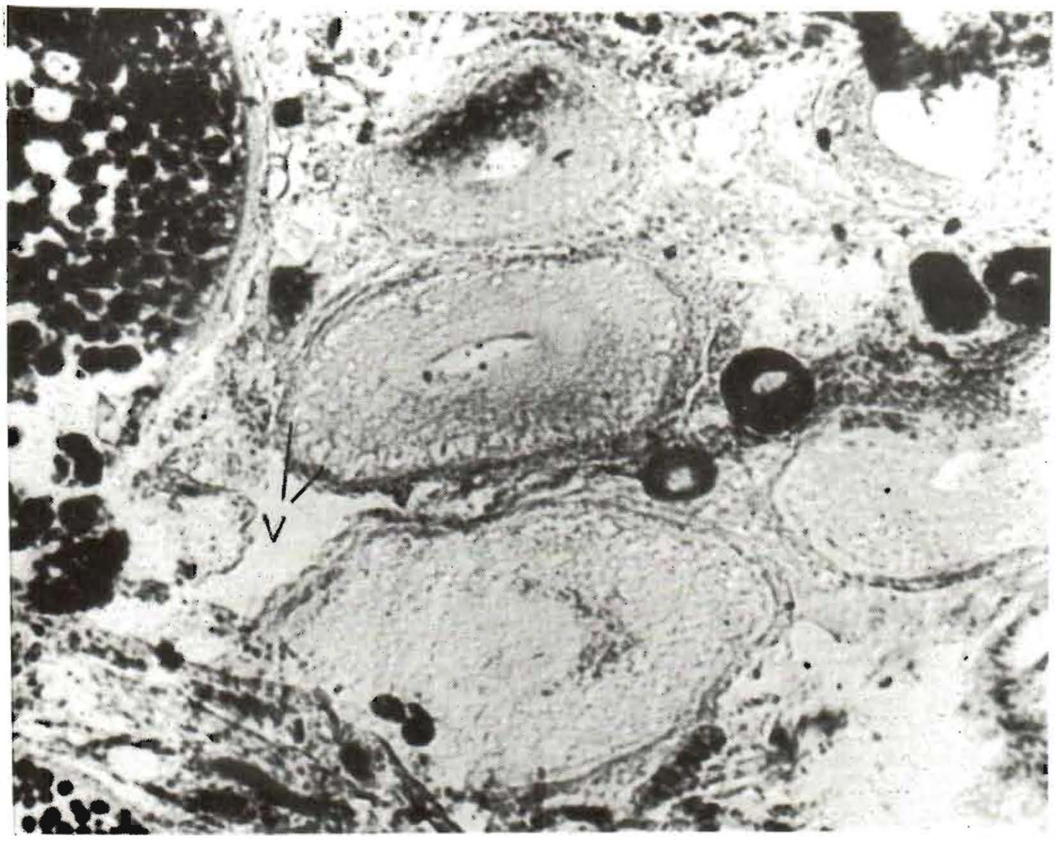

Fig. 2. Oocytes in stage II of maturation (×630). V- vacuoles.

inside the nucleus. The membrane of the oocyte is well developed and consists of a thin layer of connective tissue cells, bordered internally by a follicular epithelial layer, then the zona radiata which is noncellular.

Yolk deposition is heavy in marginal regions of the oocyte (Fig. 4). On further growth (average diameter 0.42 mm), a centripetal deposition of yolk is evident (Fig. 5). One layer of vacuoles surrounds the oocyte beneath the zona radiata. Stage III terminates as the ooplasm is fully occupied by yolk granules (Fig. 6) and as the nucleus becomes irregular in shape.

Fig. 3. Oocytes in stage II of maturation (×630). a- yolk nucleus, b- a covering layer of epithelial follicle.

Stage IV

Entry of oocytes into the ripening condition is characterized by the migration of the nucleus towards the periphery of the now pear-shaped oocyte averaging 1.0 mm in diameter. The nucleus shifts in position towards the broad base of the oocyte.

Stage V

In many fish species, especially those living in a natural habitat, it is difficult to get completely ripe eggs. Since *T. nilotica* is a polycyclic and mouth breeder fish, it is especially difficult, for its ripe eggs to appear in a critically short time.

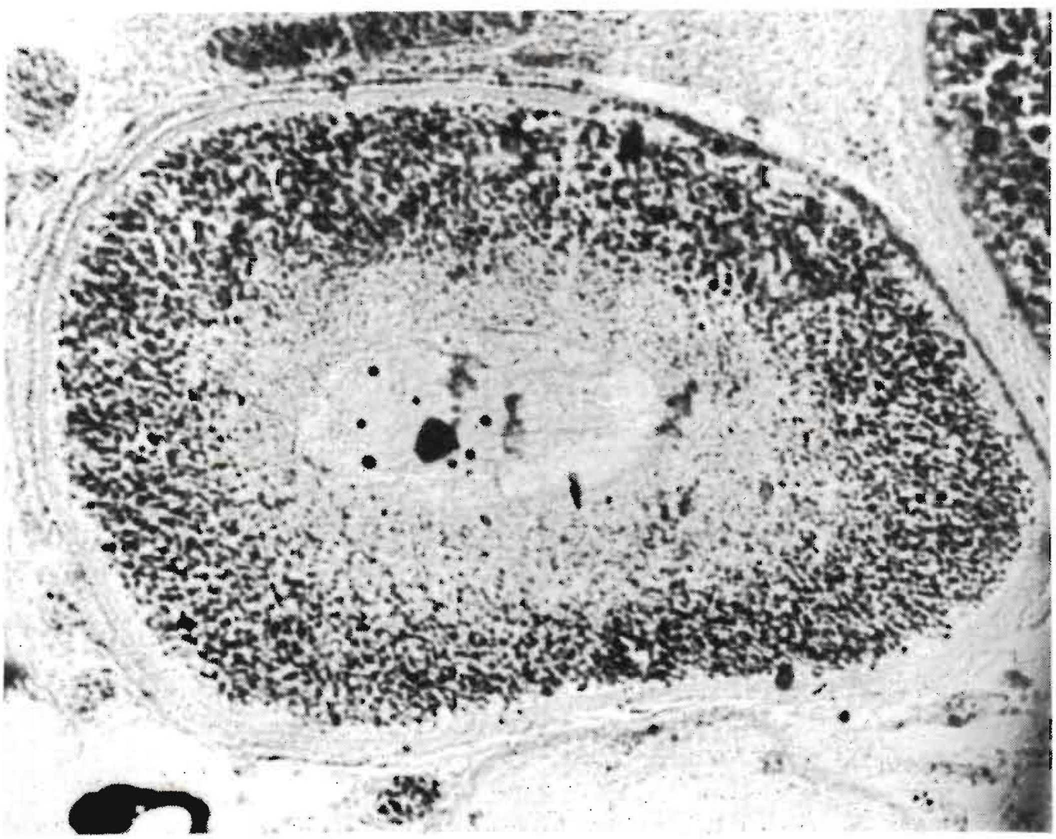

Fig. 4. Oocyte in stage III of maturation, with a marginal deposition of yolk granules (×630).

Figures 8 and 9 show the further consecutive development of oocytes. A cytoplasmic layer is formed around the deposited yolk, and an average diameter of 1.7 mm is reached. The ova reaching this stage of maturation form an aggregation ready for shedding within a short time.

2. Fecundity

Is it not easy to differentiate between various sizes of gonadal sexual cells at the early stages of maturation, *i.e.* stages I and II. The oocytes in stage III of maturation form the group that must be ovulated within the current spawning

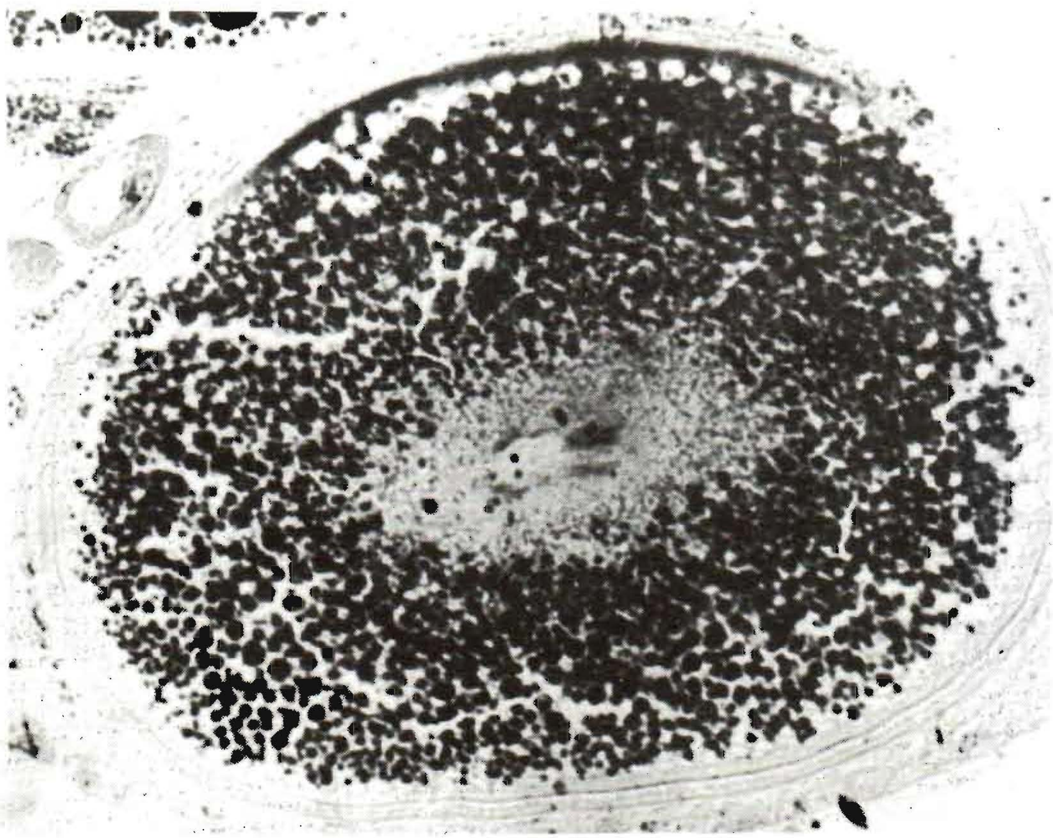

Fig. 5. Oocyte in stage III of maturation, with a centripetal deposition of yolk granules (×630).

season. Nevertheless in fish with partial spawning, such as *T. nilotica*, the actual fecundity is determined by the number of yolked oocytes in an intermediate stage (IV-V) of maturation, *i.e.* a nearly ripe fish.

Analysis of the data obtained shows an extreme decrease in the number of oocytes in both periods of protoplasmic as well as trophoplasmic growth in all examined ovaries. As indicated in Fig. 10, in the beginning of protoplasmic growth (IIa), the average number of oocytes is 3714 decreasing to 1600 oocytes in stage IIb, *i.e.* 2.3 times less than in IIa. The period of trophoplasmic growth (yolked eggs) reveals a continuous decrease in the number of oocytes. In the transition

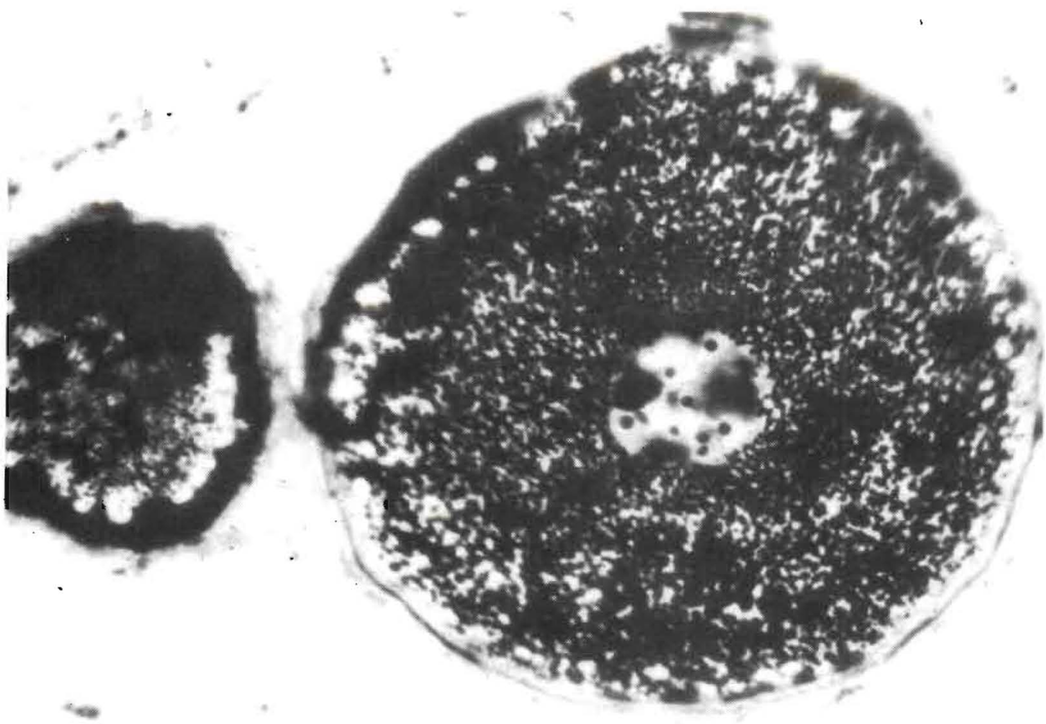

Fig. 6. Oocyte in stage III of maturation with irregular nucleus (×630).

from stage III to the intermediate stage III-IV, a decrease of 64.9% occurs. Between stage III-IV and IV, a further reduction of 24.3% occurs, and between stage IV and intermediate IV-V another 49.7% loss.

Mechanism of formation of egg groups of *T. nilotica* in Lake Manzalah is different from that of the same species inhabiting Lake Nasser in Upper Egypt. In Lake Manzalah, 4 to 5 groups of yolked eggs are formed, in Lake Nasser 2 to 7 groups (Latif and Rashid 1972).

Fig. 7. Oocyte in stage IV of maturation, nucleus starting to migrate towards the broad base (×630).

Our analysis show that not only is there a steady reduction of oocytes through the entire maturation process of each batch of eggs, but that the number of ovulated eggs also decreases from the first to the fourth batch (Fig. 11).

In some species, not all formed batches are ovulated. For instance, in *Pleurogrammus azonus* (J & M), inhabiting cold waters, four groups of eggs form successively in the ovaries, but only two groups are ovulated, the other two being resorbed. The rate of resorption of one group depends on the rate of growth and maturation of the succeeding group (Ivankov 1967).

Fig. 8. Part of an oocyte in stage V of maturation, with a thin layer of cytoplasm formed around yolk (×980).

Likewise in *T. nilotica* we found that there are successive resorbed groups. A specimen collected in July had oocytes in the process of resorption (Fig. 12). The last group of ripening eggs was still developing in the ovaries and the number of protoplasmic oocytes was abnormally small. Thus, the spawning season of that individual would soon have ended, with oviposition of the last group. Hence, no more yolked oocytes would have developed in that season.

The number of yolked oocytes in different stages increases with fish length (Fig. 13). As indicated in that figure, the number of oocytes in stage III of matura-

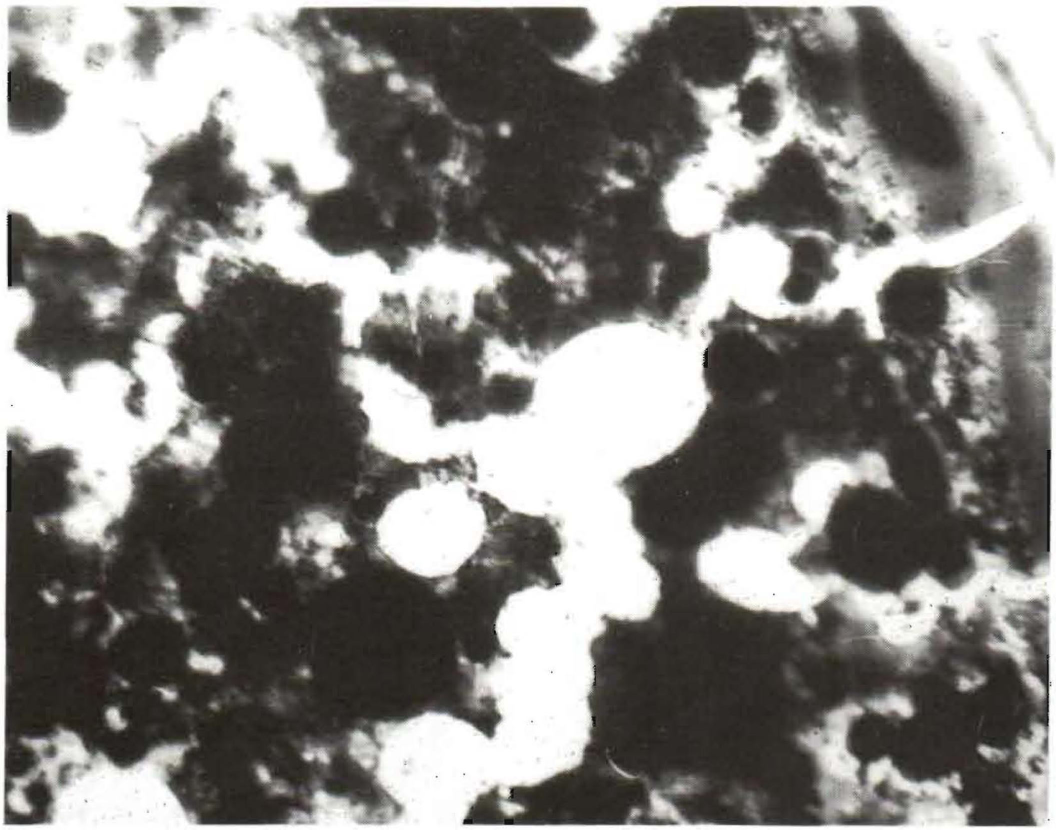

Fig. 9. Further development of an oocyte in stage V of maturation, with a thick partly-fractured cytoplasmic layer (×980).

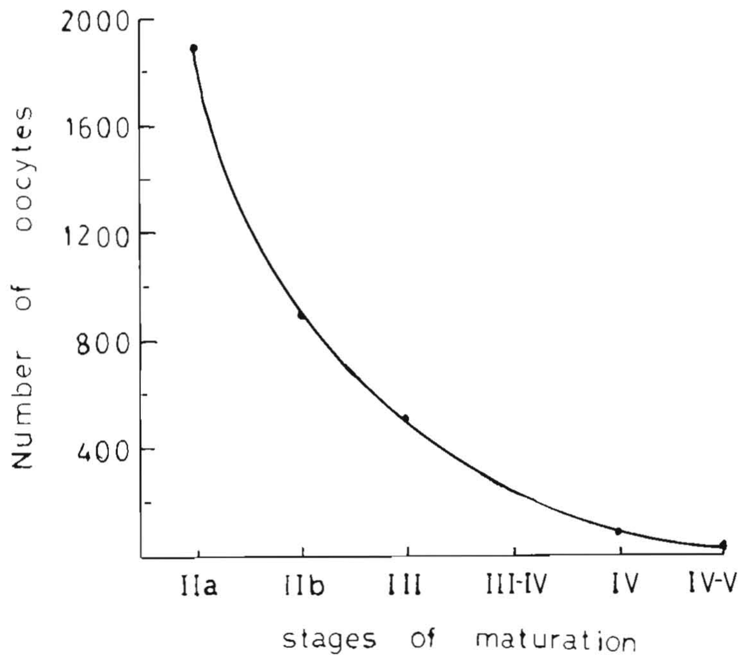

Fig. 10. The change in the number of oocytes during maturation. IIa, small protoplasmic growth; IIb, oocytes with much protoplasmic growth; III, III-IV, IV and IV-V, yolked oocytes.

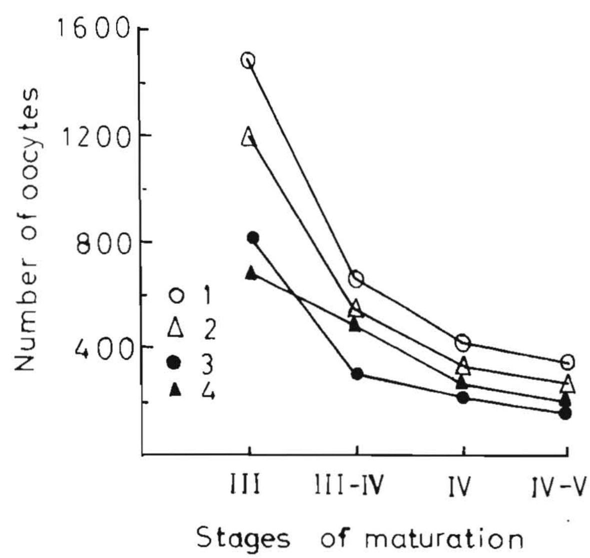

Fig. 11. The change in the number of yolked oocytes during ripening of the ovaries. 1,2, 3 and 4 correspond to the 1*st*, 2*nd*, 3*rd* and 4*th* groups, respectively.

tion increases from 840 to 1640, corresponding to a total fish length 12 and 19 cm, respectively. In ovaries at the intermediate stage (III-IV), the number of oocytes at a total length of 12 cm is 318, increasing to 720 at a total length of 19 cm. In stage IV, the number of ripening oocytes is 195 at a total length of 12 cm, increasing to 430 at a total length of 19 cm.

The group of oocytes being ovulated in the then current spawning season (stage IV-V) shows the same trend. Ripening oocytes in the ovaries of fish with a total length of 13 cm number 180, whereas at 19 cm they number 290.

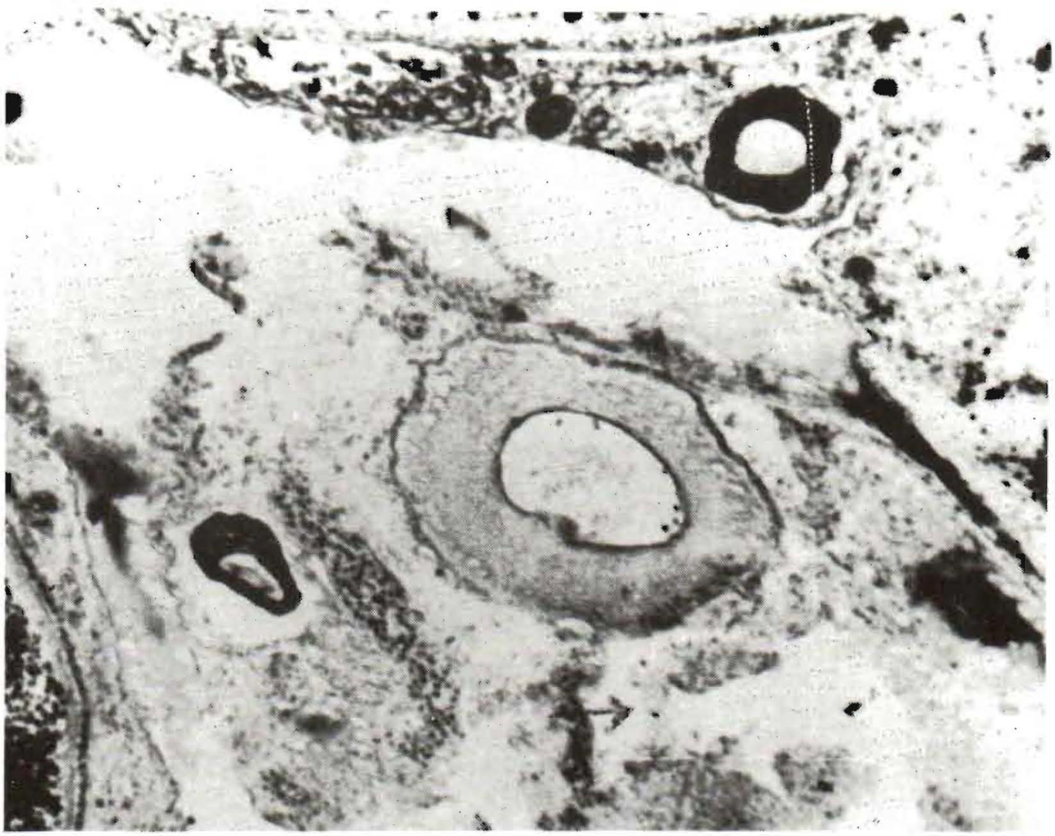

Fig. 12. A histological picture showing the resorbed oocytes (×630).

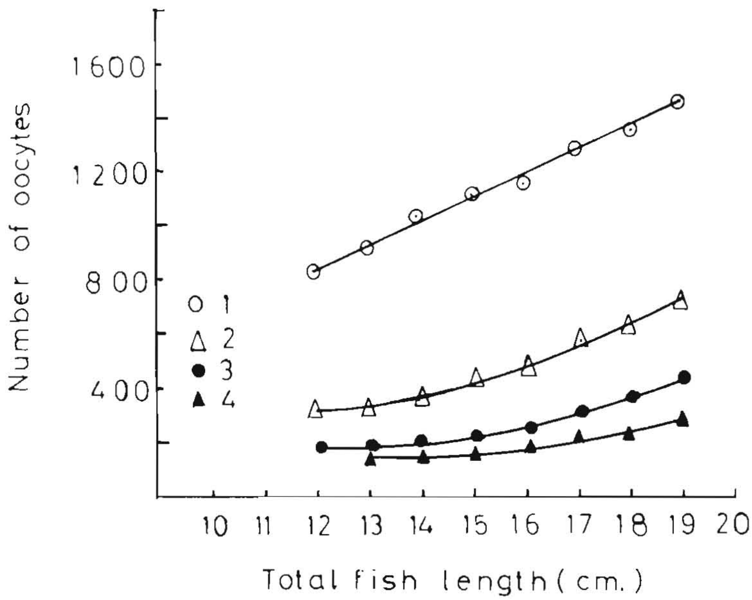

Fig. 13. Relation between total fish length and number of yolked oocytes at different stages of maturation. 1, stage III; 2, stage III-IV; 3, stage IV; 4, stage IV-V.

Discussion

The course of development of the eggs in the ovaries of sexually mature *T. nilotica* is divided into two main periods of growth, *viz.* protoplasmic and trophoplasmic. In order to differentiate the gradual changes or peculiarities during the process of maturation, the two periods of growth are further subdivided into five stages. The gonadal maturation of a partial spawning fish was early described by Kazansky (1949), who distinguished four periods. Sakun and Butskaya (1968) later divided the process of oogenesis into two main periods comprising five stages of maturation.

Ovaries of sexually mature *T. nilotica* contain several aggregations of oocytes of the same size. Although they are at different degrees of maturation, the sequence of development of each group follows the same trend as in many other monocyclic fishes. According to their size differences, oocytes were classified into 4-5 groups representing the batches being partially ovulated in the current spawning season. These deduced groups as developed in the ovaries within the spawning season of *T. nilotica* in Lake Manzalah may be controlled by the prevailing water temperature (average 16.2°C). The same species produces as many as 7 groups in Lake Nasser, where the prevailing climate is warmer (average 21.7°C), suggesting that *T nilotica* produces more batches of eggs if water temperature is relatively high.

The fecundity estimates are subject to a significant decrease in different stages of maturation. This decrease is mainly caused by the consecutive resorption of some ova of the successively formed groups. Although this resorption is considerably decreased in the more advanced stages III, IV and IV-V, it is still significant. The reduction of egg number in the ovaries of *T. nilotica* may be due to incubation of the eggs in the buccal and pharyngeal cavities of the female.

In comparison with other fish species, especially the monocyclic ones, the number of eggs in the batch ready for shedding is comparatively small, varying from 180 to 290 at corresponding fish lengths 13 and 19 cm, respectively.

Conclusion

The diversified mechanism of egg formation in different fish species necessitates the use of consecutive histological examinations of fish gonads, when analyzing the proper fecundity.

Two distinct periods of oocyte growth – protoplasmic and trophoplasmic – are distinguished during gonadal maturation, occurring in five stages. Oocytes developing in the two periods are subject to continual resorption.

The continuous decrease in the number of oocytes is less rapid after stage III. This decrease, resulting from continual resorption, must be taken into consideration in calculating final fecundity. Size of ovipositing female also influences final fecundity.

Four to five groups or batches of ripe eggs are ovulated during the extended spawning season (April-September) of *T. nilotica* in Lake Manzalah, confirming that this species is a partial spawner.

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تكوين البيض و حساب كمياته فى الأسماك مرحلية التوالد (البلطى النيلى)

خميس عبد الحميد حسين
معهد علوم البحار والمصايد - الاسكندرية - مصر

أثبتت الفحوص الهستولوجية أن أسماك البلطى النيلى تضع البيض أثناء موسم توالدها على شكل دفعات متتالية فى فترات زمنية متباعدة ويتراوح عدد هذه الدفعات من ٤ إلى ٥، والبيضة الناضجة كمثرية الشكل تحيطها طبقة سيتوبلازمية سميكة تقع تحت القشرة مباشرة.

والغريب فى عملية تطور البيض و تكوينه فى مناسل أسماك البلطى النيلى أنها تتميزبعمليات امتصاص مستمرة للبيض ليس فقط فى مراحله الأولى بل أيضا فى المراحل المتطورة، وحتى مرحلة النضوج التام. هذا الامتصاص المستمر للبيض جعلنا نعيد النظر فى عمليات حساب عدد البيض النهائى الذى تضعه الأنثى خلال موسم التوالد الواحد، مع الأخذ فى الاعتبار النقصان المستمر فى عدد البيض.

إن نسبة الامتصاص فى المراحل المختلفة من البيض وبالتالى النقصان الحاد الذى يعترى كميات البيض فى المناسل يتحكم فيه أساسا حجم الطور المعين من هذا البيض ثم حجم المناسل ذاتها وأخيرا حجم الدفعة الواحدة من البيض الناضج و المعدة لدفعها خارج الجسم إلى الماء.