THE ANOMALOUS APPEARANCE OF MALE SEXUAL CHARACTERS IN FEMALE FOWLS¹.

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(With Three Plates.)

SEX-REVERSAL was first described in birds by Boring and Pearl(3) in 1918 when they recorded, in a series of abnormal fowls, three birds which "were changing from a female to a male condition in respect to internal structure (gonads), external characters and sex behaviour." Later a series of eight sex-reversed fowls, the most remarkable of which functioned as a fertile female before, and as a fertile male after the transformation, was described by Crew(5) and Fell(6). Another case was recorded by Gatenby and Brambell(8). A fowl described by Berner(9) is probably of the same nature. These cases all occurred naturally. Benoit(1) was the first to describe an experimentally induced reversal in the fowl. He removed the ovaries from young chicks, several of which later developed testes. Cardroft and Pézard(4) achieved similar results in adult birds. Ovariectomy followed by autotransplastic ovarian grafting was performed. Subsequently sex cords and spermatic tubules were found to have invaded the stroma of the grafts. Greenwood(9) and Finley(7) obtained similar results in ovarian grafts in normal and castrated male fowls.

Many workers have maintained that the head-furnishings of the male fowl are produced by a hormone formed in the testis and that hen-feathering in the female fowl is produced by a hormone formed in the ovary. This theory is borne out by the work of the two last mentioned authors. It is known that in gonadless fowls of either sex the plumage is of the male type but is looser in texture and more luxuriant in growth; in the normal hen, and in cocks, castrated or uncastrated, into which

¹ From the Dept. of Physiology and Biochemistry, and the Dept. of Embryology and Histology, University College, London. One of the birds described (T. 1) was purchased out of a grant from the Ministry of Agriculture and Fisheries (A. S. P.). The remaining birds were purchased and maintained and all the histological expenses were met by a Grant from the Government Grants Committee of the Royal Society (to F. W. R. B.).
ovarian tissue has been successfully grafted, the plumage is of the female type; in the normal male and in ovariectomised females into which testis has been successfully grafted the plumage is male in type.

This appears to show that the ovary invariably inhibits the development of male-feathering and produces hen-feathering, and that the testis invariably produces the development of the male head-furnishings. Conversely we should expect that male-feathering can never occur with a functional ovary, nor male head-furnishings with absence of testis. Hen-feathering is sometimes found in all the males of certain breeds and occasional males in other breeds, but if the testes are absent or removed they develop plumage of the typical capen type. This does not damage the theory as it is easy to assume that the testes of these hen-feathered males have the same effect as an ovary on the plumage and at the same time the normal testicular effect on the head-furnishings.

The five birds described in this paper are of interest in this connection. The first was a functionally active female with complete male plumage. The second was possibly a case of sex-reversal. The remaining three were females with male head-furnishings, and no trace whatever of testicular tissue. Four of the five birds are in discordance, therefore, with the above-mentioned theory.

All the birds, after they came into our possession, were photographed and kept under observation for several months. If there was any apparent change in the external characters during this period they were photographed again. They were killed and dissected, and the reproductive organs photographed in situ. The gonads and other endocrine organs were fixed as soon as possible. In each case the gonad was cut serially and sections taken from the ribbon at frequent intervals were mounted and examined. Almost all of each gonad was fixed in Bouin's fluid, only minute portions being fixed in Champy's fluid.

T. I. This bird was said to have been hatched in May, 1923. It was a White Leghorn, but not pure bred, and was said to be hen-feathered until November, 1923, when male plumage, with a few black feathers on the saddle, and spurs developed. It was further stated that it did not lay, was never heard to crow nor was ever seen to tread the other hens. This bird came into our possession in September, 1924, and was then apparently in good health. The plumage was as described. The spurs were well developed, but the comb and wattles were like those of a hen. It chucked like a hen, did not court the other hens, nor was courted by the cock. This bird started to lay in the first week of December, 1924,
and was then mated with a well-bred Light Sussex male, and the eggs were hatched. A trap-nest was used to avoid all chances of mistake. Four of the eggs were fertile and hatched out. The four chicks were almost entirely black when in down. Three of them died when small and proved on dissection to be two males and one female. The fourth grew to maturity and proved to be a female. All four offspring were apparently normal in every way.

The parent bird ceased laying and started to moult in February, 1925, and in March, 1925, was still completely male-feathered, but had lost the black feathers and was almost entirely white. The head-furnishings, spurs and carriage appeared to be like those of a male. Plate VII, fig. 1 a, is a photograph of the bird at this time. It seemed healthy, but was light to handle, and very wild. It allowed the cock to tread it, but also called hens to feed as if it were a male. The cock was then separated from it. By June the moult had apparently been completed, but, between then and the end of September, a large number of black feathers were developed on the back and breast, which were retained until it was killed. The bird was mated with two pullets to which it behaved like a cock in calling them to food, but was not observed to tread them. The pullets' eggs were incubated but proved infertile. In October, 1925, T. 1 started to lay again and was in good health. Plate VII, fig. 1 b, is a photograph taken on 22 December, 1925, when the bird was killed and dissected. The plumage was entirely male with a large number of black feathers. The spurs and head-furnishings were well developed like those of a male. The bird called like a hen. Plate VIII, fig. 1, is a photograph of the dissected urogenital tract. The spleen was enlarged and tuberculous. The (left) ovary was well developed, with numerous oocytes up to 5–10 mm. in diameter. The left oviduct was also well developed. There was no trace of a gonad or oviduct on the right side. With the exception of the spleen all the organs appeared normal, and like those of a healthy hen out of the laying-period.

On histological examination the ovary was found to contain many small follicles, normal, cystic and atretic. Areas loaded with pigment granules were present. There was no trace of spermatic tissue, or undifferentiated sex-cords anywhere. In fact there was nothing abnormal about the ovary, which seemed in a state of involution typical of the ovaries of fowls just after a period of active egg-production.

T. 2. This bird, a Brown Leghorn, came into our possession in the end of May, 1925, without any previous history except that it had been
bred from good stock and had not laid an egg for two months or more. The plumage was female in type, but the head-furnishings were like a male, well developed and erect. Plate VII, fig. 2, is a photograph taken at this time. Spurs were absent. The bird weighed 2200 grm. The cock called her and attempted to tread her. This bird was killed and dissected on 15 December, 1926. At this time its weight had dropped to 1700 grm., but the bird appeared healthy. Plate VIII, fig. 2, is a photograph of the dissection of the urogenital tract. The left gonad was small, and lobulated like an ovary. No oocytes were visible, but numerous smooth cream-coloured lobules suggested the presence of testicular tissue. The left oviduct was small. There was no gonad on the right side, but a rudimentary right oviduct was present. The histological examination of the gonad of this bird showed what appeared to be an ovotestis. The ovarian regions contained many small and apparently normal oocytes. The cortex in these regions was considerably thickened, and appeared to be in an active condition. Ingrowths from the epithelium, resembling the sex-cords in the embryonic gonad, appeared to be forming. In some places groups of tubules could be found in the cortex amongst the oocytes.

The major portion of the gonad, however, was composed almost entirely of these tubules, with here and there an occasional oocyte, surrounded by its follicle, in amongst them. Plate IX, fig. 2, is a microphotograph of such a region. Some of these oocytes appeared healthy, but most of them were in more or less advanced stages of degeneration. The tubules vary in size considerably, the smaller ones being round, almost solid, cords of cells, while the larger ones had irregular outlines, like those of mature spermatic tubules cut in various directions, and large lumina. This appearance suggests that the tubules were of different ages and represented a number of successive ingrowths. Some of the tubules have a definite epithelial lining, the cells of which have brightly staining nuclei and sharply defined cytoplasm. Many of these cells exhibit mitotic figures, and the tubules appear to be healthy and growing. In these the lumen is open and large.

In other tubules, chiefly the larger ones, the nuclei of the epithelial cells are sharp and brightly staining and appear to be healthy, but do not exhibit mitosis. These cells have the entire cytoplasm whipped out, as it were, into fine threads which fill the lumen of the tubules and look deceptively like wisps of sperm-tails under the low power. Little or no cytoplasm, other than these fine threads, remains around the nuclei. While most of the tubules of this type appear healthy, some are undoubtedly degenerating, their nuclei no longer form a peripheral layer,
but have come adrift into the lumen, and both they and the cytoplasmic threads are less sharp and brightly staining. All the intermediate stages between these two types of tubules can be found. No spermatocytes can be seen in any, yet their appearance suggests that they are spermatogonial in character. Each has a well-marked fibrous sheath around it, like that around the normal spermatogonial tubule. There is little interstitial tissue between them and they are pressed close together. There is a well-developed tunica around these (spermatogonial) portions of the gonad.

T. 3. This bird, an Ancona, came into our possession in May, 1925, when it was said to be three years old. It was known to lay and was never seen to tred hens or receive attention from the cocks. It crowed perfectly. The plumage was entirely female, but the head-furnishings were male in character and very well developed. The weight was 1800 grm. The spurs were rudimentary. Plate VII, fig. 3, is a photograph of the bird at this time. This bird had every appearance of being a true case of sex-reversal. The plumage and head-furnishings remained the same and it crowed vigorously until it was killed on 15 December, 1925. The weight was then 1560 grm. The post-mortem revealed an ovary on the left side with one large cystic follicle and two tumour-like masses which proved to be large follicles in an advanced stage of degeneration. The left ovary was small. No gonad or oviduct was present on the right side. Plate VIII, fig. 3, is a photograph of the dissection of the urogenital region. Histological examination of the gonad revealed many small oocytes, mostly healthy, in the stroma. No trace of spermatogonial tissue or sex-cords could be found, although a careful and systematic search was made.

T. 7. This White Leghorn was said to have been hatched in May, 1923. It was also stated that it layed regularly and well during the pullet year, but after moulting the comb straightened and it began to crow regularly every day. It was received by us on 4 June, 1925. The plumage was then completely henny, but the comb, lobes and wattles were well developed and male in character. The spurs were rudimentary. The weight was 1250 grms. It was killed on 10 December, 1925, and then weighed 1400 grm. Plate VII, fig. 4, is a photograph of the bird at this time. Post-mortem examination revealed a small ovary on the left side with a knob of tissue about 1 cm. in diameter attached to its anterior end by a short stalk. There was no gonad on the right side. The left oviduct was small and atrophic, and there was a small right oviduct. Plate VIII, fig. 4, is a photograph of the dissection of the urogenital organs. Histological
examination of the gonad revealed abundant normal follicles up to 1 mm. in diameter in the stroma. There was one large degenerate follicle, the remains of which were about 6 mm. in diameter, as well as a considerable number of small atretic follicles. The cells in many regions were heavily loaded with pigment granules. Considerable fibrosis of the tissue, especially of the walls of the vessels, was observable in some regions of the medulla. The tumour-like knob of tissue referred to is difficult to identify, but may be a benign or malignant tumour or possibly aberrant chromaffin tissue, the position in the adrenal region suggesting the latter. Careful systematic search made failed to reveal the presence of spermatid tubules or sex-cords either in the ovary or in the attached knob of tissue.

T. 8. This bird of no particular breed was presented to us in June, 1926, when about a year old, by Mrs McEnery, of Newcastle House, Co. Wicklow, to whom we wish to express our thanks. The previous history was uncertain. The plumage was henry, but with a cock’s head-furnishings. Spurs were absent. It clucked like a hen when frightened and did not crow nor court the other birds and was ill-tempered with cocks and hens alike. It was killed on 1 January, 1926, when in good health and condition. The weight was then 1800 grm. Plate VII, fig. 5, is a photograph of the bird at that time. Plate IX, fig. 1, is a photograph of the dissection. The post-mortem showed two or three small tumours in the mesentery. The left ovary was small (3 cm. x 1 cm. approx.) and contained no oocytes over about 1 mm. in diameter. A tumour, about 1 cm. in diameter, was attached by a short stalk to its posterior end. There was no gonad on the right side. A vas deferens and an oviduct were both present and well developed on the left side. A small oviduct about 1 cm. long was found on the right side. The histological examination showed that the ovary contained many normal oocytes and was indistinguishable from that of a normal hen in a non-laying period. The tumour was an osteoma or, more probably, an osteosarcoma. Careful systematic search of both gonad and tumour revealed neither spermatid tubules nor sex-cords.

The five birds here described may be conveniently divided into three groups:

(1) T. 1.  (2) T. 2.  (3) T. 3, T. 7 and T. 8.

Of these T. 2 seems to be a typical case of sex-reversal, although spermatoocytes cannot be found in it. This history implies that the bird
had previously laid. The absence of a right gonad and of vas deferentia,
usually found in birds that have always been hermaphrodite, and the
presence of a well-developed, though small, left oviduct indicate that
the bird was originally female and that the tubules had developed in
later life. In the sections the growing tubules and sex-cords, and their
conformity with the original irregular outlines of the gonad, together
with the presence of degenerating oocytes entirely surrounded by them,
support the view that it was originally an ovary and was in process of
transformation in later life. We therefore consider T. 2 to be probably
a straightforward case of sex-reversal.

In several ways, T. 1 is undoubtedly the most remarkable of these
birds. First it had a functional ovary, and male-feathering. The simplest
explanation of the observations that castrated birds of both sexes
developed male plumage, while females and males, with engrafted ovarian
tissue, developed hen-feathering, is that the ovary causes the develop-
ment of the hen-feathering. Likewise it is easy to believe that the testes
of hen-feathered males have somehow the same influence. T. 1 is a
straightforward exception to this theory and, beyond pointing that fact
out, we can offer no explanation. Further, T. 1, T. 3, T. 7, and T. 8 are
all similar in another remarkable characteristic. They all had well-
developed male head-furnishings but no trace of spermatic tissue. The
obvious explanation of the numerous observations that the male type
of head-furnishings is always developed in the presence of testis and not
when it is absent or removed, is that testicular tissue produces and main-
tains its development. Now these four birds are emphatically contrary
to this explanation. We would wish to draw special attention to the fact
that no right gonad was present in any of them, and that a piece of
spermatic tissue in the left gonad ½ cubic mm. in size could not possibly
have passed unobserved, for the sections in our series were never more
than ½ mm. apart, and were usually not more than ½ mm. It is therefore
extremely improbable that even a much smaller piece could have
escaped detection, and if it did it must have been of negligible size. Yet
the head-furnishings were well developed and male in type, as our
photographs show. We can only record these facts without further
comment and can offer no explanation of the causes which produced
them.

We are indebted to Prof. J. P. Hill, F.R.S., and Dr J. A. Murray,
F.R.S., for advice and criticism. We would like to take this opportunity
of expressing our thanks to Miss Steward of the University College
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Farm, Reading, for keeping the first bird of this series under observation for some months, and supervising the mating and breeding experiments. Our thanks are also due to Mr F. Melville and Mr W. A. Allen for assisting us with the photography.

SUMMARY.
1. One case of probable sex-reversal in the female fowl is described.
2. One laying hen with male plumage and head-furnishings is described. There was no testis tissue present in it.
3. Three other birds with the head-furnishings of the male, but with hen-feathering, are described, though in none of them was any testis present.

BIBLIOGRAPHY.

DESCRIPTION OF PLATES VII–IX.

We are indebted to Mr F. S. Pittick for the microphotograph reproduced in Plate IX, fig. 2.

PLATES VIII–IX.

The following guide letters are used:

For further explanation see text.