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XL.—*Hermaphroditism among the Apodidæ.*
By H. M. BERNARD, M.A. Cantab., F.L.S., F.Z.S.

[Plates XI. & XII.]

IN 1890 I published a preliminary notice in the 'Jenaische Zeitschrift'* announcing that in several specimens of a small species or variety of *Lepidurus* from East Spitzbergen the posterior tip of the genital gland on each side was filled with sperm-cells, and that that representative of the family was therefore hermaphrodite.

By the kindness of Canon Norman and Prof. Möbius I was then enabled to examine representatives of three other species, viz. *Lepidurus glacialis*, *Lepidurus productus*, and *Apus cancriformis*. One of each of these was sectioned with the sole object of ascertaining whether they were also hermaphrodites. In each case the specimens examined showed in some part or other the same conversion of epithelial cells of the genital gland into the minute clear cells which I believed and still believe to be sperm-cells†. That representatives of four different types of Apodidæ from different parts of the world should show hermaphrodite conditions would be almost too marvellous a coincidence, unless hermaphroditism were under certain circumstances the rule, at least in those members of the family.

Dr. Benham, in his note on a male of *Apus cancriformis* in the February issue of this Magazine, takes me somewhat severely to task for having let four years go by without having published any detailed account of these hermaphrodite specimens. Most people will, however, readily admit that this delay was justifiable, nay, almost necessary, under the circumstances; indeed, I should hesitate before publishing this paper if I had not become convinced that the hermaphrodite condition is, after all, not that most commonly found in these animals.

In the first place, none of the specimens show clearly the method of formation of the assumed sperm-cells; it was therefore necessary to obtain better preserved material. It was some time before, through the kindness of Prof. Biedermann, I obtained well-preserved specimens of *Apus cancriformis*, *Lepidurus productus*, and *Branchipus stagnalis*. The new material, however, when examined showed none of

* Band xxv. p. 337.

† 'Nature,' vol. xliii. 1891, p. 343.

the "sperm-forming centres"; had the latter been found, the results would doubtless have ere now been published. In the meantime I have been continually hoping that someone, more fortunate in obtaining material, would publish a full account, giving the details which were not to be found in my own slides. I did not myself feel justified in publishing a detailed account based upon indifferently preserved material.

I have now, however, waited four years, and not only has no one rediscovered the hermaphrodite condition of *Apus*, but those who have actually looked for it have not succeeded in finding any traces of it. After all, then, it appears that my experience must have been a marvellous one. Three specimens belonging to separate species collected in different regions are examined in rapid succession, in order to look for a condition already ascertained to be normal in another member of the same family, and in each case the same condition is found, and since then it has never been found again! Under these circumstances I feel that any further hesitation to make the best of my slides and to give the results of my observations for what they are worth would be inadvisable. The bare facts, however lacking in finer detail, are evidently worth recording. After reading Dr. Benham's paper, therefore, I resolved to examine my slides, some of which had never been looked at again since they were prepared, and record all that the best microscopic objectives could show in them.

Before giving these results I may mention two circumstances connected with the case which will help further to justify my delay, if any more justification is needed.

While I found in Germany no hesitation in pronouncing the minute cells to be sperm-cells, in England there has been much difference of opinion. This naturally made it all the more incumbent on me to wait until I had material which showed the process of formation of the cells in question. In this I was further confirmed when, some three years ago, I asked my friend Mr. J. E. S. Moore, at that time working in the Huxley Research Laboratory of the Royal College of Science, if he would take over the whole subject and work it out. I handed him the slides and all my remaining material, including the *Branchipus*. Unfortunately the slides which I most wished him to investigate, not showing the finer processes of cell-division which at that time monopolized his thoughts, received but scant attention. In his paper "On the Origin of the Reproductive Elements in *Apus* and *Branchipus*"* he

* Quart. Journ. Micr. Sci. vol. xxxv. 1894, p. 277.

dismissed the question of hermaphroditism with the words "certainly the appearances which have come under my notice favour this view." The efforts kindly made at the time by Prof. Howes to obtain specially preserved specimens of *Apus* were unsuccessful.

On returning once more to the slides which show the hermaphrodite condition of the genital glands, I have been somewhat surprised to find how much *en evidence* the sperm-centres are. In each case the first section, passing well through the genital gland, shows almost immediately what is wanted. It is quite impossible that they could have been overlooked had they occurred in any of the specimens in which they are reported to be absent. They show, however, certain variations which make it highly probable that in each species the phenomenon is a normal one under certain life-conditions, the nature of which we can only surmise.

In what follows, in order to avoid circumlocution, I shall always speak of the cells which I believe to be sperm-cells under this name, while admitting that some different interpretation may perhaps have to be put upon them.

The Spitzbergen Variety of Lepidurus glacialis.

In all the specimens examined the epithelium of the posterior portion of the genital tube is modified to a varying extent in the manner illustrated. Fig. 1 (Pl. XI.) is a longitudinal section through this portion of the genital gland in a specimen measuring about 1 centim. long. The genital tube is seen resting on the ventral longitudinal muscle-strand, separated from it, however, by the membrane (*m*) which encircles the intestinal tube and the genital glands *. The segmental bulgings of the tube gradually diminish posteriorly, but are indicated even to the tip. This tip appears in the section as if separated from the rest, but this is simply because the section here passes somewhat tangentially. The drawing represents the appearance of the section when only a low power is used. The most anterior swelling shown in the figure occurs in about the thirteenth trunk-segment, *i. e.* two behind the one which opens externally at the base of the eleventh leg. The two descending muscles run into the twenty-third and twenty-fourth appendages.

Figure 2 shows a portion of the same section as seen under a 3 millim. apochromatic oil imm. (1.40 n. a.) of Zeiss. The

* 'The Apodidæ,' pp. 120 and 297; also fig. 14, p. 59.

epithelium appears to have been dissolved into minute, clear, round or oval cells each with a single chromosome. The cells are from 4 to 5 μ in diameter. In addition to these cells there is a great quantity of slime. Near the basal membrane these sperm-cells appear as if embedded in slime (fig. 2 a), while the lumen of the tube is filled up with a fine reticulum of hardened slime, the meshes of which appear as if they were round loculi from each of which one of the sperm-cells has escaped. A few normal epithelial cells are seen standing up among the sperm-cells; I cannot make out that any of them are in the act of breaking down. In all cases the masses of sperm-cells abut directly against apparently normal epithelial cells.

Lepidurus glacialis.

I have only one series of sections (longitudinal) through a specimen from Greenland about 23 millim. long. Fig. 3 is drawn from a section passing through one of the genital tubes. The membrane (*m*) above mentioned is seen dorsally held up by the dorso-ventral muscles (*dv*) and ventrally under the genital tube. The figure shows the section as seen under a low power. The genital epithelium up to about the twenty-fifth appendage (or twentieth leg) is completely disorganized, but after this point apparently perfectly normal. The lumen of the tube contains drops of slime, some large and clear with a few black lumps in the centre, others small, all of them highly refractive. The transition between the normal and the disorganized epithelium is again quite sudden, but it is in this case specially interesting. The disorganization seems to be undermining the normal epithelium; definite clear-cut arches run under the epithelial cells, and these arched spaces are filled with sperm-cells.

Fig. 4 shows the ventral point of transition as seen under the oil immersion lens. The cells again measure from 4 to 5 μ in diameter. The distal ends of the epithelial cells seem to be breaking down into slime. The free ends shown in the figure are not necessarily detached, although appearing so in the section. The arch running under these epithelial cells is very clear, as it is also dorsally even with a low power (fig. 3). There is but one interpretation of this arching, viz. that which is gathered from observations of the egg-formation. The cell or cells near the basement membrane, on dividing to form the four egg-cells, force apart the adjacent club-shaped epithelial cells, which then arch over the developing elements on all sides. We have in the figures now under discussion clear

indications of these sperm-cells having originated from a cell or cells close to the basement membrane, which were arched over by the adjoining epithelial cells. Further, Moore (*loc. cit. suprâ*) has pointed out that in the egg-formation the eggs develop very irregularly out of ordinary epithelial cells. It is obvious that we have the same indifference in the formation of the sperm-cells, for in the completely disorganized portion of the tube every single epithelial cell, whether arched over or not, must have divided into exactly similar sperm-cells. It looks as if the distal ends of the cells break down into slime, and the proximal ends divide up into sperm-cells. This, it seems to me, would necessarily involve the arching over of those which start the process first.

Lepidurus productus.

I have only one complete series of longitudinal sections of *Lepidurus productus*. The section is 23 millim. long; but as the animal was slightly bent, it probably measured 25 to 26 millim.

Fig. 5 is one of four or five pocket-like outgrowths found in a section passing well through the genital gland. This one was selected because it happened to be cut through longitudinally. It is situated quite anteriorly in the body and dorsally. The rest are scattered about without any apparent order on the section. There is no marked localization of the sperm-forming area at the posterior tip of the gland, as in *L. glacialis* and its minute Spitzbergen variety. Indeed, in this animal and in *Apus canceriformis* the branching of the tube is so pronounced that it is not easy to ascertain which is the posterior tip of the gland. Two pockets, however, were found opening into the axial canal in the region of the eighteenth appendage, *i. e.* very near the duct which discharges the eggs into the egg-pouch.

The figure speaks for itself; there is no special arching of epithelial cells over the aperture, but in the same section three low cells or groups of cells (*e*) close down on the basement membrane are seen arched over by the adjoining cells and apparently about to develop into eggs or perhaps into masses of sperm-cells.

Figure 5*a* is a very small pocket, which looks as if it might have been produced by the division of one, or at the most of two, cells over which the adjoining epithelial cells had arched. The proliferation of the sperm-cells, instead of forcing up the arched epithelial cells, bulges out the basement membrane. This figure is given because it again shows that

the production of these minute cells is a parallel phenomenon with that accompanying the production of the eggs. This, it seems to me, goes far to justify the assumption that these cells are the male reproductive elements.

In contrast to this minute pocket, in another section I have noticed one or two very large irregularly shaped sacs in which the epithelium was divided up into sperm-cells; one occurs, for instance, at the extreme anterior end of the gland dorsally.

I stated in my letter to 'Nature,' above cited, that these sperm-cells could be seen lurking in the folds of the genital duct, apparently for the purpose of fertilizing the eggs in their downward passage into the egg-pouch. The duct in the longitudinal sections of the Spitzbergen *Lepidurus* is contracted and is filled with a solid strand of slime resting on the round ends of the club-like epithelium, which runs far down the duct almost to its aperture. In the sections of *Lepidurus productus* the ducts must have been recently stretched. The following structural details can be made out (Pl. XI. fig. 5 b). Externally is a thin layer of irregularly branching or crossing muscle-fibres (*mf*). Upon these rests the basement membrane (*bm*), which is finely wrinkled. Upon this membrane small clear nuclei, each with a single chromosome and exactly resembling the cells above described, occur irregularly, here thickly, there very sparsely. Over the whole is an irregular reticulum of slime with slime-granules. These clear cells are evidently the cells which I referred to as the lurking sperm-cells. Re-examination of them has not shown that they are not; but beyond their close resemblance to the sperm-cells, taken in conjunction with the fact that pockets of such cells occur in the main genital tube quite close to the duct, there is nothing to show for certain that they are. It is possible that they may be the nuclei of the cells lining the duct, which, in its contracted state, are long and club-like, but in its stretched state must be flat and extended. They may be perhaps a trifle larger than the sperm-cells, which range from 4 to 5 μ , these from 5 to 6 μ . On the other hand, they occur very irregularly, often in groups, whereas we should rather expect the nuclei of the epithelial cells to be uniformly and rather sparsely spread over the surface.

Most of the unripe eggs in this specimen appear to be degenerating.

Apus canceriformis.

Of the three series of sections of this species, as above stated, only one, and that the very first examined five years

ago, shows the sperm-forming centres. The original specimen is just under 3 centim. long, and is peculiar in one point, which from the first attracted my attention: the alimentary canal is distended with fine grit. In this very little can be found which looks like organic matter from which nourishment could be obtained. The animal had apparently sought to allay the pangs of hunger by swallowing enormous quantities of fine mud*. This mud shows as a broad black or brown streak along the section, and the particles of it have unfortunately escaped in the process of cutting and mounting and have spoiled many of the slides. The alimentary canal, thus heavily weighted with inorganic matter, has changed its position. It runs along close under the dorsal surface, having displaced all the branching tubules of the genital gland which normally arch over it dorsally. The whole genital gland now lies below the intestinal canal and probably partially at its sides. This dorsal position of the weighted alimentary canal is doubtless due to the habit of the animal of swimming always on its back.

Fig. 6 (Pl. XII.) shows portions of four branches of the genital tube and a ripe egg (*e*) cut through. One branch contains a ripe egg in its passage along the tube (only partially shown), while two of them (*dt*) show portions of the epithelium dissolved into sperm-cells. One of these is cut transversely and the other longitudinally. The part drawn is in the region of the eighteenth to nineteenth appendage, *i. e.* not far from the genital duct. Fig. 7 is a magnification of part of the longitudinally-cut branch shown in fig. 6, as seen under the oil immersion objective. The transition between the normal epithelial cells and the masses of sperm-cells is quite sudden, and the reduction of the cells has given rise to the usual slime-globules. The sperm-cells again measure from 4 to 5 μ .

Fig. 8 shows a portion of the main or axial tube of the genital gland some way behind the duct leading to the exterior. A small pocket is seen on the ventral side, bulging down the basal membrane. In the next section in one direction this pocket is nearly flattened out. I did not come across it again in any other section. In the centre of the tube is a large egg (*e*) squeezed out lengthways and perhaps cut tangentially; the slimy covering of the egg, hardened by the alcohol, has been broken up by the microtome-razor. In this case the egg is certainly ripe, and, if the sperm-cells are

* It is worth remarking that the Trilobites had, under certain circumstances, the same habit. Strands of argillaceous matter have been found running through the fossils (Barrande).

ripe, it is difficult to see why the eggs should not be fertilized by the sperm-cells. The only hindrance would be the coating of slime. There is no reason to believe that this, which in the living state would be quite soft, would be sufficient to prevent one or more sperm-cells from finding their way into the egg. They may perhaps be mechanically squeezed through the slimy covering in the process of stretching the duct on their passage to the egg-pouch.

Fig. 9 shows two tubules lying across one another, in both of which a portion of the epithelium has broken down into sperm-cells. One of these alone need engage our attention. An egg, which has all the appearance of degenerating, occurs at the tip, while the epithelium of the neck of the tubule which carries the egg has broken up into sperm-cells and slime. On one side the proliferation of the cells has caused the neck to bulge out greatly.

Figure 10 shows the same phenomenon. A couple of eggs developing at the tip of a tubule dorsally in the region of the fourth leg or ninth appendage appear to be rapidly degenerating. On the other hand, the neck of the stalk-like tubule is swelling up (from *a* to *b*) by the rapid division of the epithelial cells into masses of sperm-cells.

In the foregoing, in order to avoid needless circumlocution, it has been assumed that these minute cells are sperm-cells. The question, then, is—Are they or are they not? The evidence here adduced leaves little doubt that they are. Until, therefore, it is shown, by direct comparison with the undoubted sperm-cells of a male, that they do not resemble such cells in any way, differing entirely in size, shape*, and mode of origin as far as the last has here been sketched, it seems to me that we are justified in asserting that the Apodidæ are hermaphrodite under certain conditions of existence.

Before endeavouring to ascertain what the necessary conditions are which lead to this hermaphroditism, one point raised by Dr. Benham's paper calls for brief comment. He speaks of hermaphroditism in *Apus* as improbable. Nearly all who have worked comparatively at ovigenesis or spermatogenesis have emphasized the already admitted fact that both ova and sperm develop from the same elements, and that the

* Very little can be made out of Kozubowski's figures and account (Arch. f. Naturg. xxiii.) of the sperm-cells of a male *Apus*. It is very doubtful whether he saw the ultimate sperm-cells. His figures show what appear to be spherical packets of cells resembling somewhat those found in the sperm-forming centres of the hermaphrodite specimens.

causes which result in different ultimate products are mainly physiological.

Confining our attention entirely to Crustacea, eggs and sperm have been frequently found developing in the same gland. Nebeski * found that in *Orchestia* the sperm develops in the posterior end of the gland, eggs in the anterior. In a Decapod—*Gebia major*—all the males examined by Ishikawa † had eggs developing in the posterior end of the gland. Rudimentary eggs have been found in the testis of a Crayfish, and the process of the formation of these eggs out of the same cells, which elsewhere normally form sperm, has been followed out in detail ‡. This is also insisted upon by Moore in the paper above quoted with reference to *Branchipus*. Hermaphrodite individuals are said not to be uncommon among the parthenogenetic Cladocera, appearing about the same time as the males. To this I shall have to refer again §. In the face of these records it is difficult to see why there should be any special improbability in sperm-cells occasionally appearing along with eggs in the long, branched, and apparently but little differentiated genital glands of the Apodidæ, a family, be it remembered, in which the males, in several species at least, are very rare.

My experience, however, shows more than this. The specimens from high latitudes, containing a rather large *L. glacialis* from Greenland and several specimens of the minute *L. spitzbergensis*, show one particular portion of the reproductive gland apparently normally transformed into a sperm-forming region, while the rest produces eggs. These arctic dwellers are perhaps arrested rather early in their development ||. The posterior end of the genital gland does not grow out into rich branchings, but tapers off

* "Beiträge zur Kenntniss der Amphipoden der Adria," Arb. Zool. Inst. Wien, vol. iii. 1880, p. 24.

† Zool. Anz. xiv. 1891, p. 70.

‡ La Valette St. George, "Innere Zwitterbildung beim Flusskrebs," Arch. mikr. Anat. Bd. xxxix. 1892, p. 504.

§ In addition to these, the well-known cases of the Cirripedes and of certain Isopods may be cited. With regard to the latter, cf. Bullar, Journ. of Anat. and Physiol. xi. 1876, p. 118; Mayer, Mitth. aus der zool. Stat. Neapel, Bd. i. 1879, p. 165; Leichman, Bibliotheca Zool. Bd. iii. Heft x. 1891.

|| As they were caught in large numbers by Prof. Kükenthal and the late Dr. Alfred Walter a week or two before the arctic winter set in, it is impossible to consider the specimens as immature. According to Dr. A. S. Packard ("North-American Phyllopod Crustacea," U.S. Geol. and Geogr. Surv. 12th Ann. Rep. 1883) 14 millim. was the average size of his specimens of *L. glacialis*, which were nevertheless adults—that is, if we may judge from the size of their tail-plates.

gradually with mere periodical swellings. May we not assume that the failure to form the typical branchings indicates a lack of nutrition, one result of which is that the cells which here, under more favourable conditions, might have produced eggs, divide up into sperm-cells? The evidence, therefore, certainly points to a normal hermaphroditism among the arctic Apodidæ. With regard to the more central European species, both the hermaphrodite specimens of *L. productus* and of *Apus cancriformis* above described were apparently suffering some privation in the way of nourishment, if we may judge from the generally collapsed condition of the immature eggs; while, further, the condition of the alimentary canal of the specimen of *Apus cancriformis* clearly indicates a state of semi-starvation.

In these facts, then, it seems that we have some indications of the conditions which induce hermaphroditism. It appears that the Apodidæ which, under favourable circumstances, produce parthenogenetically, may become hermaphrodites when food is scarce. This hermaphroditism is thus superimposed upon the parthenogenetic females.

On comparing this with observations which have been made on kindred forms, interesting speculations are suggested as to the relations of these hermaphrodites to true males. The males of different families of Cladocera begin to appear when the year is waning and food is getting scarce. Kurz * found that the males of *Daphnia* always appeared whenever the puddles began to dry up, and he even succeeded in some cases in producing males artificially by slowly draining off the water in which the animals lived. This observer, on accidentally finding hermaphrodite specimens of four distinct species just about the time when the males begin to appear, suggested that such were probably of frequent occurrence and that this might be a sort of provisional arrangement. The needed males were not immediately forthcoming, and hermaphroditism tided over the interval.

Kerhervé's observations led to the same conclusion; not only do males appear on the advent of "hard times," but the females undergo a change. "Quelques jours suffisent pour transformer une Daphnie parthénogénétique, indifférente aux mâles en femelle éphippiale douée d'affection sexuelle, en pondeuse d'œufs destinés à être fécondés. Le facteur principal de cette modification, ici je le répète, est la pénurie des vivres" †.

* Kurz, "Ueber Androgyne Missbildung bei Cladoceren," SB. Akad. Wien, lxi. Abth. i. 1874, p. 40.

† Mém. Soc. Zool. de France, v. p. 227 (1892).

In this latter case the transformation takes place in the same individuals, parthenogenetic females becoming sexual females. Where do the males, which this rapid transformation in the females implies, come from? Kurz speaks of the interval of time which must necessarily elapse before any of the young can develop into males, and during such an interval, he suggests, hermaphroditism may occur. Are these hermaphrodites transformed parthenogenetic females, as the hermaphrodite *Apodidæ* appear to be? If so, is it absolutely necessary to suppose that they stop at hermaphroditism?

With regard to the *Apodidæ*, the records of "finds" do not show that the males begin to appear in the fall of the year. The rain-pools in which *Apus* lives are most likely to dry up and render life difficult in midsummer. Hence males may occur at any time of the year, whenever, in fact, the rain-pools threaten to dry up; that is, if the law is the same for *Apus* as for *Cladocera*—that males appear when the conditions of life are unfavourable.

If this be the case, where do these much-needed males of *Apus* come from? Do they develop from eggs specially laid under the influence of the adverse conditions, or do a certain number of developing young ones become males instead of becoming parthenogenetic females, as, under favourable circumstances, would have been the case? These are questions which cannot be finally answered for want of data. A few points, however, are worth considering.

Claus* found that a developing *Apus cancriformis* at the twelfth ecdysis showed clear signs of the transformation of the eleventh leg into the egg-pouch, but that at this stage its dorsal shield measured only $2\frac{1}{2}$ millim.—that is, the animal was still very small. How long it took to grow to this size is apparently not stated. Brauer† found that *Lepidurus productus* was 7 millim. long after the seventh ecdysis and sexually mature after the twelfth, which took place thirty-seven days after hatching. Here are certainly remarkable differences between the courses of development in these two forms, but they appear to agree in showing that the process is a slow one. It appears certain, then, that males could not be produced from eggs for an emergency. It would take too long. The eggs laid when the pools were in process of drying up would certainly take more than a month to hatch out and develop into sexually mature animals. Indeed, the assumed unfavourable conditions under which they would be growing would still further retard their development. It seems more

* Abh. k. Ges. Wiss. Göttingen, Phys. Class. xviii. (1873).

† SB. Akad. Wiss. Wien, Bd. lxi. Abth. i. 1874, p. 130.

probable, therefore, that the genital glands of developing young, instead of producing exclusively eggs, might produce exclusively sperm, and that the needed males might be more quickly obtained in this way. As far as I can see, there is only one difficulty in believing that this takes place. The male and female glands have, according to Kozubowski, the same shape, and we know from the hermaphrodite specimens above described that the epithelium may produce sperm or eggs. The difficulty, however, lies in the early modification of the eleventh pair of legs into egg-pouches. This occurs apparently much earlier in *Apus cancriformis* than in *Lepidurus productus*. If this modification has already set in, when the direction of development is changed from parthenogenetic female into male—if, indeed, this change ever takes place—then we should have to assume that these legs, during subsequent ecdyses, revert to the normal type.

There is one feature in my hermaphrodite specimens of *Lepidurus productus* and *Apus cancriformis* which appears to me of significance in this connexion. The unripe eggs in both specimens were, as stated, in process of degeneration. Those which were quite ripe, *i. e.* were filled with well-developed yolk-granules, beyond being somewhat small, seemed to be unaffected and to be escaping through the gland towards the egg-pouch. Nearly all the rest, *i. e.* the unripe eggs, showed signs of shrinking, as if they were being resorbed, the material being probably needed for nourishment. In one or two cases it appears as if there had been a struggle between the yolk-forming tendency of the egg-cells and the rest of the animal organization seeking to resorb the egg-protoplasm. The nuclei were embedded in small compact masses of yolk-disks, while the rest of the staining protoplasm of the egg-cells was full of vacuoles and irregular spaces from which the material had been drawn. It seems obvious that in these two hermaphrodites an egg-producing stage was coming to an end.

On the other hand, indications are not wanting that a sperm-producing stage is in process of development. The following can be gathered from the figures. The sperm-masses have been in most cases but very slightly drawn upon; fresh pockets completely filled with sperm-cells appear to be forming (figs. 5 *a* and 8); and, lastly, at the tips of certain branches where eggs are degenerating, the cells just below such eggs appear to be actively producing sperm-cells (figs. 9 and 10). The appearances therefore all tend to suggest that a sperm-forming phase was about to succeed an egg-producing phase. It looks, therefore, as if the hermaphrodite specimens were parthenogenetic females in process of becoming males!

I do not assert that this *is* the case. Much more evidence, if possible based upon direct experiment, is needed before such a transformation could be admittedly established. Appearances, however, point so decidedly that way that I feel justified in hazarding the suggestion.

I may, perhaps, add that, startling as is even the suggestion of such a transformation, there is in this particular case hardly any serious morphological difficulty to be overcome—so far as I know, none more serious than the reversion of a single pair of modified limbs to the normal type. In view of the marvellous transformations which occur in other members of the Arthropod phylum at times of ecdysis, such a reversion can hardly be claimed as a difficulty. It seems to me that the most serious objection lies in the extreme improbability of an egg-producing gland changing completely into a sperm-producing gland. If the possibility of such a change is granted, other difficulties appear trifles in comparison. But it is just this change which appears to be so clearly indicated by my slides.

A propos of the fact that these transformations take place in the parthenogenetic females, it will be remembered that Pelseneer, in a valuable paper on "Hermaphroditism in Mollusca," endeavoured to show that here also this condition has been superimposed upon the female*. He suggests the following stages:—production of spermatozoa in parts of the ovaries; reduction in size and number of the males; complete replacement of females by hermaphrodites; final disappearance of the degraded males. Viewing the Apodidæ in the same manner, we may suggest the following account of the reproductive arrangements of the family:—Parthenogenetic reproduction with suppression of males was brought about by the superabundance of food in the early summer, *i. e.* during the season of growth and most rapid multiplication. When the pools dry up and food becomes scarce it is necessary to produce resting eggs, for which fertilization is necessary.

* Quart. Journ. Micr. Sci. vol. xxxvii. 1895. Pelseneer, following Brock (Zeitschr. wiss. Zool. xlv. 1886), claims that the same is also true of the fishes. The recent announcement by Schneider (Mém. Acad. Imp. Sci. St. Pétersb. (8) t. ii. no. 2) that in *Cobitis* and *Phoxinus* the genital ducts of the opposite sexes are homologous with each other and with the Müllerian duct appears to support this. Pelseneer, however, makes no mention of the recent papers by Howes (Journ. Linn. Soc., Zool. vol. xxiii. p. 539) and Stewart (*ibid.* vol. xxiv. pp. 69, 70), nor of others dealing with the subject, therein cited; this is the more unfortunate, as Stewart's description of a hermaphrodite trout with fully developed genital ducts and "fundamentally a male," tells directly against Brock's hypothesis.

A certain number of parthenogenetic females become hermaphrodites by the production of sperm in parts of the ovaries. It is possible that their transformation may continue until in some cases, the developing eggs being completely resorbed, the whole gland becomes a testis, and adult males are thus rapidly produced. At the same time, it is more probable that the true males are developed, under the influence of the same unfavourable conditions, out of younger specimens not yet sexually ripe.

The whole subject of hermaphroditism in the animal kingdom is one of vast interest and deserves a special study. The Apodidæ promise to yield useful results, inasmuch as they could be experimented upon as Kurz (*loc. cit.*) experimented with Cladocera. Indeed, the experiments of Kurz with Cladocera might themselves be profitably repeated, and individual specimens be carefully examined by the most recent methods of fixing and staining. Much welcome light might be thrown in this way upon the whole subject. In the meantime, in view of the fact that the majority of Apodidæ which come into the hands of students are parthenogenetic females and that the hermaphrodite specimens here described are as yet unique, Professor Howes has kindly consented to my depositing the slides in the Huxley Research Laboratory at the Royal College of Science, South Kensington, where they can be examined by any one interested in the subject.

EXPLANATION OF PLATES XI. & XII.

[The detailed explanation of the figures will be found in the text.]

Figs. 1, 2. The sperm-forming portion of the genital gland of *Lepidurus glacialis*, var. *spitzbergensis* (see pp. 298-299).

Figs. 3, 4. Ditto of *Lepidurus glacialis* (see pp. 299-300).

Figs. 5, 5 a. Sperm-formation in the genital gland of a specimen of *Lepidurus productus* (see pp. 300-301).

Fig. 5 b. Portion of duct of same.

Figs. 6-10. Sperm-formation in a specimen of *Apus cancriformis* (see pp. 301-303).

XLI.—*Descriptions of new Fishes from the Upper Congo.*

By G. A. BOULENGER, F.R.S.

THE new fishes here described were contained in a small collection made some 50 miles south of Mangala by Mr. J. H. Weeks and presented by him to the British Museum. The known species are the following:—*Hemichromis fasciatus*,

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