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*Photographic Records of Pedigree Stock.*

By FRANCIS GALTON, D.C.L. (Oxf.), Hon. Sc.D.(Camb.), F.R.S.

[PLATE IV].

It is my purpose shortly to communicate with the Councils of some of the Societies who publish stud or herd books, urging the systematic collection of photographs of pedigree stock and of more information about them than is now procurable. Believing that if my proposals were carried into effect, they would greatly facilitate the study of heredity, I desire, before approaching the Societies, to submit my intended proposals to the criticism of a scientific body, and none seems more appropriate for the purpose than the Zoological Section of the British Association.

The following remarks are based on the Ancestral Law, which will be explained. Its purport is to *measure* the importance to the breeder of taking into account the various members of the ancestry of the animals he proposes to mate together, so much of the heritage coming *on the average* from each of them. Then the methods of utilising this bulky knowledge will be discussed, that of composite portraiture being one means of dealing with numerous photographs; another way is by obtaining measures, which can be arithmetically combined, from the photographs themselves, provided they have been taken in accordance with certain simple instructions. Next, the plan will be explained by which the Societies referred to above might initiate and maintain a systematic collection of photographs and other information useful to breeders, which should become self-supporting. Lastly, an allusion will be made to the huge waste of opportunities of advancing the art of breeding that goes on unchecked.

*The Ancestral Law.*—I have lately shown how the general knowledge that offspring can inherit peculiarities from the various members of their ancestry as well as from their parents may be superseded by a definite law whose nature was first suggested to me by theoretical considerations. Being subsequently in a position to verify its accordance with a large number of pertinent facts, I submitted the results to the Royal Society in a communication entitled 'On the Average Contribution of each Several Ancestor to the Total Heritage of the Offspring.'<sup>1</sup> My theory was thoroughly examined from fresh points of view by Professor Karl Pearson, F.R.S., in one of his remarkable 'Contributions to the Mathematical Theory of Evolution,'<sup>2</sup> in which he showed that the theory accorded with other observations, and accounted for other conclusions that had already been reached. Assuming, then, that the Ancestral Law may be accepted

<sup>1</sup> *Proc. Roy. Soc.*, 1897.

<sup>2</sup> *Ibid.*, 1898.

as at least approximately true, it will be found most serviceable in showing the relative importance and range of the data which breeders must take into account, if they pursue their art with thoroughness. The law is that, *on the average*, the two parents contribute between them one-half of the total heritage of the offspring, that the four grandparents contribute between them one-quarter, the eight great-grandparents one-eighth, and so on. Consequently, since  $\frac{1}{2} + \frac{1}{4} + \frac{1}{8} + \frac{1}{16} + \&c. = 1$ , the whole of the heritage is accounted for. The same law may be stated in another form, namely, that each parent contributes *on the average* one-quarter, each grandparent one-sixteenth, each great-grandparent one sixty-fourth, and so on. It is a property of the first series of fractions that each term is equal to the sum of all those that follow ( $\frac{1}{2}$  being equal to  $\frac{1}{4} + \frac{1}{8} + \frac{1}{16} + \&c.$ ;  $\frac{1}{4}$  to  $\frac{1}{8} + \frac{1}{16} + \&c.$ ), therefore it results that if genealogical knowledge should cease with the grandparents, inasmuch as they contributed one-quarter, another quarter of the heritage will remain indetermined; if it ceases with the great-grandparents one-eighth will remain indetermined; if with the next ascending grade, one-sixteenth, &c.

[It must be understood that the law is intended to apply only to what may be called *plain* heredity, that is to cases where qualities are capable of blending freely, or, if they refuse to blend, where they present themselves as alternative possibilities. The necessary modifications have yet to be investigated when it has to be applied to hybrid heredity, and to those partial forms of hybridism which occur in cross-breeding, especially in plants, where two parental qualities seem to produce a third and different quality in the offspring. Again, it takes no notice of prepotency, because it considers prepotency as likely to occur with equal frequency in each and all of the ancestral places, but when the prepotencies of particular ancestors are known or suspected it is easy to take them into account. Similarly the law takes no cognisance of the prepotency of one sex over the other, which must be allowed for in those particular races and qualities where it is known to exist. Lastly, as it relates to averages, its predictions will be truer for the mean of many offspring than for any one of them in particular. However, as we know that fraternal variation admits of being defined with mathematical precision for any measurable quality in any race, the diminution in trustworthiness when a prediction relating to a fraternity is applied to a single member of it, is easily calculated.]

The ancestral law specifies the number, the grades, and the relative importance of the ancestors whom breeders must take into account, in order to predict with any given degree of certainty the *most probable* character of the future produce. It clearly shows the necessity of a much more comprehensive system of records than now exists. A breeder ought to be in a position to compare the records of at least the four parents of the animals he proposes to mate together, in respect to the qualities in which he is interested. More especially he ought to have access to photographs which indicate form and general attitude far more vividly than verbal descriptions. But the information in stud and herd books is too meagre for the requirements of the breeder, while the photographs published in newspapers and elsewhere are inadequate for making complete genealogical collections.

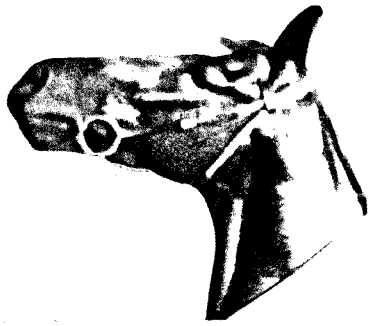
*Utilisation of the Records.*—My principal suggestion is that a system of collecting photographs should be established, which would be serviceable

PORTRAITS of RACE HORSES and COMPOSITES of them.

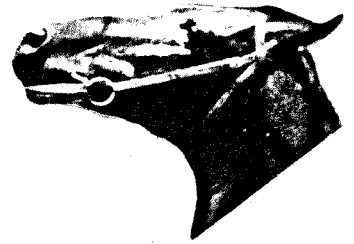
Letters refer to horses, numerals to units of exposure. Total, 12 units in each case.



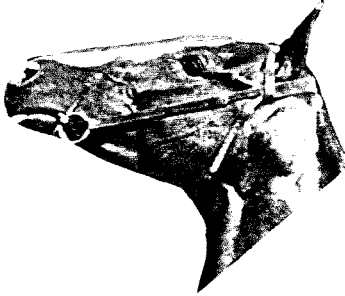
A, 12.—Sir Visto.



C, 12.—Raconteur.



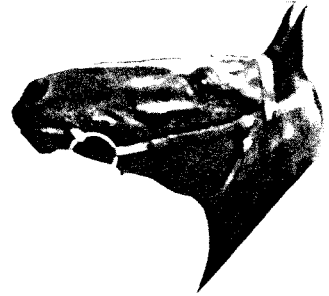
E, 12.—Speedwell.



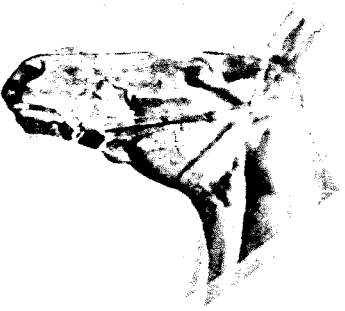
B, 12.—Solaro.



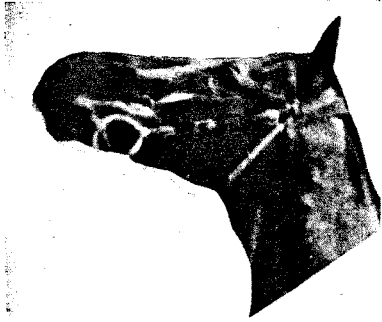
D, 12.—St. Marnock.



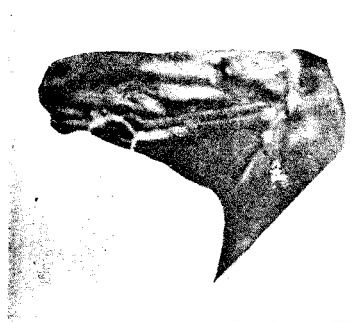
F, 12.—Salebeia.



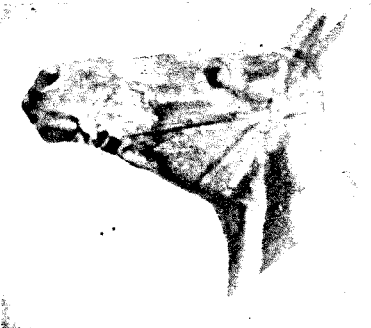
A, 6; B, 6.



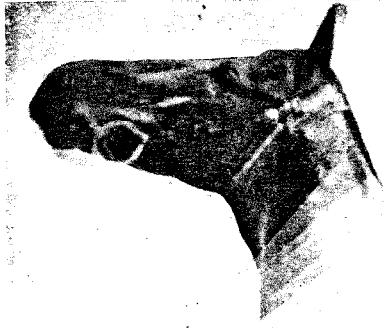
C, 6; D, 6.



E, 6; F, 6.



A, 4; B, 4; C, 1; D, 1; E, 1; F, 1.



C, 4; D, 4; A, 1; B, 1; E, 1; F, 1.



E, 4; F, 4; A, 1; B, 1; C, 1; D, 1.

Photographed by FRANCIS GALTON, F.R.S., to illustrate his memoir on 'Photographic Records of Pedigree Stock'

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to breeders. They should be serviceable to them not only as portraits, but also as affording means of obtaining measurements of the animal. It will be shown that the system might be easily initiated, and be afterwards self-supporting, but for the moment it will be convenient to take these important conditions on trust, and to begin by considering what could be done if we had the photographs. I will suppose, then, that the system has been in successful operation for many years and that it has become possible to obtain photographs of the parents, grandparents, and other ancestors of each of a large number of pure-bred horses and cattle taken under specified conditions. We have to explain how such photographs might be employed in improving the art of breeding.

An habitual study of the form of each pure-bred animal in connection with the portraits of all its nearer ancestors would test current opinions and decide between conflicting ones, and it could not fail to suggest new ideas. Likenesses would be traced to prepotent ancestors and the amount of their several prepotencies would be defined; forms and features that supplement one another, or, as it is termed, 'nick in,' and others that clash or combine awkwardly, would be observed and recorded: conclusions which are based on incomplete and inaccurate memories of the appearance of the several members of the ancestry would be superseded by others derived from a study of their actual photographs. The value of the ancestral law would be adequately tested, and it would be possible to amend it where required. Thus the effects of organic stability, to which I have often called attention, have yet to be dealt with if they are not indirectly included in the law as it stands. Lastly, it is not unreasonable to suppose that every important stallion or bull would have a pamphlet all to himself, with photographs of his ancestors, and with appropriate particulars about each of them. Such pamphlets would become recognised as a just form of advertisement.

*Composite Photography.*—It may be said that, even if all the ancestral photographs were spread in full view on a table, no human brain could combine into a single mental image the peculiarities in feature even of the two parents, and of the four grandparents, in the proportion laid down by the ancestral law. There is, however, a method by which a substitute for a mental picture may be obtained, which may possibly prove serviceable in practice. It is by making composites of the photographs, allotting to each portrait its appropriate time of exposure.<sup>1</sup> I submit a few composites which I have made of the heads of racehorses: the component portraits are from the earlier numbers of the 'Racing Illustrated.' I enlarged them to an uniform scale, reckoning from the middle of the eyeball to the fold within the nostril, cut them out to get rid of the confusion introduced by a variety of background, and then combined them in various proportions. Especially I took six, those of (A) Sir Visto, (B) Solaro, (C) Raconteur, (D) St. Marnock, (E) Speedwell, and (F) Salebeia, which will henceforth be distinguished by those letters. With the plate, stop, and the two small electric lamps that I used for illumination, it required an exposure of 240 seconds, say of 12 units of time, each consisting of 20 seconds, to give a good copy of any one of the portraits, so I proceeded as follows:—First, I made a composite of A and B, allowing 6 units of exposure to each

<sup>1</sup> Composite Portraits, *Nature*, 1878; Composite Portraiture, *Journ. Phot. Soc.*, 1881.

of them, or 12 units in all ; then I made another composite of A, B, and the four others, allowing 4 units to A, 4 units to B, and 1 unit to each of the four others, forming a total as before of 12 units. So while the composite which I will call A 6, B 6, illustrates the combined features of the two parents, that of A 4, B 4, C 1, D 1, E 1, F 1 illustrates those of two parents and four grandparents in the proportions laid down by the ancestral law. I proceeded similarly with C, D and with C, D and the other four, and again with E, F and with E, F and the other four ; I submit these six composites. Of course the process could be extended indefinitely, working backwards to include as many previous generations of ancestors as desired, and it might be equally well applied to portraits of other animals than horses, including men and women, whose features combine unexpectedly well in composites, though one sex be bearded and the other not. A composite may be made of any separate part of an animal, but hardly of the whole animal at once, because each separate joint is liable to be flexed differently in the different portraits. The ears of the horses in the illustration indicate what would then occur. This is not the place to enter further into the details of composite making, which I have now reduced to a very simple process whose accuracy is evidenced by the identity of the composites that have been re-made at different times from the same components. The specimens I submit would have been better if they had been made from the original photographs and not from photo-process copies of them, still they will serve to gauge the amount of information which composites are likely to give to the breeder. They should be carefully scrutinised and compared, when more differences and points of interest will be found than are apparent at a first glance.

*Measurement of Photographs.*—A photograph considered merely as a portrait tells about as much of an animal as can be gathered from a single view of it ; it defines the contour, the slope of the shoulders, the set of the head, the forms and the positions of the limbs, but this is by no means all that is obtainable from a photograph. It may be so taken that measurements made upon the photograph, after certain corrections have been applied to them, will be nearly as good as those made on the animal itself. Now, measurements are of the highest importance to the theoretical study of heredity, for science is based on numerical data, and the science of heredity is no exception to the general rule. Its progress depends primarily upon the power of procuring large collections of measurements of the same parts, which admit of being combined in any proportions by simple arithmetic. It matters little what limb, or bodily part, or faculty is the subject of measurement, because laws which are true for one particular quality, and for one particular race of animals or plants, will presumably apply with small modifications to any other quality and race. Therefore it would be no unworthy occupation for a scientific man to devote years of labour to carefully measuring each of many parts in the photographs of offspring and their ancestry, and to discuss the results by the elaborate methods of the higher statistics.

The photographs of which I speak are assumed to have been taken under the following conditions. They would represent side views of the animals and therefore be comparable on equal terms so far as position is concerned. The animals would have been photographed at a distance of *not less* than thirty feet from the camera, in order to avoid sensible distortion of the portrait. They should be taken while standing

on hard ground, that the feet may be clearly shown, and no mistake arise about their heights. The height of the camera above the ground and its distance from the animal should be roughly measured and noted. Lastly, two direct measurements of the height of the animal should be made, one at its withers, the other at its croup. The photograph now becomes more than a mere picture, because the recorded data, together with others afforded by the photograph itself, supply corrections that will cause the measurements made upon it to correspond with more or less accuracy to those made on the animal itself. Of course, their correspondence would not be so exact as it would be in photographs taken in a 'hippometric' laboratory provided with marked lines on the ground and walls, but such a laboratory is impracticable on many grounds. Thoroughbred horses are so easily frightened in unfamiliar places and at unfamiliar objects that the best plan is to photograph them leisurely among their accustomed surroundings. It is difficult and dangerous to apply tapes and calipers, which tickle and irritate, for thoroughbred horses are exceedingly sensitive, timid, fidgety, and often vicious, while they are supple and sudden in their movements of offence. Measurements of the two vertical heights, made in the usual way, are comparatively easy to manage.

I find, moreover, that vertical measurements of all kinds may be made quickly and accurately without touching the objects at all, by means of a simple instrument which I roughly put together for trial. [I submit its working part.] Its principle is that of a collimator, with additions and modifications. It seems very suitable for use at agricultural and other shows where many animals are collected.

Though many useful measurements can be made on a plain photograph, it would be a decided gain to select two, three or more important osseous protuberances, such as can be easily felt, and to mark their positions by sticking on the animal small wafers of sufficiently adhesive paper—say, one quarter of an inch in diameter. The corresponding marks on the photographs will be too small to attract notice, but they are easily found when looked for, and afford excellent points from which to measure. I may add that measurements I have made, and had made, both on horses and on their photographs, show that the relative dimensions of horses differ considerably. If some five different measurements were made on an adult racehorse, it would be as easy to identify him by a 'Bertillon process' as it is to identify prisoners.

It will be observed that the measured height of the animals at the wither and croup, supply a scale for vertical measures on the photograph at those points. If the line to which vertical measures are drawn on the photograph be the one that touches the edge of the feet nearest to the camera, a slight and simple correction has to be made. There is difficulty in respect to the relation between the vertical and the horizontal scales, but less so than might be anticipated, for the tilt of the camera is found closely enough by a rough knowledge of the height of the camera and its distance from the animal, combined with data supplied by the photograph itself. Again, the length between the rounded ends of the body, and the diameters of the limbs, are not sensibly affected by the animal standing very slightly askew. The necessary corrections admit of being easily found from appropriate tables. It is curious in how many different ways the required corrections may be determined when the range of available

measures is slightly increased. I have already discussed the question for a different and more complicated series of data in 'Photographic Measurements of Horses and other Animals' (*Nature*, Jan. 6, 1898), which will show the general character of the problem, but I cannot enter into particulars now. The primary question is, will photographers and grooms take the proposed measurements with sufficient correctness, and are any additions to them feasible? To settle this question, many experiments should be concentrated by more than one photographer upon the same quiet and well-measured animals. These ought to determine the trustworthiness of the results according to the data in use, and would show the minimum of effort that is necessary to afford the required degree of accuracy. I should be content if the average error in the calculated height and length of the horse did not exceed one inch, or say one-and-a-half per cent.

*Systematic Collection of Photographs.*—It remains to consider what has hitherto been taken for granted—the best method of starting a systematic collection of photographs of pedigree stock. My proposal is to suggest to the principal Societies which publish stud or herd books, that they should proceed as follows :

(1) To arrange with a photographer to store such negatives as the Society may hand over to his charge ; he undertaking to supply prints from them to the public at a moderate cost and under reasonable regulations.

(2) To invite owners of pure-bred stock to send to the Society with which they are in connection, a negative photographic plate of each of the animals which they use for breeding, and which are therefore adult, on the understanding that if the negative be accepted by the Society it will be handed over to the photographer.

(3) Only those negatives will be considered suitable for acceptance (a) which are of good quality ; (b) which do not transgress specified limits of size ; (c) which scrutiny shows to be strictly side views ; (d) which have been taken at a distance from the animal of not less than 30 feet ; and (e) which show the animal standing on hard ground.

(4) The following information is to be stamped or written on the negative in such a way as to be clearly legible in the prints : (1) the name and sex of the animal, (2) year of its birth, (3) year and month of taking the photograph, (4) heights at its withers and croup, (5) height of camera and its distance from the animal.

(5) The Society shall order an asterisk to be affixed to the name of each animal entered in its stud or herd book, when the photographic negatives of its sire and dam have been accepted.

It seems to me that a system such as this would be efficient, self-supporting and acceptable to all parties. Breeders would be pleased that photographs of their animals should be publicly recognised as serviceable for the advancement of their art. Owners of valuable animals are almost sure to order photographs of them on their own account, so the gift of the negatives to the Society would deprive them of nothing. The asterisks applied to the names of the offspring would be a valued distinction, and would help

to introduce the system. Later on, when they had become common, the absence of an asterisk would excite suspicion and require explanation. Lastly, the printing of the photographs would be self-supporting. I have already expressed a belief that the custom would arise of printing a separate pamphlet for every important stallion or bull, containing its photograph and those of its nearer ancestors, together with other appropriate information. Larger publications of a more costly kind would doubtless be issued under the auspices of each Society, to correspond with an awakened demand for fuller information on the antecedents of pedigree stock.

*Printed Records.*—As regards useful additions to the printed matter in stud and herd books, I would now merely allude to the need for them, and to the propriety of carefully reconsidering how much of real utility could be asked for from breeders that they would supply willingly and truthfully. The measurements of adult animals, of which I spoke, would be appropriate entries. An accumulation even of these during two or three generations would be exceedingly valuable, considering how many coherent results in the science of heredity have been derived from observations of human stature, though limited to comparatively small numbers of parents and their offspring.

*Conclusion.*—The amount of money annually spent in rearing pedigree stock is enormous; so is the care and thought bestowed upon it, and so also is its national importance. The non-preservation of adequate records of pedigree stock is a cruel waste of opportunity, and has been most prejudicial to the acquirement of a sound knowledge of the art of breeding. If the scheme I have sketched be found feasible, it will cause much to be noted that has hitherto been overlooked, and much that is commonly observed to be placed permanently on record, instead of being ill remembered and soon wholly forgotten.

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*The Climatology of Africa.*—*Seventh Report of a Committee consisting of Mr. E. G. RAVENSTEIN (Chairman), Sir JOHN KIRK, Mr. G. J. SYMONS, Dr. H. R. MILL, and Mr. H. N. DICKSON (Secretary). (Drawn up by the Chairman.)*

METEOROLOGICAL returns have reached your Committee, in the course of last year, from twenty-six stations in Tropical Africa.

*Niger Territories.*—No returns have been received from Wari since the hostile operations against Benin, and there is reason to believe that the instruments at that station have been destroyed. Mr. E. G. Fenton has forwarded three months' observations from Old Calabar. These will be published as soon as a full year's record is to hand. The promised abstracts of observations from several stations in the territories of the Royal Niger Company have not hitherto been received.

*Lambarene (Ogowai).*—The set of instruments lent to the late M. Bonzon of the 'Missions Evangéliques' has been returned to Paris. The Rev. M. Coillard, well known for his excellent work in the Barotse country, and a trustworthy observer, having expressed a desire to purchase these instruments for 6*l.*, the Committee have gladly accepted this offer, as a station in that part of Africa is much wanted. The set has been