

[For Private Circulation.]

PEDIGREE MOTHS.

- I. On a proposed series of experiments in breeding Moths, by FRANCIS GALTON, F.R.S.
- II. Appendix asking for living specimens of, and information about *Selenia Illustraria* (Purple Thorn) by FREDERIC MERRIFIELD.

I desire to institute a system of experimental breedings, to be continued for several years, with the object of procuring some much-needed Hereditary data.

The information I have thus far succeeded in obtaining and using, refers only to two or three consecutive generations; nevertheless, it has already yielded important results. These I greatly desire to verify and to extend by help of special experiments prolonged for many more generations. It is intended in each case to procure broods through a succession of selected specimens, along three lines of descent from a single pair of individuals, so that there would be three parallel broods in each generation. The particular characteristic that is selected for these experiments must admit of being accurately measured, in other respects the choice is immaterial. For brevity of explanation I will suppose it to be *size*. Then, starting from the brood of the original pair, (1) a few of the largest of either sex would be separated and mated; out of their progeny a few of the largest would again be taken and mated, and so on, for several successive generations. (2) Exactly the same process just described would be gone through, after substituting throughout the words "medium-sized" for "largest." (3) Similarly after substituting the word "smallest" for "largest."

The result will be to obtain a precise measure of the diminution of rate at which a divergence from the average of the race proceeds in successive generations of continually selected animals. The rate during the first few generations is probably the same whatever may be the characteristic observed (whether size or anything else) and whatever may be the kind of animal or plant experimented on. It will depend on the amount of the ancestral divergencies, measured with a special and relative unit ("probable error" as mathematicians call it), that I have often written about and cannot stop now to describe. This unit enables us to treat on equal terms individuals of either sex, or those in separate broods that have been affected by differences of nourishment, &c. I have shewn the rate of divergence to be the same within the limits of statistical error, in the case of (1) weight and size of sweet peas; (2) human stature; (3) human eye-colour. The course of investigation pursued is necessarily technical; it will be found described in—*Law of Regression, Journ. Anthropol. Inst., 1885*; *Family Likeness in Stature Proc. Royal Soc., 1886*; *Family Likeness in Eye-colour, Proc. Royal Soc., 1886*.

From the data obtained in these inquiries I derived the law of "Regression," which leads to many curious results. One is, that each parent contributes, on the average, one quarter of the total hereditary peculiarities of the child, each grand-parent one-sixteenth, and so on. In other words, that the two parents together contribute one half, the four grand-parents a quarter, the eight great-grand-parents one-eighth, and so on, the whole heritage being thus accounted for. It is, however, highly probable from other considerations, that though this simple formula may be closely true for the parents, and nearly true for the grand-parents, it may become sensibly and increasingly different for remoter progenitors. It is this fact that I want to investigate, because all theory concerning the nature of stability of type, and of much else, must be based upon the facts of Regression, which such experiments as those proposed can alone, so far as I see, be likely to declare in a trustworthy way.

For the purpose of an independent verification of the observed results, I hope, after the sixth generation shall have been reached, to institute another series of experiments in the converse direction, by breeding from mediocre representatives of each of these parallel broods, and again from mediocre representatives of their offspring, and so on continuously until no trace remains of their several temporary ancestral differences.

The most suitable animal or plant would be one that is hardy, quickly breeding, of small size, easily measured and preserved, and bearing broods of about 50 or 100 individuals. Mr. F. Merrifield, of 24, Vernon Terrace, Brighton, suggested, in answer to my inquiries, that English Moths which breed normally twice in the year, and that *Selenia Illustraria* in particular, would be very suitable. He, moreover, most kindly offered to carry on a series of experiments for me. From all I can as yet learn, Mr. Merrifield's suggestion seems to be a peculiarly happy one, and the wing-length seems to be a good subject for measurement. I have accepted his offer gratefully, more especially as he has had considerable experience in breeding this moth in former years. There are, however, many points on which he still desires as much information and assistance as he can obtain from experts. These are explained by himself in the annexed memorandum. Entomologists would help in a good cause if they would reply, so far as they are able, either to him or to myself.

I should add that the details of the whole procedure have been provisionally settled, but it is reasonable to anticipate that the proposed methods will be somewhat modified after a little experience. Then I shall hope to be able to describe them fully and clearly, in trust that others may be induced to co-operate on the same lines. It is important that more than one stock should exist of the same species of Moths having known pedigrees, in order that they may be cross-bred and the evil of too close interbreeding within a single stock be avoided.

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APPENDIX,

BY FREDERIC MERRIFIELD.

1. *At least Twenty Pupæ* are desired, to breed from next Spring; in default of these, 200 or more *eggs* next Spring. If 100 or more pupæ can now be supplied there will be a gain of one generation, as the first selection can in that case be made next Spring. It is *essential* that the pupæ or eggs should be fair representatives of the insect in its natural wild condition; those which result from interbreeding, or from larvæ fed up under unnatural conditions will be disqualified. The origin or history, therefore, of any which are offered must be accurately stated. Pupæ dug this winter, or eggs from moths caught wild next Spring are preferable. Any information as to where fresh pupæ can now be obtained, or supplying the names and addresses, &c., of persons by whom the obtaining of eggs in the Spring can be *guaranteed*, will be valued. The insect seems diffused over the South of England, and is recorded as plentiful in the New Forest and at Plymouth. A fair price will be paid for pupæ or eggs supplied.

2. *Number of Eggs*.—Entomologists, who have bred *Selenia Illustraria*, will oblige by stating what is the *usual* and what the *least* number that one healthy individual lays; and what, if any, difference there is in this respect between the Spring and the Summer breed of Moths.

3. *Mating, and Laying of fertile Eggs*.—The results of experience as to the best means of rendering certain these ends are desired. Especial attention is called to the following points. (a) May each pair which it is desired to mate be kept separate from all other pairs, or should two or more pairs be placed together for mating according to natural individual preferences? The former course is preferable unless it will seriously imperil results. (b) What space should be allowed—would muslin bags, of about 6in. by 3in., supported by enclosing in them a small spray of growing birch, be sufficient for one pair?

4. *Preserving the Moths in a Living State*.—The Spring brood of Moths in ordinary seasons emerges from about the beginning of April to the middle of May. All, or nearly all, of a brood have to be preserved alive and vigorous, that the selection of pairs for breeding may be made. It is proposed to attain this end by placing the pupæ, each in a separate chip box (about 1½ inch diameter, with a black net lid), in a warm room, as soon as the first moth emerges; to move all the moths, as they emerge, in their chip boxes, into a cool room, keeping them in absolute darkness and in a cold and rather moist air by a covering constructed on the evaporating zinc butter-cooler principle. Can any improvement on this plan be suggested? It is believed that the moths thus kept will live in a state of suspended animation for four or five weeks and be vigorous at the end. Is this so? Do they require feeding? It is thought not, as the tongue seems imperfect.

For purposes of accurate measurement, it may be advisable to temporarily stupefy the moths. Actual experience of safe agents for this purpose will be valuable—chloroform or ether vapour, &c., or cold. Will this or allied species survive, in full health, a freezing temperature?

5. *Feeding up the Larvæ*.—it being important to bring up the broods with as little loss of individual lives as may be, of full size and in a healthy condition. It is proposed to start the broods in a cool room, in jam pots with the rims ground level, and covered with pieces of plate glass (laid on an inner covering of muslin held in place by an elastic band, so as to allow of occasional airing by wholly or partially sliding away the glass); and, when the larvæ are a little over half an inch long, to transfer them into ordinary breeding cages kept in a cool and shady place out of doors; these cages constructed with glass tops and ends and cheesecloth sides so as to admit of a thorough draught, but capable of being closed by a light shutter on either side in windy weather, &c.

What cubical space is necessary for health? It is considered that 15in. by 13in. by 6in.—1170 cubic inches—would be enough for from 120 to 150 larvæ; this would allow from 8 to 10 cubic inches each.

It is believed that *Selenia Illustraria* is not prone to dwindle in captivity, but any suggestions for obviating all risk of such a result will be acceptable; as to ventilation, keeping the food-plant healthy, and general treatment. Is not occasional sprinkling with a fine spray of soft water desirable? Is change of food-plant, which may be sometimes convenient, injurious to this or allied species? Does it thrive better on one of its ordinary food-plants (birch, oak, ash, willow, hawthorn, &c.) than another? Any experience as to feeding on growing trees, protected by (muslin?) bags, will be welcome.

6. *Preserving Pupæ Alive and Well*.—It is proposed to keep them out of doors but sheltered, and to lay them, in their slight cocoons, on sandy peat, well baked to kill enemies, and kept slightly moist by infiltration and not by surface watering.

Any information or suggestions on the points above indicated, or any others thought material, especially from those who have had practical experience in successfully breeding Moths such as *Selenia Illustraria* for several successive generations, will be gratefully acknowledged.

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