The Ovaries of Fishes.

By

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In connection with the inquiries which I undertook at the beginning of the present year into the question of the destruction of immature fish I have been investigating since the issue of the last number of the Journal the development of eggs in the ovary of some flat fishes and the history of the ovary before and after maturity is attained. I have made it my special object to trace the history of the ovary from one spawning period to the next, in order that it might be possible to understand more clearly than at present, from the appearance of an ovary examined at any given time, in what stage of development it was. Mr. Holt has made some observations on this subject, and discussed them in his paper in the number of this Journal for November, 1892. He states there that the first approach to maturity in the ovary is denoted by an enlargement of some of the ova, and the assumption by them of an opaque condition. He terms those ova which have begun to get opaque, "active," and those which have not, "inactive." In a footnote it is stated that the changes which give rise to the opaque condition are not the same in all species, but that they appear to possess the same significance. Mr. Holt leaves undecided the question whether all the active ova are expelled during the spawning period, so that there is a period following the process of spawning when only "inactive" ova being present, the condition of the ovary is not distinguished by internal structure from that of a fish which has not begun to breed, which is immature. He says that he has met with no such condition in the plaice, but that dabs presented such a condition in September after spawning about April. He says that when spent plaice are examined the ovary always contains a number of small active ova, in addition to a host of inactive, but he is uncertain whether the "active" ova represent the early condition of next season's crop, or only ova which, though they pass the inactive stage, are absorbed without becoming ripe. Mr. Calderwood in his paper on Fish Ovaries in the same number of the Journal dis-

tinguishes the ova into three stages, the great, the small, and the minute. The great are those to be extruded at the next spawning season, and correspond to the "active" ova of Mr. Holt's paper, while the small and the minute are the "inactive." Scharff in his paper in the Quart. Journ. Mic. Sci., 1888, on which Mr. Calderwood's views are largely based, describes the smaller ova and the larger ova. The latter correspond to the "active" ova of Holt's paper, and Scharff describes the formation of yolk in them, but does not deal with the process in relation to the periodic changes which take place in the ovary.

A comparison of these papers shows that the history of the formation of the yolk in the ova of fishes in connection with the periodic development of the crop of ova which are shed at each spawning season has not yet been thoroughly investigated. My own observations show that the opacity which distinguishes the active ova in Mr. Holt's description is due entirely to the development of the yolk. I will describe what I have observed in the ovaries of various species, commencing with the plaice.

Of the plaice I examined in January some were ripe or nearly ripe and some immature. In the immature ovary the ova are all transparent, and when they are examined with the microscope in the fresh state their structure can be clearly seen. Leaving aside the tissue of the ovary, the stroma, which forms membranes round the eggs, the egg itself is seen to consist of structureless transparent protoplasm containing the nucleus, almost equally transparent, in the centre. The nucleus or germinal vesicle is enclosed by a membrane and contains the nucleoli, rounded bodies distributed at the periphery in contact with the inner surface of the membrane. The appearance of these young yolkless ova in the fresh state is shown in Fig. 1, *a*. In the other fish which are mature, and which are about to spawn, some of these yolkless eggs are present, but they are in small proportion to the opaque yolked eggs which make up the bulk of the enlarged ovary. The yolked eggs are so opaque that it is impossible to see into their interior, but by examination of their surface the yolk can be seen to consist of separate globules or spherules of various sizes. In some specimens eggs which are very nearly ripe and ready for extrusion are seen. These are more transparent, and the transparency is seen to be due to a fusion of the yolk globules into a homogeneous mass. When this takes place, and the egg becomes ripe, the transparent mass of yolk occupies the whole central region of the egg, and the protoplasm forms a thin layer surrounding it. The germinal vesicle cannot be seen in the fresh ripe egg, but it is well known that it is represented by structures which can be demonstrated by appropriate methods in the external layer of

protoplasm. It is worthy of note that in the ovary of the plaice, when spawning commences, the ripe eggs are scattered here and there uniformly throughout the germinal tissue, not confined to one place. In other words one part of the ovary does not get ripe before another, but in all parts the eggs ripen in succession, until all are shed.

When all the eggs of the season have been shed the ovary is found in a flaccid, empty condition, the germinal tissue on the walls of the ovary being thin and containing much blood. The fish is now spent. The first specimen I found in this condition last season was obtained on January 28th. The specimen was 24 inches long; the ovary had not shrunk greatly in length, it was $7\frac{3}{4}$ inches long, measuring from the anterior end of the ventral fin, and the end of it was $4\frac{1}{4}$ inches from the posterior end of the same fin. In the internal cavity of the ovary a number of detached, ripe eggs were found; these were dead, but fresh, and seemed to have shed after the death of the fish. No ripe or nearly ripe eggs remained in the stroma or germinal tissue of the ovary. When a portion of this tissue was examined it was found to consist chiefly of transparent, yolkless ova exactly similar to those seen in the immature fish, but besides these there were scattered here and there singly, ova which showed a thin layer of yolk granules round the periphery. The appearance of the eggs from a small portion of the germinal tissue is shown in Fig. 1. The yolked eggs were somewhat opaque and

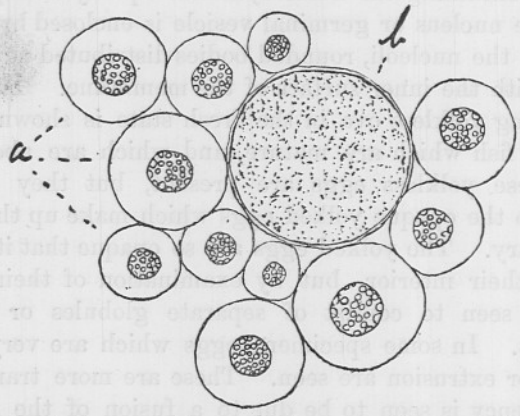

FIG. 1.—Eggs in the ovary of a spent plaice. *a*, yolkless ova; *b*, yolked ovum destined to degenerate.

presented a dull, unhealthy appearance. The smallest of the yolked eggs was ·27 mm. in diameter, and the largest of the yolkless eggs very little smaller; the largest yolked eggs were ·36 mm. in diameter. I was at first inclined to interpret this condition as

showing that the formation of yolk in the eggs for the next spawning season had begun by the time the present spawning was finished. This is the condition referred to by Mr. Holt on p. 369, Vol. II of this Journal, and he states that he was uncertain whether the yolked ova represented the early condition of next season's crop, or only ova which remain undeveloped in the spent fish and are absorbed without developing further. The question is, therefore, whether the ripening of the eggs from the immature condition for the next spawning commences before the spawning of one season is concluded, that is to say, whether the development of the yolk takes a little more than, or less than the interval between two spawning seasons.

Examination of other shotten fish, which of course became more numerous as time went on, showed clearly that no advance, but, on the contrary, a retrogression took place in them in the development of yolk. On February 2nd I examined a shotten plaice, 15¼ inches long, in which there were ripe but dead eggs in the cavity of the ovary. In the germinal tissue examined under the microscope there was a good deal of loose yolk from ripe eggs which had been broken during the spawning, but there were no small yolked eggs as in the specimen described above.

On February 24th I examined a female plaice which appeared to be spent from the external appearance of the ovary alone. The right ovary was 3¾ inches long and the distance from the end of it to the end of the ventral fin 3⅜ inches. In immature specimens the length of the ovary is always much less than this latter distance. The fact that it was a spent fish was placed beyond doubt by the presence of dead ripe eggs in the cavity of the ovary. Yet in the germinal tissue itself, when examined under the microscope, not a trace of yolk was to be seen in any of the eggs, the largest of which was ·29 mm. in diameter.

In March I examined no plaice, but in April several, some of which were evidently spent. On April 7th a specimen 14⅜ inches long had a right ovary 2⅞ inches long, and the end of it was 4½ inches from the end of the ventral fin. This fish might, from the size and appearance of the ovary, have been set down as immature, but in the stroma, under the microscope, could be seen here and there shrivelled remains of yolked eggs, much fewer in number than the yolked eggs in spent ovaries previously seen, but evidently of the same kind, and suggesting clearly that the ovary was spent, and reverting to the yolkless condition. Another specimen of the same size, examined on the same date, had the ovary in a similar condition, but the degenerating ova were still fewer in number. The size and external appearance of the ovary in these

specimens are not different from those seen in a specimen which is certainly immature.

In May I examined three plaice; one was a spent female, the right ovary measuring $4\frac{1}{2}$ inches in length, and $4\frac{1}{8}$ inches from the posterior end of the ventral fin. There were remains of ripe ova still in the oviduct, and some partially opaque yolked ova in the germinal tissue. The other two were over 15 inches long, and had no yolked ova in the ovary, nor any other indication that they had previously spawned.

In June I examined few plaice. On the 9th I opened a female $14\frac{3}{8}$ inches long; the end of the right ovary was $3\frac{7}{8}$ inches from the anterior end of the ventral fin, $3\frac{5}{8}$ inches from the posterior end. There were the remains of dead ripe eggs in the cavity of the ovary, but at first no trace of yolked ova was found in the germinal tissue; afterwards a few shrunken yolked ova were found, evidently in process of absorption.

In July, on the 15th, I first found that the formation of the yolk in the ova of next season's crop had commenced. In one specimen, 16 inches long, the length of the right ovary was $4\frac{5}{8}$ inches, its distance from the posterior end of the ventral fin $3\frac{5}{8}$ inches. The germinal tissue appeared to the naked eye opaque, white, and evidently yolked. Under the microscope the majority of the ova were seen to contain so much yolk as to be quite opaque, and the largest of them were ·5 mm. in diameter, that is considerably larger than the largest yolkless ova. Fig. 2 shows the appearance of the

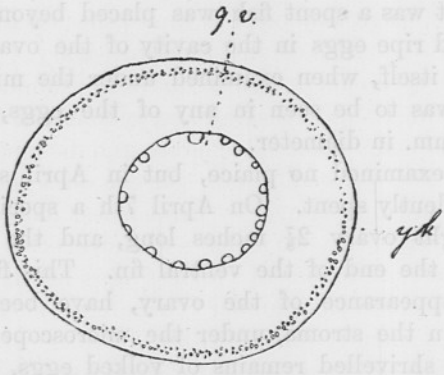

FIG. 2.—Ovum of plaice in which formation of yolk has commenced, magnified about 200 times. *yk.*, yolk; *g. v.*, germinal vesicle or nucleus with nucleoli at periphery.

smallest ova in which yolk had begun to be formed. Nothing was seen to denote that this fish had spawned previously, but considering its large size it probably had.

Another specimen, 15¼ inches long, exhibited a less advanced stage in the development of the yolk. The right ovary was 3½ inches long, 4⅛ inches from the posterior end of the ventral fin. In the majority of the ova the yolk was present in an external zone of the egg. There was nothing in the germinal tissue to show that this ovary had spawned before, but a small free clump in the cavity seemed to consist of the membranes of old ova of last season.

Another specimen, 14½ inches long, was still less advanced, the yolk being present only as a thin layer of small granules in the most external region of the egg, and the quantity of it was so small that the transparency of the ova was scarcely diminished. Other specimens larger than this last showed no trace of yolk or indications that they had previously spawned, and were either immature, or in the resting condition.

On August 8th I took a plaice from a tank in the aquarium, one of a number which were observed to spawn in the beginning of the year. The specimen was 18⅛ inches long. The right ovary was 3½ inches long and 5¾ inches from the posterior end of the ventral fin. There were no indications that the fish had spawned before. The formation of yolk for next spawning was already somewhat advanced. The largest of the yolked eggs, which were quite opaque, was ·5 mm., the smaller ·2 to ·3 mm. ; the largest of the yolkless eggs was ·19 mm. Another large specimen from the same source, killed on August 17th, was found to be in a similar condition.

It is quite certain from these observations that, so far as the microscopic appearance of the germinal tissue is concerned, the spent ovary of the plaice, when examined in the fresh state under the microscope, may be quite similar to an immature ovary. This is clearly exemplified by the specimen described above as examined on February 24th. It is certain, I think, that all the yolked ova left in an ovary after spawning has taken place degenerate and disappear, and the formation of yolk in the succeeding crops of ova does not commence till some time after spawning is over. The earliest date at which I have observed the formation of yolk to have commenced is July 15th. It is also certain that the number of yolkless eggs left in the ovary after spawning is far less than the number of ripe eggs shed in the following season. Consequently the greater number of the eggs of one season's crop are produced *ab initio* during the year. It is to be noted that after a comparison has been made between an ovary in which yolk is commencing to develop and a spent ovary containing superfluous yolked ova the latter cannot be mistaken for ova which are developing for the next season. They are few in number and scattered singly, while the developing ova are abundant everywhere, and they have a dull, unwholesome appearance.

The cases in which I found only yolkless ova in spent ovaries were recognised as spent, like the dabs in the same condition described by Mr. Holt, by the presence of the remains of ripe eggs in the ovarian cavity. Are there cases in which, these remains having been expelled, nothing is left to distinguish a fish that has recovered from spawning from one that has never spawned? I have no evidence by which to answer this question conclusively, but it is certain that ovaries which are known to have previously spawned, from the presence of degenerating yolked ova, are sometimes no larger than others which are, from the absence of any indication to the contrary, set down as immature. For instance, in a plaice, $14\frac{3}{8}$ inches long, the spent ovary was $2\frac{7}{8}$ inches, and the end of it $4\frac{1}{2}$ inches from the end of the ventral fin, while in a specimen $13\frac{1}{4}$ inches long, apparently immature, the ovary was 3 inches long and only 4 inches from the end of the ventral fin. To avoid this possible uncertainty in distinguishing immature fish it would be advisable, in order to ascertain the limit of size at which maturity commences, to examine a large number of specimens within a short space of time—one month for example—in the middle of the spawning period. At this time there would be no mature specimens in which yolk had not commenced to develop, and no spent specimens which had reverted to the resting condition.

Dab.

I have not studied the dab in the spent condition, but I have found that the formation of yolk certainly commences in some specimens in September. I killed one specimen $11\frac{1}{2}$ inches long on September 18th; the ovary was $2\frac{1}{8}$ inches long, $3\frac{7}{8}$ inches from the end of the ventral fin. The yolk formed a thin layer of very small granules in the extreme outer region of the egg, and was not sufficient to diminish its transparency to any great extent. The diameter of the largest of the yolked eggs was ·17 mm. In some of the ova under microscopic examination the membrane of the germinal vesicle was seen to be slightly wrinkled. The appearance of one of the eggs is shown in Fig. 3.

Flounder.

Mature flounders examined in January had ovaries in an advanced condition. In February many were ripe. In July I killed two from the aquarium which were known to have spawned in the spring. One was 11 inches long, the ovary was flaccid and rather large, and did not resemble an immature ovary in external appearance. Microscopically examined, only yolkless ova were found in the germinal tissue, with here and there a shapeless opaque mass, obviously a

degenerate yolked ovum left at the previous spawning. In another of the same size the right ovary was $2\frac{3}{4}$ inches long, $2\frac{5}{8}$ inches from

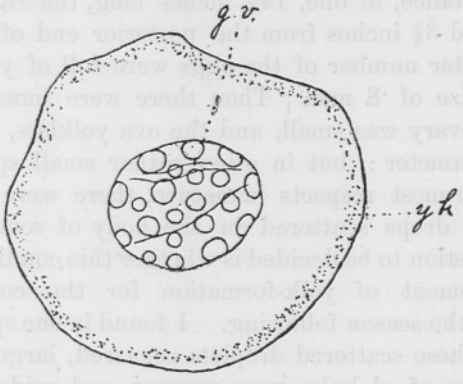

FIG. 3.—Ovum of dab in which yolk has just commenced to develop; magnified about 250 times. *yk.*, yolk; *g. v.*, germinal vesicle with nucleoli. In Fig. 2 the germinal vesicle is shown in optical section, here in surface view.

the posterior end of the ventral fin, and was in the same condition. These flounders spawned at the end of April and beginning of May, and it is seen that the condition of the germinal tissue had almost reverted to that of the immature ovary, but the size and appearance of the ovary showed that the fish had spawned. Another specimen, $12\frac{3}{8}$ inches long, from the same tank, was killed on August 25th; the germinal tissue exhibited only yolkless ova, all traces of previous spawning had disappeared. On August 31st I examined a specimen $15\frac{5}{8}$ inches long caught in the Hamoaze. The ovary was large and flaccid, and had evidently spawned before. The formation of yolk in next season's eggs had just commenced, and no trace of the previous spawning was left in the appearance of the germinal tissue under the microscope.

I have not yet been able to examine the spent condition or to determine the period at which yolk commences to develop in the merry sole (*Pleuronectes microcephalus*). In December and January mature specimens were in an advanced condition but not ripe. Ripe specimens were obtained from February to July, but none in the spent condition.

Common Sole.

My observations on the ovary of this species are far from complete, and I shall hope to resume the discussion of it on a future occasion. From what I have hitherto observed I am inclined to infer that the development of the yolk in the sole extends beyond the period of a year, so that the maturation of one

crop of ova begins before the preceding crop has been shed. In January large mature specimens had the ovary in an advanced condition, for instance, in one, $14\frac{1}{4}$ inches long, the right ovary was 6 inches long and $3\frac{3}{8}$ inches from the posterior end of the ventral fin, while the greater number of the eggs were full of yolk and reached a maximum size of ·8 mm. Then there were immature specimens in which the ovary was small, and the ova yolkless, the largest only ·17 mm. in diameter; but in other rather small specimens, whose ovaries were in most respects immature, there were a small number of minute oily drops scattered in the body of some of the largest ova. The question to be decided is whether this condition represented the commencement of yolk-formation for the coming spawning season, or for the season following. I found in one specimen, besides ova in which these scattered droplets occurred, larger ova in which a larger number of globules were present, and evidently constituted the commencement of yolk formation. This specimen was $12\frac{3}{8}$ inches long and the ovary was only 3 inches long, $5\frac{1}{8}$ inches from the end of the ventral fin. As soles have for the most part finished spawning in May it seemed improbable that this specimen was ripening for the approaching season. The condition of the ova is seen in fig. 4.

FIG. 4. FIG. 5.

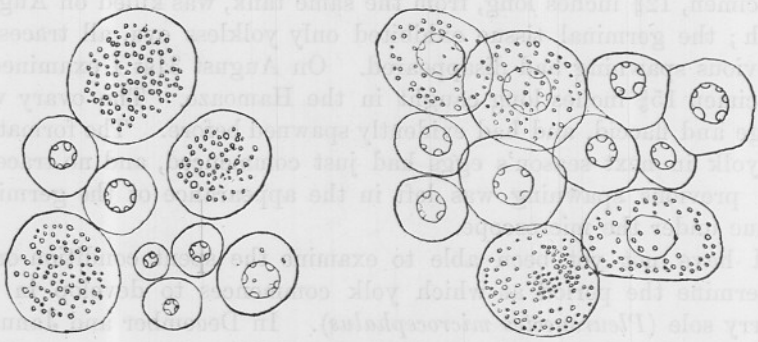

FIG. 4.—Ova from the ovary of a sole $12\frac{3}{8}$ in. long, examined January 27th. Low power.

FIG. 5.—From a sole $12\frac{1}{8}$ in. long, examined February 3rd.

In February specimens between 12 and 13 inches long were found in the condition described, as well as larger fish, which were almost ripe. The condition of the ova in a specimen $12\frac{1}{8}$ inches opened on February 3rd is shown in Fig. 5. The same condition was found also in March, in which month many mature specimens were ripe. In April no soles were examined, but in May some specimens still presented the condition described, while in large specimens diagnosed

as spent the minute globules, or the commencement of yolk, were observed in a number of the ova, and seemed to denote, not as in the plaice ova destined to degenerate, but the development of yolk for next season's crop. A number of small soles were examined in June, $6\frac{5}{8}$ inches to $10\frac{1}{2}$ inches in length, and in many of these the globules were present in the ova. A more complete study of the sole's ovary, especially in the spent condition, will be necessary in order to fully elucidate the matter, but it is clear that the development of the yolk in this species is somewhat different from that observed in the plaice and flounder. In distinguishing between mature and immature soles I have always set down those in which only the minute globules were present in the ova, or in which the yolk was only just commenced, as immature, since it was evident that such ovaries could not reach the mature condition in the season in which they were examined.

Turbot.

In a turbot, 30 inches long, examined on January 27th, the roe was flaccid and collapsed, evidently one that had previously spawned. Under the microscope the yolk was found to be commencing to develop in some of the largest eggs, while here and there yellowish opaque masses and one or two shrunken dead eggs represented the

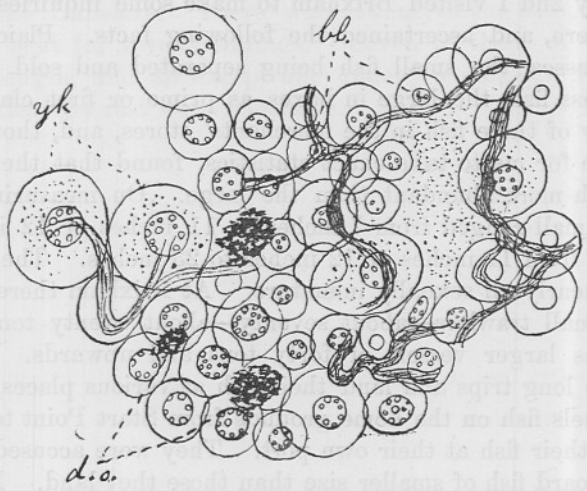

FIG. 6.—Portion of the germinal tissue from ovary of a turbot 30 in. long, examined January 27th. *yk.*, ova in which formation of yolk has commenced; *bl.*, blood-vessels; *d. o.*, degenerate ova left from previous spawning.

remnants of the previous spawning. The condition of the germinal tissue in this specimen is shown in Fig. 6. In immature specimens examined on the same date, $15\frac{5}{8}$ inches and 17 inches in length, the

ova were all transparent, not a trace of yolk was visible, nor were any degenerating eggs present. A specimen, 19¾ inches, examined on March 4th showed the yolk commencing in an immature specimen, but whether it would have spawned the same summer I cannot be certain. I have not been able to trace the history of spent specimens.

Brill.

A specimen, 16⅛ inches long, on January 25th, had the yolk advanced in development. A few opened in March were ripe, or nearly so.

With regard to the relation of maturity to size, and of the destruction of immature fish, I have not much to add to my paper on *The Immature Fish Question* in the last number of the Journal, but a brief record of a few subsequent observations is necessary.

A few merry soles landed from trawlers were examined in April, May, June, and July, and all were mature, for the most part actually ripe. On June 3rd a specimen, 7⅛ inches long, was taken in our own otter trawl five or six miles south of the Mewstone; it was a female and immature, all the ova being transparent without a trace of yolk. This is the only immature merry sole I have yet obtained at Plymouth.

On May 2nd I visited Brixham to make some inquiries about the fishing there, and ascertained the following facts. Plaice are sold in two classes, the small fish being separated and sold as offal or second class fish, the large in boxes as prime or first class. I saw a quantity of these fish in the merchants' stores, and, though it was impossible for me to take exact statistics, found that the small fish were much more abundant than the large. On measuring I found that the small ranged from 7 inches to 11 inches or 12 inches, and the large from 11 inches or 12 inches to 23 inches. The small fish must be nearly all sexually immature. At Brixham there is a large fleet of small trawlers—about seventy—about twenty tons burthen, as well as larger vessels of forty tons and upwards. The large vessels go long trips and land their fish at various places, while the small vessels fish on the home grounds from Start Point to Portland, and land their fish at their own port. They were accused of throwing overboard fish of smaller size than those they land. Besides the plaice I saw large numbers of small whiting 8½ inches long. Small soles were scarce, and none were under 8 inches. Of lemon soles very few were small, and all I saw were ripe or spent. The smallest I could find measured 10½ inches.

The Devon Sea Fisheries Committee has now prohibited trawling within certain limits in the region where these Brixham trawlers fish.

On May 4th I saw a tuck-net hauled for flat fish at Beesands near Torcross. The mesh of the net was $1\frac{1}{4}$ inches square. The whole net was 100 feet long, and it was hauled by fourteen men, seven at each end. The catch was very small, a few small fish were thrown back before I saw them, besides these there were thirty flounders $6\frac{3}{8}$ to $13\frac{3}{4}$ inches long, four plaice under 8 inches, and six above, and a few dabs. The men told me that the fishing was unusually poor, but as they have scarcely any market for flat-fish, and use the produce of their seines principally to bait their crab-pots with, it is certain that the seine fishery at Beesands is too small to be of great importance in relation to the destruction of immature fish.

On June 8th I obtained on the Barbican, Plymouth, a number of small soles brought in from Saltash, and probably caught by tuck seines in the Hamoaze. There were twenty-seven altogether, and they were sold for seven shillings. Seven of them were under 8 inches in length, and all except one under 10 inches. Eight were mature males, the rest were immature.