HEREDITY IN POULTRY

BY

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TO

WILLIAM BATESON

WHOSE EXPERIMENTS WITH POULTRY
OFFERED THE FIRST DEMONSTRATION
OF MENDELIAN HEREDITY
IN THE ANIMAL KINGDOM

PREFACE

In putting together this little book, my path has been made easy. For when, nearly twenty years ago, I was invited by Mr. Bateson to join him in his work, I found at Grantchester a set of experiments on poultry in full swing. No introduction to the genetical study of the fowl could have been more happy. Later, when Mr. Bateson left Cambridge, I was fortunate in obtaining from the Development Commissioners material support, without which my own small share of the work could never have been undertaken. For this, I wish to express my deep appreciation. During all these years the hen has seldom been out of my thoughts, and this must be my chief excuse for the present compilation. Of its defects I am well aware. Some are of presentation, and for these the responsibility is entirely mine. But I feel confident that my critics will bring them home to me, and, in this anticipation, offer them my thanks. More serious, however, are the defects of omission, and for these we, the experimental workers, are hardly to blame.

Had more support been forthcoming in the past twenty years, a very different book would have been possible to-day. Happily there are signs that the poultry industry is beginning to recognise the practical value of organised research, and it is in the hope of stimulating that recognition that I have tried to summarise our present knowledge, meagre though it is. At any rate, I trust that the book will serve as a handy guide to such work as has already been accomplished, and will direct the reader straight to original sources in connection with any matter in which he is specially interested.

R. C. P.

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CHAPTER I

ELEMENTARY

WHEN Mendel's discovery in heredity was generally made known in 1900, it was at once evident to a few scientific minds that a new era in this study had begun. Since that date progress has never looked back. The rising flood of facts has already swept away many old prejudices, and the world is beginning to recognise that an accurate knowledge of heredity is at last possible. Mendel placed in the hands of the breeder a tool of precision far beyond any that he had hitherto dreamt of. Nor, in many cases, has the breeder been slow in availing himself of its power. We have but to glance at the results already achieved by some of the great plant-breeding institutes to realise the control that can now be exercised over the making and fixation of newer and better varieties of crops. With animals progress has been slower. As a rule they are less prolific, so that the necessary process of analysis takes more time; the separation of the sexes introduces complications from which most plants are free; while lastly, and perhaps most important reason of all, they are less favoured by the scientific worker owing to their greater cost. In spite of these difficulties, however, some progress has been made, and much of the experience gained by the worker, whose aim has been solely that of knowledge, has a direct bearing upon the practice of the utilitarian breeder. Nor is it improbable that much which at present appears to the breeder irrelevant or trivial, will ultimately turn out to possess an economic value of high importance.

The fowl was the first animal in which the Mendelian principles of heredity were shown to hold good. Since Bateson's early experiments, poultry have attracted the attention of other workers in the field, with the result that a beginning has been made in the analysis of the many and varied characters that are found in the different domestic breeds. Many years must inevitably elapse before that analysis can be completed, even for the more easily worked characters involving visible differences of structure or colour. But the method of analysis is clear. If we wish to analyse the fowl into its various characteristics, so that we may recombine them at our will, with certainty and with the minimum of time and labour, the way of doing it is now obvious. In much of the work no deep erudition is required. For intelligent observation and accurate recording, illuminated by what may be termed the Mendelian point of view, there is now wide scope for obtaining results of definite and permanent value. Large numbers of those who keep poultry have it in their power to help materially in building up that complete knowledge which we may some day hope for.

Keen observation is largely a natural gift, but the Mendelian standpoint can be readily acquired without great effort. It is the purpose of the following pages to put forward a few examples illustrating the growth of our knowledge of heredity in poultry. We may commence with one of the simplest. Rose-comb Bantams exist in two well-

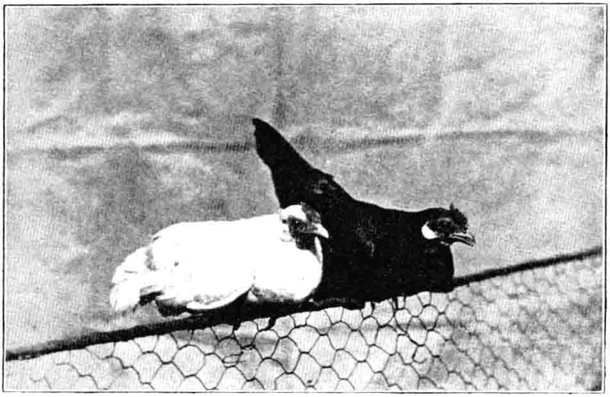

FIG. I.
Black and White.

marked varieties—black and white. Between these two varieties there is no essential difference save that of colour. When birds of a true-breeding black strain are crossed with white, all the offspring are black.[1] It makes no difference which way the cross is made, whether we mate a white cock with a black hen or *vice versa*. In either case the

[1] First-cross birds may show a little gold in the hackle and saddle feathers. To this point we shall recur later (p. 133). From our present point of view such birds are blacks.

offspring are black, showing no trace of white in their plumage. When such first-cross birds are bred together they produce a generation consisting of blacks and of whites, the former being about three times as numerous as the latter. Intermediates do not occur, the birds of this second, or F_2 generation, being either black or white. Black and white here form an alternative pair of characters of which the former is **dominant** and the latter **recessive** in the cross. Further experiments reveal the following facts. (1) The F_2 whites when bred among themselves breed true to white. They never throw a black in spite of the fact that both of their parents and half of their grandparents were blacks. (2) Certain of the F_2 blacks breed true to blacks when mated together, and produce blacks only when mated with white. They behave, in fact, as the original black parent. Of the blacks that appear in the F_2 generation about one-third behave in this way. (3) The rest of the F_2 blacks, forming about two-thirds of the F_2 generation, behave like their F_1 parents. When bred together they produce black and white in the ratio 3 : 1; when mated with whites they produce black and white in equal numbers.

There is only one kind of white bird, whatever its parents may have been. There are two kinds of black birds, viz. those which, when suitably mated, can throw whites, and those which cannot. These are the essential facts connected with what is termed a simple Mendelian case, and, thanks to Mendel, we are able to offer a simple explanation which covers them all.

This explanation turns upon the nature of the germ-cells, whether eggs or sperms, in relation to a pair of alternative characters such as black and white of the Rose-comb Bantams. With regard to such a pair of characters we suppose the germ-cells to be of two kinds, viz. those which contain something that has the property of causing black pigment to develop in the plumage, and those which lack it. This something, whatever it may be, it is convenient to denote by the word **factor**. When a bird has been made by the union of an egg and a sperm, each containing the black factor, all of the germ-cells produced by such a bird will contain that factor, and the bird is said to be **homozygous** for black (Fig. 2). Such a bird, mated with its like, will breed true to black, or when crossed with a white will give only blacks. A bird that arises from the union of two germ-cells both lacking the black factor is a white, and all of the germ-cells produced by such a bird are also lacking in the black factor (Fig. 2). Since it has arisen from the union of two like germ-cells, every white bird is homozygous. When a bird is formed by the union of two unlike germ-cells, one containing the black factor and the other lacking it, it is said to be **heterozygous** for black. Such a bird is black to look at, for the black factor coming in from one side of the cross only is sufficient to cause complete dominance of the black plumage. What happens, however, when the heterozygous black forms germ-cells? To explain the experimental facts we must suppose that, in respect of the black and white characters, it produces two kinds of germ-cells, and two kinds only, and moreover produces them in equal numbers (Fig. 2). This is the essence of Mendel's conception of the hereditary process. The heterozygote does not

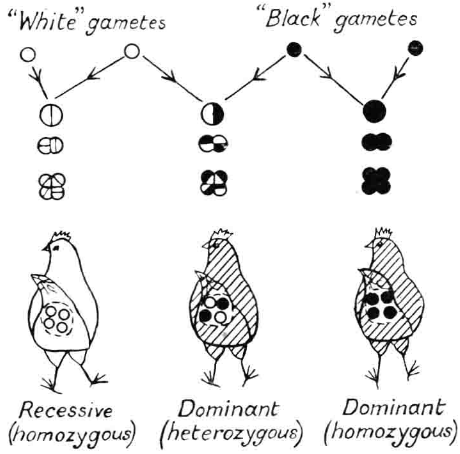

FIG. 2.

Illustrating the constitution of the three possible types of birds in a case of simple dominance such as black over white. On the right two gametes, or germ-cells, unite to form a zygote, or fertilised egg, which, by repeated cell-division, gives rise to a black bird. Since the gametes here were alike in both containing the factor for black, such a bird is said to be homozygous for black; and itself, as indicated diagrammatically, produces only germ-cells carrying the factor for black. Such a bird is a pure dominant, or true breeding black. On the left is shown a recessive white which, being produced by two like germ-cells—in this case "white"—is also homozygous, and produces only "white" germ-cells. The third alternative arises when a "white" germ-cell meets a "black" germ-cell, as shown in the middle of the figure. Being produced by the union of two unlike germ-cells such a bird is termed heterozygous. Since black is here dominant to white the bird so formed grows into a black. But it produces "black" germ-cells and "white" ones in equal numbers, and may be termed an impure dominant.

produce a series of germ cells containing various proportions of the black factor. If so we should expect to get various blends of black and white in the F_2 generation. But there is a complete separation between the black and the non-black in the germ-cells which such a bird produces, so that half of them contain the black factor in its entirety, while the other half are entirely without it. We may now examine how this conception, involving the purity of the germ-cells produced by the cross-bred bird, tallies with the experimental data outlined above.

The mating between a true-breeding, or homozygous black with a white always means the union between a black and a non-black germ-cell. Since black is dominant to white the F_1 birds will all be black. On the Mendelian conception these heterozygous blacks produce black and non-black germ-cells in equal numbers (Fig. 3). Any "black" egg has an equal chance of being fertilised by a black or by a "non-black" sperm. Consequently half of the eggs containing the black factor will give rise to homozygous black birds and the other half to heterozygous blacks. Again, every "white" egg has also an equal chance of being fertilised by a "black" or by a "white" sperm. Therefore half of the eggs lacking the black factor will give rise to heterozygous blacks, and the other half to whites. And as the

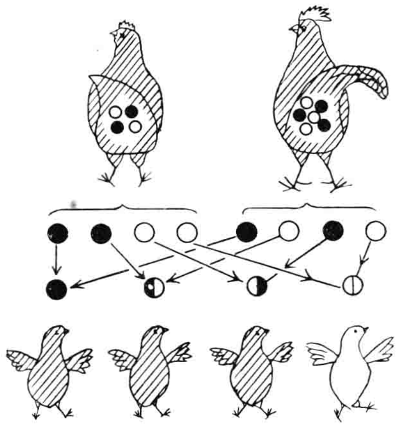

FIG. 3.
Illustrating the result of breeding two heterozygous blacks together.

heterozygous hen produced "black" and "white" eggs in equal numbers, the result of mating her to a heterozygous cock is the production of black and of white chicks in the ratio 3 : 1 (cf. Fig. 3). Of the blacks one in three will be homozygous and subsequently breed true, while the rest will be heterozygous, producing in their turn equal numbers of germ-cells with and without the black factor. Though the blacks are not visibly distinct, the difference between them is brought out by mating them with the recessive white. A homozygous black gives black chicks only. A heterozygous black produces equal numbers of black and of white chicks. For since his or her output of germ-cells consists of equal numbers of those containing and of those lacking the black factor, it is clear that when such a bird is mated with a white the chicks must be of two kinds, viz. whites and heterozygous blacks in equal proportions (cf. Fig. 4).

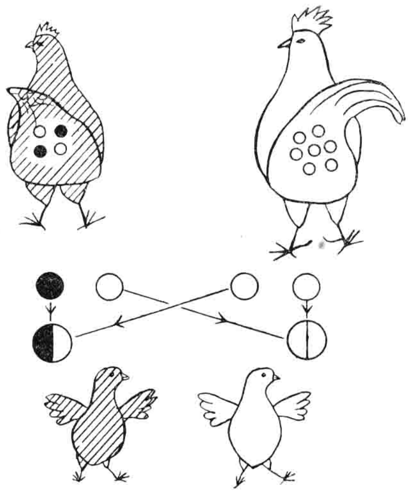

FIG. 4.
Illustrating the result of mating a heterozygous black with a recessive white.

As will appear later, a number of characters in