THE TORTOISESHELL TOMCAT — A SUGGESTION.

By L. DONCASTER, F.R.S.

Professor of Zoology, Liverpool University.

In the *Journal of Genetics*, VIII. 1919, p. 279, C. C. Little puts forward a new hypothesis to account for the origin of the tortoiseshell tomcat. He suggests that the sterile tortoiseshell male is comparable with the XO males produced in *Drosophila* by the fertilization of a non-disjunctional ovum bearing no sex-chromosome by an X-bearing spermatozoon. Such males in *Drosophila* are sterile, and not infrequently show mosaic characters. Little therefore suggests that the sterile tortoiseshell male is of similar origin, is sterile from the same cause, and is tortoiseshell instead of yellow owing to a tendency to mosaic distribution of the yellow factor. Fertile tortoiseshell males are explained on the assumption that by secondary non-disjunction the X and Y (X and θ) chromosomes come into the zygote from the same parent, and it is suggested that under these circumstances the "θ" chromosome does not have its normal effect, and that what would otherwise have been a yellow male becomes a tortoiseshell. For this second assumption there is little or no real evidence, and its author himself seems somewhat diffident about it. The comparison of the sterile tortoiseshell male with the sterile XO type of male in *Drosophila* is at first sight more attractive. The comparison, however, really rests only on the fact of sterility, for the tendency to a mosaic distribution of factors does not seem to be comparable in the two cases. In *Drosophila*, as Morgan, Bridges and Sturtevant show in their recent monograph on *Drosophila* (7), the mosaic distribution of factors is almost certainly due to abnormal distribution of the X-chromosome in the segmentation of the egg, and the flies are almost always mosaics of sex-characters (gynandromorphs) no less than of inherited factors. The inherited factors accompany the abnormal distribution of the sex-factors, so that different parts of the fly show not only different inherited characters but also different sexual

features. There seems to be no reason for supposing that this is so, or for expecting that it should be so, in a tortoiseshell cat of chromosome constitution XO instead of XY ($X-$ instead of $X\theta$).

The purpose of this note is to put forward another suggestion—equally speculative, but more easily capable of verification. In a recent paper Magnusson (6) has described the anatomy, both gross and microscopic, of some 70 free-martins. He finds that although in all of them the external features are predominantly female, internally they approximate more or less nearly to the male. In more than half of them the gonads were in the position of ovaries, the uterus was distinctly developed and the vasa deferentia rudimentary, but even in these the gonad was at least as much like a rudimentary testis in structure as like an ovary. The examples described by Miss Chapin (1) from Lillie's material seem to correspond with this group of Magnusson's cases. In the remainder of his cases Magnusson found a series of stages in which the uterus was more and more reduced down to complete absence, the vasa deferentia and epididymis well developed, and in several instances the gonads had passed into the inguinal canal. In these examples of more male type the testis contained seminal tubules with interstitial tissue, including Leydig's interstitial cells, between them. The tubules sometimes contained Sertoli cells, but never any trace of true seminal cells, and Magnusson describes them as closely similar to those found in retained (cryptorchid) testes of true males. Further, it should be noted that in a number of his examples the interstitial tissue was much more abundant than in normal testes. Magnusson's description of the microscopic structure of the gonad in the more masculine of his free-martins in Cattle immediately recalls the condition described by D. W. Cutler and the writer (2) in the testis of a sterile tortoiseshell tomcat; the structure of the cat's testis appears to be almost identical with that of the gonad in some of the free-martins. This suggests the possibility that the tortoiseshell tomcat may possibly be in fact a free-martin. Lillie (4) has shown almost beyond doubt that the free-martin is derived from a female embryo which has been "masculized" by the confluence of its vascular system with that of a neighbouring male foetus. Magnusson, not knowing Lillie's work, believes that the free-martin is one of a pair of uniovular male twins, but his evidence for this is entirely unconvincing, and it may be assumed with confidence that Lillie's explanation is the true one. If in Cats, as in Cattle, the embryonic membranes of two foetuses may coalesce so that their blood-system becomes confluent, and if in them the same masculization of a female embryo results,

occasionally a tortoiseshell female embryo would be masculized. It must be assumed that the masculization is more complete in the Cat than in Cattle, so that the testes, instead of only comparatively rarely descending into the inguinal canal, regularly reach the scrotum, and the external genitalia also assume the male type. Since, however, Magnusson finds a series of stages between an almost female and a nearly male condition, it is not a very improbable assumption that in the cat the process is habitually carried further. Possibly the fertile tortoiseshell male, which on the evidence of Sir Claud Alexander (quoted by Cutler and Doncaster) must be admitted to exist, is the final stage of the series. Complete conversion into males of embryos which are genetically female appears to exist in some of Goldschmidt's *Lymantria* crosses (3) and in several hybrids between different species of moths.

This hypothesis involves the assumption that females of colours other than tortoiseshell must also at times be changed into apparent males, but since these would naturally be regarded as males which for some reason or other were not successful breeders, no record of them would be preserved. The suggestion here put forward does not seem difficult to test. By collecting gravid uteri of cats and examining the foetal membranes it should not be difficult to find out whether confluence between the blood-systems of neighbouring foetuses ever takes place. If it did, and if one of the foetuses was definitely male, then according to the hypothesis the other foetus should, in two cases out of three, have testis-like gonads with no seminal cells in the tubules.

The writer does not feel confident of being able to carry out the considerable labour involved in testing the hypothesis in the immediate future, and he puts it forward in the hope that some other may be able to obtain and examine the necessary material.

PAPERS REFERRED TO.

1. CHAPIN, CATHARINE L. "A microscopic study of the reproductive system of foetal free-martins." *Journ. Exp. Zool.* Vol. XXIII. 1917, p. 453.
2. CUTLER, D. W. and DONCASTER, L. "The Sterility of the Tortoiseshell Tom-cat." *Journal of Genetics*, Vol. v. 1915, p. 65.
3. GOLDSCHMIDT, R. "Experimental Intersexuality and the Sex Problem." *Amer. Nat.* Vol. L. 1916, p. 705.
4. LILLIE, F. R. "The Free-martin: a study of the action of sex-hormones in the foetal life of cattle." *Journ. Exp. Zool.* Vol. XXIII. 1917, p. 371.

5. LITTLE, C. C. "Colour Inheritance in Cats, with special reference to the Colours Black, Yellow and Tortoiseshell." *Journal of Genetics*, Vol. VIII. 1919, p. 279.

6. MAGNUSSON, H. "Geschlechtslose Zwillinge. Eine gewöhnliche Form von Hermaphroditismus beim Rinde." *Arch. f. Anat. u. Physiol.* Anat. Abt. 1918, Vol. I. p. 29.

7. MORGAN, T. H. and BRIDGES, C. B. "The Origin of Gynandromorphs." In "Contributions to the Genetics of *Drosophila melanogastes*." *Carnegie Inst. Publ.* Washington, 1919.