

with carmine and broadly edged with yellow or orange, the yellow bands occupying the upper and lower fourths of the caudal. Female paler, more translucent, at times pinkish; fins white, dorsal and anal dotted with carmine.

Total length 42 mm.

Several specimens.

Allied to *F. gardneri* Blgr.

This species will be figured in the forthcoming third volume of the British Museum Catalogue of African Freshwater Fishes.

EXPLANATION OF PLATE III.

Fig. 1. *Barbus spurrelli*.

2. *Barilius macrostoma*.

2a. " " Head from above. Natural size.

4. On some Parasites of the Scoter Duck (*Ædemia nigra*), and their Relation to the Pearl-inducing Trematode in the Edible Mussel (*Mytilus edulis*). By H. LYSTER JAMESON, M.A., D.Sc., Ph.D., and WILLIAM NICOLL, M.A., D.Sc., M.D.

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(Text-figures 11 & 12.)

INDEX.

Systematic:	Page
<i>Gymnophallus ædemie</i> , nom. nov.	57
<i>G. affinis</i> , sp. n.	58
<i>G. macroporus</i> , sp. n.	60
<i>G. ovoplenus</i> , sp. n.	62

Of the many questions connected with the formation of pearls in the common Edible Mussel (*Mytilus edulis*) the identity and life-history of the pearl-inducing organism is one of the most important. It was shown ten years ago by Jameson (1902) that the agent in this particular case is the larva of a parasitic Trematode, which, instead of secreting a cyst of its own, as is usual with such larvæ, stimulates the mussel to form around it a sac of epidermal cells. These cells possess the same physiological properties as the outer shell-secreting epidermis, and eventually, on the death of the Trematode larva, secrete conchyolin and calcareous salts, which, deposited in concentric layers around the remains of the worm, become the pearl. Attempts were made by Jameson to trace the life-history of this parasite, but the difficulties in the way of working out the complete life-cycle of digenetic Trematodes are considerable, and the results obtained by him in 1902 have not been accepted as entirely conclusive.

With regard to the parasite in *Mytilus*, the two main questions to be solved were: (1) Whence does it come? and (2) Whither does

it go? From a consideration of Trematode development in general, it was obvious that these larvæ in *Mytilus* must have passed a previous stage, as a sporocyst or redia, in some other molluscan host, and it was equally obvious that they were destined to become adult in some final vertebrate host, to be sought among the animals that eat the mussel.

With regard to the earlier part of the life-history, Jameson was struck by the occurrence in *Tapes decussatus*, which lives associated with the pearl-bearing mussels in the harbour of Billiers (Morbihan), Brittany, of sporocysts containing *Cercarice* closely resembling those in *Mytilus* and differing from them chiefly in size. Jameson subsequently found similar sporocysts in a different situation in the common Cockle (*Cardium edule*) on the pearl-bearing mussel-beds at Piel, Lancashire, and these have since been rediscovered by Lebour (1906) and Nicoll (1906). The occurrence of these sporocysts in *Cardium* is of particular interest in view of the fact that the cockle, as a rule, lives in close association with the mussel and is on that account a not unlikely intermediate host for the mussel parasite.

Herdman (1903-6) failed to find this parasite in Piel cockles, and seems to have doubted Jameson's assertion that it occurred there; but we have found it over and over again in cockles both from the original station at Piel, and from the cockle-bed at Foulney in the same neighbourhood.

Infection-experiments were undertaken by Jameson in 1901, in order to prove the transference of the parasite from *Tapes* to *Mytilus*, but although he claimed success in these experiments, they are still open to the objection that some at least of the mussels used were already infected before the experiment was undertaken*.

Pending the results of further experiments, there are only the structural characters of the two larval forms to go upon. Morphologically there is a very close agreement between the cercaria in *Cardium* and that in *Mytilus*. They both agree in having the oral sucker not more than one-fifth of the body-length, and in its being not more than one-third as large again as the ventral sucker. In both the pharynx is comparatively large. The differences which exist are small. For instance, the oral sucker in the *Mytilus* cercaria is relatively larger than that in the *Cardium* cercaria; the ventral sucker is larger in the former in proportion to the oral and it is slightly nearer the posterior end of the body instead of, as might have been expected, further forward. Again, the œsophagus is shorter and the diverticula longer. These discrepancies, although minute, are sufficient to give pause in too hastily concluding that the two forms belong to one and the same species.

With regard to the final host of this parasite, there can be little doubt but that Jameson was right in supposing it to be one of the

* [I am at present repeating these experiments, with the aid of a Government Grant from the Royal Society.—H. L. J.]

mussel-eating ducks, such as the Scoter and the Eider; but the form he figured as the adult in 1902 from the Common Scoter, which he referred to *Gymnophallus* (*Lecithodendrium*) *somateriae*, and which we are now describing below under the name *G. ædemie*, is certainly not the adult of the larva which occurs in *Mytilus*, but is a much smaller species*.

In order to reconcile the small size of the larvæ which he found in the Scoter at Billiers in 1902 with the larger dimensions of the larvæ in the mussel, Jameson was obliged to have recourse to an unlikely hypothesis. This was commented on by Odhner, who suggested that Jameson had probably encountered a mixture of two species, one probably being *G. bursicola* and the other a new species of the same genus. As the present investigation will show, the latter part of Odhner's supposition was correct; while, with regard to the former, until further specimens from Billiers can be examined, it is impossible to say whether the larger examples observed by Jameson at that station were *G. bursicola* or *G. dapsilis*.

Since the publication of Jameson's paper, two species, namely *Gymnophallus bursicola* Odhner and *G. dapsilis* Nicoll, have been suggested as the possible adult form. Before the discovery of the second of these species Odhner (1904) gave it as his opinion that the probable adult was *G. bursicola*, a parasite of the Bursa Fabricii of the Eider Duck (*Somateria mollissima*). At the same time he stated that a larva identical with that in *Mytilus* occurs in *Saxicava rugosa* in the Arctic regions. At that time there could be little question as to the probable correctness of his view, for no other known species was so likely to be the adult of the parasite in *Mytilus*. The discovery by Nicoll (1907) in the Scoters of a second bursicolous *Gymnophallus* closely resembling, yet distinct from, *G. bursicola*, showed that Odhner's conclusions could not be accepted without further study, for *G. dapsilis* appears to have even stronger claims than *G. bursicola* to be considered the adult of the larva in the Piel pearl-bearing *Mytili*†.

The two chief facts in favour of such a view are that the sizes of the suckers and the position of the ventral sucker, in the Piel pearl-inducing Trematode, correspond more closely with those in *G. dapsilis*, while the firm brittle consistency of the body reminds one more of *G. dapsilis* than of the softer *G. bursicola*. The position of the testis in relation to the ventral sucker is also a feature of some moment. It is, of course, quite possible that two closely allied Trematodes are concerned with pearl-formation in *Mytilus*—the one derived from *Tapes*, the other from *Cardium*,—and it may be that the adults of these two species are respectively *G. bursicola* and *G. dapsilis*.

Jameson foresaw that it would be necessary to prove in some

* [I distinctly remember the occurrence of a small number of larger *Gymnophalli* in the Billiers *Ædemie*, though it did not occur to me at the time that more than one species might be present. I referred them all to the only species then known to me, *G. somateriae*.—H. L. J.]

† We have not so far had an opportunity of re-examining the larvæ found in the Billiers mussels.

conclusive fashion the correctness of his views in regard to the life-history of the pearl-forming Trematode in *Mytilus*, and towards that end an endeavour was made in 1901 to perform feeding-experiments with a Pochard (*Fuligula ferina*), the only likely diving duck which was available at the time. These experiments were unsuccessful.

It was in continuance of this work that the present investigation was undertaken. Arrangements were made* to obtain some live Scoters (*Edemia nigra*) and have them fed upon mussels infected with the pearl-inducing cercariæ. Three Scoters were purchased on our behalf by the Zoological Society from D. G. Schuijl, of Rotterdam, who stated that they were all caught on the Zwarte Water, in the province of Overijssel. In addition, four dead Scoters, stated to come from the same locality, were kindly sent to us for examination by the Superintendent of the Brighton Aquarium. With one exception, these four birds were found to be heavily infected with intestinal parasites, including a considerable number of *Gymnophalli*. These will be referred to later. Of the three live Scoters, which were housed in the Society's Gardens, one died shortly after arrival, and was found to harbour numerous specimens of *Tocotrema concavum* and immature Cestodes in its intestine. The second Scoter was removed to the Lister Institute with the object of making a feeding-experiment, but it died within 24 hours. Its intestine contained only a few immature Cestodes. The third was kept from 8th to 24th December, 1911, when the experiment was started. It was fed at intervals with mussels from the beds at Foulney, near Piel, which were infected with the pearl-inducing *Gymnophallus*. Altogether about 1000 mussels were given to it. Check-examinations of samples of these mussels showed that out of 78 mussels 32 were infected, the number of live *Gymnophalli* being 64. On February 27th, 1912, the bird was killed and thoroughly examined. The only parasitic worms present were a few immature tapeworms in the intestine and two specimens of *Metorchis xanthosomus* in the gall-bladder.

It is difficult to draw any satisfactory conclusion from the result of this experiment. At first sight the most obvious inference would appear to be that the larva in *Mytilus* does not become adult in *Edemia*, but in some other host. This inference, however, is not without objection, for, quite apart from the evidence furnished by the close resemblance between the parasite in the mussel and in the duck, other factors may require to be taken into consideration—for instance, the somewhat unnatural mode of feeding, the unsuitability of the season, the effect of captivity, and so forth. In this connection, the complete absence of other Trematodes from the intestine is significant, as suggesting that the intestine may possibly have been cleared of parasites as a result of digestive derangements following on change of

* [Thanks to a grant from the Government Grant Committee of the Royal Society.—H. L. J.]

food. It is, however, useless to speculate on these matters, and for the present we are content to record the negative result of this particular experiment.

Our main object in submitting the present communication is to give an account of the new species of *Gymnophallus* which were encountered in the course of examining the Scoters, and also to note the occurrence of a few other Trematode parasites which have hitherto not been recorded from this host. Nicoll (1907) gives the following list of Trematode parasites from *Ædemia nigra* examined at St. Andrews:—

<i>Gymnophallus dapsilis</i> Nicoll.	Bursa Fabricii.
<i>Psilostomum brevicolle</i> Creplin.	Intestine.
<i>Spelotrema pygmæum</i> Levinsen.	Intestine.

The following have been recorded by other authors:—

<i>Psilochasmus oxyurus</i> Creplin.	Intestine.
<i>Echinostomum revolutum</i> Froelich.	Intestine.
<i>Monostomum</i> sp.	Respiratory tract.
<i>Strigea tarda</i> Steenstrup.	Intestine.

In the course of our examination we found the following:—

<i>Psilostomum brevicolle</i> Creplin.	Intestine.
<i>Tocotrema concavum</i> Creplin.	Intestine.
<i>Levinseniella brachysoma</i> Creplin.	Intestine.
<i>Metorchis xanthosomus</i> Creplin.	Gall-bladder.
<i>Gymnophallus dapsilis</i> Nicoll.	Intestine.
<i>Gymnophallus bursicola</i> Odhner	Bursa Fabricii.
<i>Gymnophallus ædemie</i> , sp. n.	Intestine.
<i>Gymnophallus affinis</i> , sp. n.	Intestine.
<i>Gymnophallus macroporus</i> , nom. nov.	Intestine.
<i>Gymnophallus ovoplenus</i> , sp. n.	Intestine.
<i>Catatropis verrucosa</i> Froelich.	Bursa Fabricii.

This makes a total of 15 distinct species from this single host, of which 9 are here recorded for the first time. Such a wealth of varieties of Trematode parasites in a single host is rather remarkable*.

The new species which we are describing were all obtained from the Scoters supplied by the Brighton Aquarium. The birds originally came from the same quarter as those purchased through the Zoological Society, and it is rather striking that they should have been so heavily infected, while the others were almost free from Trematodes.

GYMNOPHALLUS ÆDEMIE, nom. nov.

= *Lecithodendrium somateriæ* Jameson, 1902 (*ex parte*).

This was the least common of the four species, and occurred in

* [To the list must be added *Paramonostomum alveatum* Mehlis, which was obtained from a Scoter (*Ædemia nigra*) which died in the Society's Gardens on Nov. 19th, 1911.—W. N.]

only two of the birds examined. It is the adult form depicted by Jameson (1902, pl. xvi. fig. 11) and to which the greater part of his description (pp. 159-160) applies.

The body is somewhat flat and oval, with pointed extremities. Its length is $\cdot 19$ – $\cdot 25$ mm. and its maximum breadth is usually a little more than half the length. The cuticle is entirely covered with minute spines. The oral sucker measures $\cdot 030$ – $\cdot 037$ mm. in diameter and the ventral sucker $\cdot 024$ – $\cdot 032$ mm., the ratio being approximately 6 : 5. The ventral sucker is situated at a distance of $\cdot 11$ – $\cdot 15$ mm. from the anterior end, the distance being about three-fifths of the body-length.

The pharynx is contiguous with the oral sucker and is about $\cdot 017$ mm. long. It is followed by a narrow œsophagus which may be nearly twice as long as the pharynx. The intestinal diverticula diverge fairly widely and barely reach the middle of the body. The excretory vesicle consists of a very wide main stem and two long branches, which nearly reach the oral sucker.

The testes lie some distance behind the ventral sucker, but nearer it than the end of the body. They are small and irregularly globular. The vesicula seminalis is situated over the left side of the ventral sucker, usually a little in front, but sometimes extending to the posterior border of the sucker. From it issues a short pars prostatica, of the usual *Gymnophallus* type, opening on the anterior lip of the sucker.

The ovary lies on the right side, on the same level as the ventral sucker, and it is nearly as large as the sucker. The yolk-glands are situated over the anterior half of the ventral sucker. They are somewhat irregular. The uterus lies almost entirely in front of the ventral sucker, and extends forwards almost to the oral sucker, filling up most of the anterior part of the body. The eggs, which usually number 30–100, measure $\cdot 018$ – $\cdot 020$ mm. in length and $\cdot 013$ – $\cdot 014$ mm. in breadth.

GYMNOPHALLUS AFFINIS, sp. n. (Text-fig. 11.)

This species, although about the same size as *G. œdemice*, is at once distinguished from it by the large size of the oral sucker and by the disposition of the uterus. It measures $\cdot 2$ – $\cdot 25$ mm. in length and $\cdot 11$ – $\cdot 13$ mm. in breadth, the body being flat and oval. The ends are not usually so pointed as in the previous species.

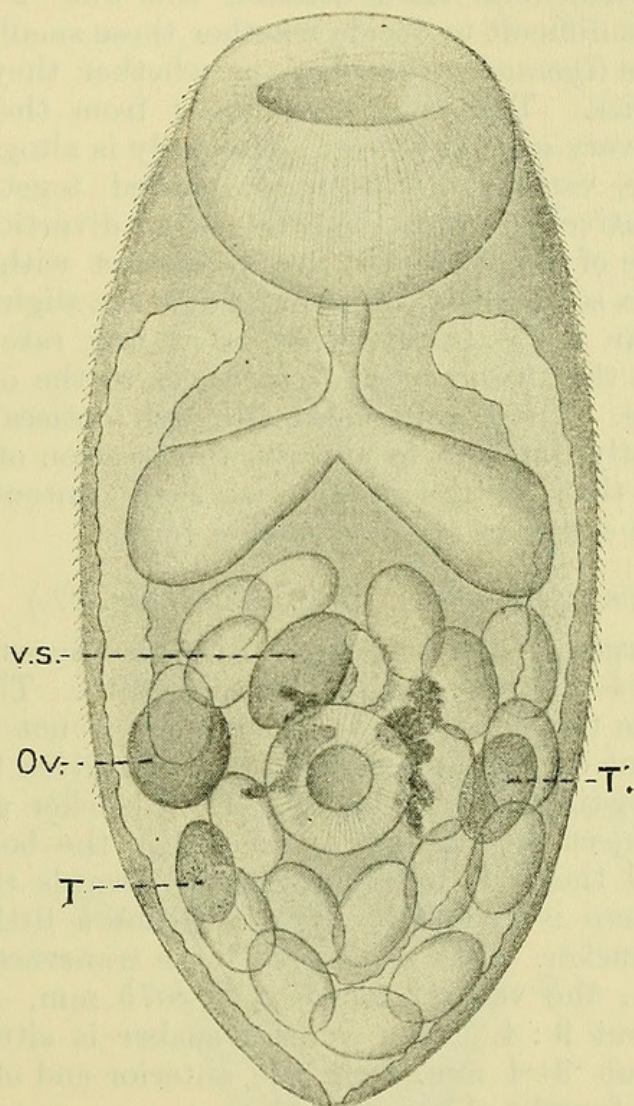
The oral sucker has a transverse diameter of $\cdot 065$ – $\cdot 085$ mm. The ventral sucker is very much smaller, measuring only $\cdot 030$ – $\cdot 045$ mm., and the ratio is usually about 2 : 1. The ventral sucker is situated $\cdot 16$ – $\cdot 18$ mm. from the anterior end, *i. e.*, a little more than two-thirds of the body-length.

The pharynx, which is contiguous with the oral sucker, measures $\cdot 015$ – $\cdot 018$ mm. in length by $\cdot 012$ – $\cdot 017$ mm. in breadth. It is followed by an œsophagus of about the same length. The intestinal diverticula diverge very widely and are usually much dilated. As a rule, they do not reach the middle of the body

The excretory vesicle is V-shaped, the main stem being very short.

The testes are two elongated oval bodies, measuring about $\cdot 025 \times \cdot 014$ mm. That on the left lies on the same level as the ventral sucker, the one on the right being somewhat behind. The vesicula seminalis lies adjacent to the anterior border of the ventral sucker, and from its anterior end issues the pars prostatica.

Text-fig. 11.



Gymnophallus affinis, sp. n. Ventral view, $\times 400$.

Ov. Ovary. T. Testes. V.S. Vesicula seminalis.

The ovary is considerably larger than the testes, measuring $\cdot 027 \times \cdot 023$ mm., and is more nearly globular. It is situated almost immediately in front of the right testis and on the level of the anterior border of the ventral sucker. The yolk-glands lie over the anterior half of the ventral sucker. Each gland consists of a somewhat crescentic mass of very irregular contour, the concavities of the crescent being directed outwards.

The uterus lies mostly behind and to the left side of the

ventral sucker. It seems to form a single loop, starting from the ovary, passing behind the ventral sucker and up along the left side of the body to some distance in front of the sucker, then returning in the same way. The eggs are of conspicuously large size, measuring $\cdot 021\text{--}\cdot 028 \times \cdot 013\text{--}\cdot 018$ mm.

There were a considerable number of much smaller specimens ($\cdot 13\text{--}\cdot 19$ mm. in length) bearing a close resemblance to the foregoing. Even the smallest of them, measuring only $\cdot 135$ mm. in length, was fully mature and contained about a dozen large eggs. All intermediate sizes between this and $\cdot 2$ mm. were observed. It is difficult to decide whether these small specimens are the same as *Gymnophallus affinis* or whether they represent a distinct species. The differences, apart from the difference in size, are not very easy to detect. The body is altogether more plump and the various organs more packed together. The suckers are relatively larger. The intestinal diverticula extend past the middle of the body and are in contact with the ovary and the vesicula seminalis. The yolk-glands are slightly further back and appear to be partly fused or at any rate very close together, while the uterus extends forwards to the oral suckers on the left side. These differences, although noticeable, do not appear sufficiently constant to warrant the creation of a further new species, so that for the present we shall content ourselves with noting the existence of these smaller forms.

GYMNOPHALLUS MACROPORUS, sp. n. (Text-fig. 12.)

This is the largest of the four species, and measures $\cdot 4\text{--}\cdot 5$ mm. in length by $\cdot 14\text{--}\cdot 23$ mm. in maximum breadth. The greatest breadth is across the middle of the body, but is not very much greater than that of the oral sucker, and this gives the animal a very characteristic shape. The lips of the sucker are usually everted and project well beyond the sides of the body. From the anterior end the body tapers gradually towards the pointed tail, though there is usually a slight inflation a little in front of the ventral sucker. The oral sucker has a transverse diameter of $\cdot 14\text{--}\cdot 17$ mm., the ventral sucker $\cdot 065\text{--}\cdot 075$ mm. The ratio is generally about 9 : 4. The ventral sucker is situated at a distance of about $\cdot 3\text{--}\cdot 4$ mm. from the anterior end of the body, *i. e.* about three-fourths of body-length.

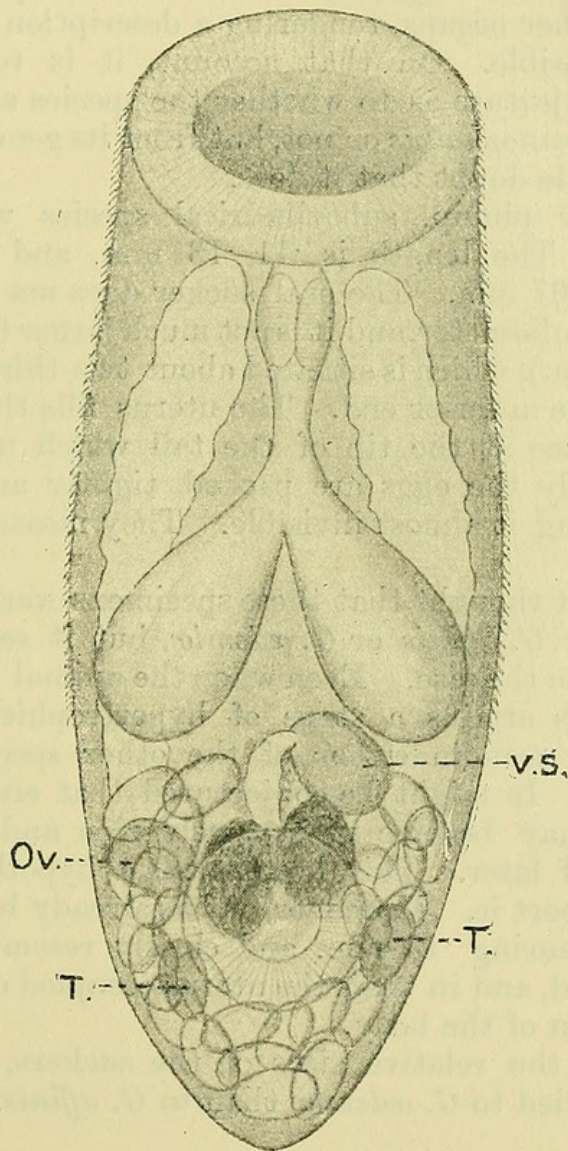
Almost contiguous with the oral sucker is a comparatively large pharynx measuring $\cdot 040 \times \cdot 035$ mm. The œsophagus is slightly longer than the pharynx, measuring $\cdot 05$ mm. The intestinal diverticula are usually moderately distended and form an acute angle with each other. Their ends reach well past the middle of the body.

The excretory vesicle is V-shaped and the limbs are frequently enormously distended, compressing the intestine and giving the anterior part of the body a hollow appearance.

Owing to the close packing together of the eggs the ovary and testes were extremely difficult to discern. They appear, however,

to have much the same disposition with regard to the ventral sucker as in *Gymnophallus affinis*, the ovary lying on the right at the level of the anterior border of the sucker, the right testis being at the posterior border and the left testis occupying an intermediate level. The yolk-glands differ from those in *G. affinis* in being much more compact, their outlines, in fact, being quite oval. They usually lie over the anterior half of the ventral sucker or a little in front of it.

Text-fig. 12.



Gymnophallus macroporus, sp. n. Ventral view, $\times 250$.

Ov. Ovary. T. Testes. V.S. Vesicula seminalis.

The vesicula seminalis lies immediately in front of the yolk-glands, sometimes median, at other times displaced laterally. From its anterior end issues a short wide pars prostatica, running down towards the ventral sucker. The uterus is disposed around the ventral sucker and does not extend in front of the intestinal

diverticula. The eggs do not show the same tendency to be massed towards the left side as is seen in *G. affinis*. They are of relatively enormous size, measuring $\cdot 029\text{--}\cdot 034 \times \cdot 015\text{--}\cdot 020$ mm., the average being $\cdot 032 \times \cdot 0175$ mm. There are usually about 30–100 eggs.

GYMNOPHALLUS OVOPLENUS, sp. n.

This fourth species, which is undoubtedly distinct from all the others, was characterised by its extremely minute size and by the enormous overgrowth of the uterus, which completely filled the body. The numerous eggs seen in the smallest specimen entirely obscured the other organs, rendering a description of the internal anatomy impossible. On that account, it is to some extent a matter of conjecture as to whether the species actually belongs to the genus *Gymnophallus* or not, but from its general appearance there seems little doubt that it does.

It is a very plump, subcylindrical species with somewhat pointed ends. The length is $\cdot 11\text{--}\cdot 13$ mm. and the maximum breadth about $\cdot 07$ mm. The oral sucker does not measure more than $\cdot 024$ mm. in diameter, and it is not much larger than the ventral sucker ($\cdot 019$ mm.), which is situated about two-thirds of the body-length from the anterior end. The uterus fills the body, except for a small space at the tip of the tail which usually remains free. Anteriorly the eggs are packed tightly around the oral sucker, rendering it almost invisible. They measure $\cdot 016\text{--}\cdot 019 \times \cdot 011\text{--}\cdot 012$ mm.

It was at first thought that these specimens were simply young forms of either *G. affinis* or *G. ædemiæ*, but it seems impossible that such can be the case. Even when the animal is only $\cdot 12$ mm. long the uterus attains a stage of hypertrophied development which is never seen in either of the other species even when twice as large. It might be conjectured that either or both of these species may become prematurely ripe and that egg-production falls off later. This, however, is a hypothesis which has nothing to support it. Moreover, as has already been mentioned, specimens measuring $\cdot 13$ mm. and closely resembling *G. affinis* have been found, and in them the uterus occupied only a relatively small proportion of the body.

Judging by the relative sizes of the suckers, this species is more closely allied to *G. ædemiæ* than to *G. affinis*.

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