

A NOTE ON THE SEX OF *ANODONTA ANATINA*.
By H. H. Bloomer, F.L.S.

Read 8th May, 1936.
[PLATE 14.]

This note treats of an inquiry into the sex of *Anodonta anatina* L. from three localities. They are the Newport and Brecon canal (Monmouthshire and Brecon canal), Breconshire, Beam Brook, Surrey, and Newdigate, Surrey.

The animals from each locality were kept in a manner similar to that of *A. cygnea* described in a previous note,¹ and in examining them the same procedure was pursued, so that a smear of the gonad of each individual was taken and in a number of instances microscopic sections were made as well. In addition the outer gills were macroscopically examined, and many microscopic sections prepared.

1935, *Sample 1. Newport and Brecon Canal.*² Gathered 22nd and 23rd July. Examined between 25th and 31st July.

The number of individuals is 29, ranging in size from 5.7 to 8.3 cm., and consists of 14 males, 10 females, and 5 hermaphrodites.

The 14 males, 5.7 to 7.8, of which 5 are from 5.7 to 6.0, 2 from 6.1 to 6.6, and 7 from 7.2 to 7.8, show, through their smears, sperm to predominate by far, sometimes in dense masses with comparatively few sperm-morulae; sections of the gonad of a few individuals reveal large numbers of sperm besides sperm-morulae.

The outer gills of all the individuals are of a non-marsupial nature. Of the 10 females (6.5 to 8.0) 7 have the outer gills partly to moderately well, but not fully, filled with embryos all showing the membrane and usually undergoing segmentation. The 3 non-gravid ones, though possessing marsupial gills, only have a few ova in their smears.

The 5 hermaphrodites. The smears reveal (a, 8.3) a few ova and very few sperm, but there are no sperm or sperm-morulae in the sections of the gonad, just a few scattered patches of ova: the outer gills are of a marsupial type containing a few embryos; (b, 6.2) a

¹ *Proc. Mal. Soc.*, vol. 21, p. 309 (1935).

² The mussels were gathered by myself from the canal near Llangynidr, between there and Crickhowell, within about 6 feet of the bank on the east side, in water from 1 to 2 feet deep, generally at places where the sunshine reached the water, of an otherwise shaded stretch, due to the many trees fringing the canal. The mussels were found nearly buried in the stony sediment with only a small part of the posterior end exposed to view. On former visits, the last about twelve years ago, they were far more plentiful; furthermore, there was only *A. cygnea* too, but on the present visit not a single living specimen of that species was seen, though from the occasional dead shells found it is possible they may have moved into deeper water. The form examined from this water is usually the more common one of typical *anatina*, in contrast to the variety *piscinatis*. All measurements are antero-posterior ones and are given in cms.

³ VOL. XXII.—NOVEMBER, 1936.

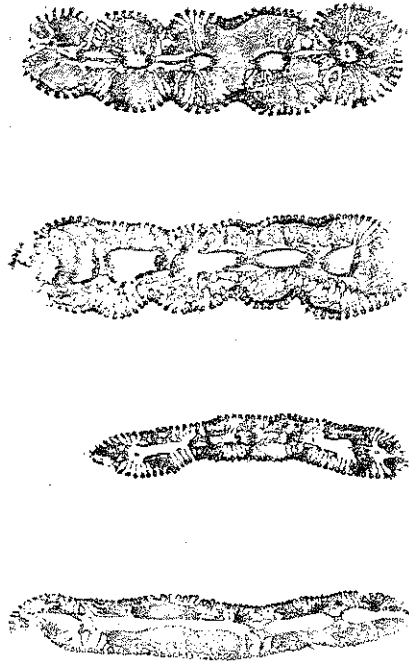


FIG. 1.

FIG. 2.

FIG. 3.

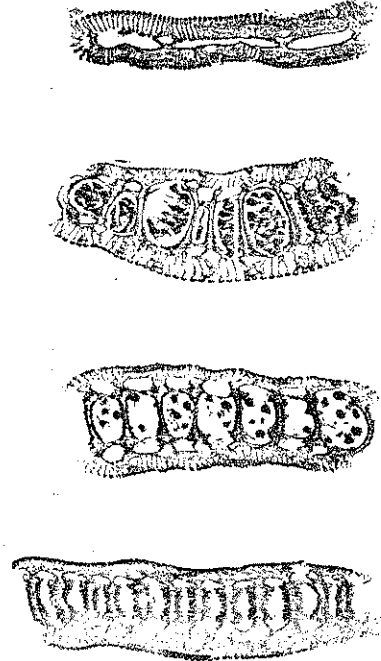


FIG. 4.

FIG. 5.

FIG. 6.

FIG. 7.

FIG. 8.

GILL SECTIONS OF *ANODONTA ANATINA*. × 12.

- FIG. 1.—N. and B. canal, male, horizontal section of outer gill.
FIG. 2.—Beam Brook, male, horizontal section of outer gill.
FIG. 3.—Newdigate Place, male, horizontal section of outer gill.
FIG. 4.—Newdigate Place, female, non-gravid, horizontal section of outer gill.
FIG. 5.—N. and B. canal, female, gravid, horizontal section of outer gill.
FIG. 6.—N. and B. canal, female, gravid, horizontal section of outer gill.
FIG. 7.—Beam Brook, female, gravid, horizontal section of outer gill.
FIG. 8.—Beam Brook, female, horizontal section of inner gill.

Facing p. 129.]

moderate mass of ova, some with the membrane, and a few degenerating sperm; outer gills marsupial but empty; (c, 7-9) some developing ova with a moderate number of sperm and possibly a very few sperm-morulae; outer gills marsupial but non-gravid; (d, 6-0) has developing ova and many ripe sperm and a few sperm-morulae; sections have patches of developing ova, but no sperm-morulae; outer gills well filled with embryos, some showing segmentation; and (e, 6-5) rather large mass of ova, many ripe ones, with some sperm, and some, not many, sperm-morulae; sections show neither sperm-morulae nor sperm; outer gills marsupial but non-gravid.

The outer gills of the male (fig. 1) are of a non-marsupial kind, hence the lamellae lie close together and the interlamellar septa are narrow and generally lacunar, but occasionally may be slightly wider than is normal. There, however, seems to be a little more sub-filamentar tissue, which is somewhat denser than is noticeable in *A. cygnea*.⁴ The number of filaments between the interlamellar septa is 7 to 32, more commonly 12 to 20.

The outer gills of the non-gravid female have the characteristic features of the marsupial gill, but when compared with those of *A. cygnea* reveal some differences. Seemingly there is a greater depth of sub-filamentar tissue; the interlamellar septa tend to be deeper and curve outwards where they merge into the interlamellar edges, consequently the interlamellar spaces—water tubes—are, in transverse section, more of a sub-spherical or sub-oblong shape; the muscle fibres running from the sub-filamentar tissue and through the interlamellar septa appear to be more distinct and continuous; the epithelium bordering the interlamellar spaces—water tubes—and in particular the edges of the interlamellar septa, shows, in transverse section, a more digitate than folded appearance (fig. 5).⁵ The number of filaments between the interlamellar septa is 3 to 9, more commonly 4 to 7. Transverse sections of the outer gill of the gravid female disclose the secondary septa, dividing each interlamellar space—water-tube—into three parts, forming or formed (fig. 6).

The following samples were obtained from *L. Haig, Beam Brook, Newdigate, Surrey*.⁶

⁴ *Proc. Malac. Soc.*, vol. 21, p. 22 (1934).
⁵ Compare *Proc. Malac. Soc.*, vol. 21, pl. 3, fig. 1 (1934).
⁶ *L. Haig* informs me that the pools are artificial ones made by him within the last ten years; that he stocked them with anodontas a few years ago that may have been obtained from more than one source, and that the Beam Brook samples are their progeny. In shape these may be more akin to the var. *pisciculus* than to the probable type. Both *A. cygnea* and *A. anatina* are present and are comparatively young animals. Furthermore, the necessity of exercising the greatest care in discriminating between the two species cannot be too strongly emphasized. This is none too easy for the inexperienced though the characters when once known are found to be distinct.
 The distinguishing shell-characters of the two species will be dealt with elsewhere, but it may not be inopportune to mention again (cf. *Proc. Malac. Soc.*

Sample 1. 1935. Collected 20th August. Examined between 21st and 23rd August.

Ten individuals, consisting of 5 males, 4 females, and 1 hermaphrodite.

The smears of the 5 males (5-3 to 6-6) show from a few to a comparatively moderate number of sperm-morulae and sperm, but not any great quantity of either: the sections of the gonad of two (5-3 and 6-5) reveal in a number of scattered places sperm-morulae and a few sperm.

The smears of the four females (5-5 to 6-1) disclose a few relic ova and the sections of one (5-6) have a fair number of small patches of ova. The outer gills of all the individuals contain embryos exhibiting the early stages of segmentation with one exception where the glochidial shell is forming. The sex of two individuals (5-5 and 6-1) is open to question, because besides ova a very few degenerating sperm may be present, but this is not altogether certain: sections of one show ova only and no sections of the other were made.

The hermaphrodite (6-4). The smear is thin, yet a few undeveloped ova and some sperm are to be seen and probably a few sperm-morulae, whilst the sections disclose a few small patches of ova, a number of small masses of sperm assembled in several places that appear to be ductules and in some instances near these small masses are a few sperm-morulae. The outer gills do not contain embryos, but the sections indicate that they are of a marsupial nature with the interlamellar septa situated from 3 to 5 filaments apart.

Sample 2. Collected 3rd September. Examined 10th to 13th September.

Nine individuals, made up of 3 males and 6 females.

The smears of the three males show (a, 5-7) a moderate number of sperm-morulae and in the sections a dense mass of them; (b, 5-6) vol. 12, p. 205, 1917) some of the differences in the external features of the animals. They are (1) the inhalant aperture of *A. anatina* is relatively larger than that of *A. cygnea*, whilst the reverse obtains in the exhalant aperture, (2) the number of papillae bordering the inhalant aperture of *A. anatina* is greater than that of *A. cygnea*, and (3) the size of the papillae themselves, especially the inner or anterior ones, is larger in *A. cygnea*.
 The number of papillae on each side of the inhalant aperture of each species in which the question of sex has been investigated, and so far as observed, is:—

| | | |
|--------------------------|-----------------|------------------|
| | <i>cygnea</i> . | <i>anatina</i> . |
| Epping Forest | 50-70 | 90-100 |
| Newport and Brecon Canal | 50-70 | 80-130 |
| Beam Brook, Newdigate | 25-45 | 50-80 |
| Newdigate Place | about 50 | 70-120 |

The number for each species may differ in a locality as well as from locality to locality, which is to be expected considering the variability of the individuals, but I have no record of overlapping of the numbers in any water where both species are found.
 The possibility of hybridization is an aspect that cannot be disregarded, but there appears to be no evidence that any of the individuals examined in connexion with the sex of the Anodontas are hybrids.

very few sperm only, sections a very few sperm-morulae and sperm; and (c, 5-3) a very few sperm-morulae and a moderate number of sperm.

The smears of the females (5-5 to 6-8) reveal from a few to a very moderate number of relict ova, and the outer gills of all are partly to fully charged with embryos, in two individuals showing membrane, but in the majority having the glochidial shell just forming or nearly formed.

Sample 3. Collected 10th October. Examined 12th December.

One female (6-6), the smear discloses relict ova; the outer gills contain some embryos with the membrane and others with the glochidial shell formed.

Sample 4. Collected 17th December. Examined 20th December.

Two individuals. One male (5-7), smear shows probably a very few sperm-morulae and many though scattered sperm; and one female (6-5), smear exhibits some relict ova, and the outer gills carry embryos, some with the membrane and some with the glochidial shell formed.

The gills: The observations to add to those given on the Newport and Brecon canal ones are that in a few of the males the transverse sections of the outer gills show some of the interlamellar septa to be a little broader and denser than is usual, whilst the other septa of the same sections are normal (fig. 2). In one female the sections of the outer gills are seen to be partly filled with embryos and are interesting in that they reveal the changes the interlamellar septa undergo upon the individual passing to a gravid state (fig. 7). A section of an inner gill is given in fig. 8.

Lake in the grounds of Newdigate Place, Newdigate, Surrey.

1935. *Sample 1. Collected 2nd September. Examined 4th September.*
Six large individuals (9-6 to 12-0) all males: the smears show (a, 10-3) many sperm-morulae and a large mass of sperm, (b, 10-2) a moderate number of sperm-morulae and very few sperm; sections disclose large and dense masses of sperm-morulae and very few sperm, (c, 10-3) a very few sperm-morulae and sperm; sections reveal the same condition: (d, 9-6) some sperm-morulae and a moderate number of sperm; and (e, 12-0) a few sperm-morulae and a moderate number of sperm; and (f, 10-1) a moderate number of sperm-morulae and very few sperm; sections sperm-morulae only.

The naturally increased size of the outer gills of these large individuals seems to be reflected in the increased amount of sub-filamentar tissue which in some instances is of a dense nature. In two individuals, one in particular (f), some of the interlamellar

septa depart from the normal, become broader and possess muscle fibres, not noticeable as a rule in males, and in a measure suggestive of a marsupial gill, but with from 5 to 12 filaments separating the interlamellar septa from each other (fig. 3); and in another individual (c) and towards the ventral edge of the gill, the interlamellar spaces, in transverse section, are small and spherical in shape with the filaments adjacent to each interlamellar space—water-tube—having a radiating arrangement (fig. 4); higher up the gill this condition gradually disappears, though the interlamellar spaces remain small.

SUMMARY OF SAMPLES.

| | Males. | Females. | Hermaphroditic. | Total. |
|-----------------------------------|--------|----------|-----------------|--------|
| Newport and Brecon Canal— | | | | |
| Sample 1 | 14 | 10 | 5 | 29 |
| Beam Brook, Newdigate— | | | | |
| Sample 1 | 5 | 4 | 1 | 10 |
| " 2 | 3 | 6 | — | 9 |
| " 3 | — | 1 | — | 1 |
| " 4 | 1 | 1 | — | 2 |
| Lake, Newdigate Place, Newdigate— | | | | |
| Sample 1 | 9 | 12 | 1 | 22 |
| " | 6 | — | — | 6 |
| " | 29 | 22 | 6 | 57 |

Thus it is seen that the total of the samples comprises 29 males, 22 females, and 6 hermaphrodites.

The high proportion of the males in the Newport and Brecon canal sample was unexpected in the light of my researches on *A. caprea* and the records of previous investigators, and if the samples had been limited to this locality alone may have opened up the question of whether it has anything to do with a tendency of the sexes to segregate at certain seasons, or if the females on becoming gravid are prone to migrate to deeper water and consequently away from the side of the canal, but neither of these explanations appears to be altogether convincing, especially after the examination of the Beam Brook samples, and rather points to a more equal balance of the sexes in this species. Then the surprising result of the scrutiny of the Newdigate Place sample, admittedly selected for their large size, and in which all the individuals proved to be males, also provides another problem, unless it is that the males inhabiting this water obtain a greater age than the females. In this respect it is well to remember that the Beam Brook samples are composed of young to somewhat a little older animals, whereas the range of age in the Newport and Brecon canal ones is much greater.

The presence of sperm-morulae and sperm only in the smears and sections of the gonads, and the non-marsupial character of the outer

⁷ Supplied by L. Haig.

gills, notwithstanding that in a few instances some of the inter-lamellar septa have their structure more or less modified, show there are males complete and separate.

Of the 22 females, 19 are gravid: the remaining 3 non-gravid ones, all with marsupial type of outer gills, belong to the Newport and Brecon canal sample and as the smears do not reveal many ova it seems they would not have spawned that year.

It will be noticed that in the Newport and Brecon canal sample are five hermaphrodites, in three of which the evidence of hermaphroditism is somewhat meagre, and that in the remaining two it is more definite. The Beam Brook samples, excluding for reasons already given, two doubtful, but gravid, individuals, contain one example that clearly discloses the male as well as the female elements. Whilst the inquiry possibly has not been wide enough in its scope to say that all hermaphrodites in this species are hermaphroditic females, yet it points in that direction; moreover, it would appear as far as observations go, that hermaphroditism is not so common an occurrence, and that maleness in a hermaphroditic individual is usually confined to very small areas of the gonad.

The inquiry being incomplete, and pending further research, no conclusions are here drawn.

I wish to express my thanks to Professor J. H. Orton for his usual kindness in perusing this paper.

With reference to the footnote giving a quotation from Alcock (*supra*, vol. 21, p. 304, 1935) and stating that *A. imbecillis* completes its metamorphosis in the marsupia, H. van der Schalie of the Museum of Zoology, University of Michigan, kindly informs me that M. F. Tucker in her work entitled "Studies on the Life Cycle of two species of Fresh Water Mussels belonging to the genus *Anodonta*" (*Bull. Bull.*, vol. 54, pp. 117-127, 1928) says: "The claim that metamorphosis in *Anodonta imbecillis* occurs in the marsupia of the parent has not been confirmed by this investigation," and H. van der Schalie further adds: "Actually we do not have any definite evidence of any North American Naiad which completes its cycle without period of parasitism."

BOOK NOTES.

By J. R. LE B. TOMLIN, M.A.

Read 3rd April and 8th May, 1936.

3. "THE GLORY OF THE SEA."

The present note has been prompted by the discovery of a book so entitled on a second-hand stall. It is a story book which deals with the bequest of a very fine collection of shells to an invalid girl, with very fair descriptions and notes introduced on most of the molluscan families.

Soon after the arrival of the collection *Comus gloria-maris*, which was kept in a secret drawer, disappears, and a detective arrives on the scene. Suspicion falls upon various members of the household, but the real culprit eventually proves to be the girl's father, who is a somnambulist and is subsequently watched by his wife one night abstracting and hiding away an *Argonauta*. The missing cone is, of course, found in the same hiding place.

Sowerby's name is mentioned more than once. A tradition is cited which I have never seen alluded to elsewhere, that the children of Israel subsisted to some extent on snails in their journeyings through the desert; such a diet is, however, not permissible under the Mosaic Law.

The book ends with a Table of the Principal British Shells. The theme of somnambulism was very likely suggested by the novel *Nyctester Sound*, which had, I fancy, appeared a few years before and, like its companion volume, *Valentine Vox*, was for long a best seller.

The author's name, Darley Dale, is obviously a pseudonym. The publishers were the Religious Tract Society, and they give me the date as 1887, but are unable to furnish any further information beyond the fact that the same author wrote three other books for them, viz. *The Jersey Boys*, 1878, *The Great Auk's Eggs*, 1886, and *Snail-tails and Skippers*, 1886.

After some little trouble I succeeded in ascertaining who the writer was who adopted this pseudonym, and in getting into touch with members of the family.

I am indebted especially to two nieces for most of the following biographical details.

Darley Dale—a name adopted as one guessed from the Derbyshire valley—was Miss Fanny Maria Steele, a descendant of Sir Richard Steele, of *Tattler* and *Spectator* fame.

Her grandfather was a doctor of Stoke Ferry and her father, Robert Peter Steele, was secretary of the Royal Exchange Assurance Corporation. Miss Steele was born on 21st April, 1848. When her father retired in 1875 the family moved to Jersey and, on his death nine years later, to Minchinhampton and subsequently to Stroud, Gloucester. She died at Stroud on 2nd August, 1931, and was buried