

the distilled water were full of Bacteria, the others remaining barren. This was done to show that the liquid, although deprived of its power of germination, is as capable as before of supporting the life of Bacteria.

The results of the preceding experiments may be summed up as follows:—In sixteen experiments the liquids were subjected to the temperature of boiling at the normal pressure; of these, eight were heated for 15 minutes, and all bred Bacteria; six were heated for 30 minutes, of which two bred Bacteria; two for an hour, both of which were barren.

Of ten subjected to the temperature of ebullition at pressures not exceeding one inch, eight were barren. Both the liquids which were found to be pregnant had been heated for 30 minutes, one under a pressure of one-tenth of an inch, the other of one inch.

In the twelve experiments in which the liquids were heated under pressures exceeding one inch, all were barren, although half of them were subjected to that temperature for only 15 minutes.

It is unnecessary for me to draw any inferences from the preceding experiments; it may not, however, be superfluous to point out that, although all the flasks heated above 101° C. remained sterile, this fact affords no ground for concluding that any definite relation exists between that precise temperature and the destruction of the germinating power of the liquid in question. All that has been shown is that the chance that such a liquid will breed Bacteria is diminished either by slightly increasing the temperature to which it is heated, or increasing the duration of the heating. Thus it appears to me quite probable that if a sufficiently large number of flasks were heated even to 102° C., some of them would still be found to be pregnant.

University Coll., London, June 7 J. BURDON SANDERSON

#### Fertilisation of the Pansy.—Ground Ivy

THERE is one further point in the structure of *Viola tricolor* which is not mentioned by Mr. Bennett or by Mr. Hart, but which seems to confirm the theory of the former gentleman that *V. tricolor*, as distinguished from most other *Violas*, is fertilised by a small insect such as Thrips instead of by the proboscis of larger insects.

Before I saw Mr. Bennett's paper, my attention had been called by Miss Dowson to the fact that whereas in the Sweet and Dog Violets, the circle of anthers presses close to the style all round, there is in *V. tricolor* an opening between the two appendaged stamens. The use of this opening will evidently be to allow the small creature to enter in and crawl down the stamen to the nectary at the end of the appendage. This structure may be also seen in *V. cornuta*, which seems to be fertilised in the same way. In *V. tricolor* the opening is exactly opposite to the black streak, or guide-post, as Mr. Bennett has termed it. In *V. cornuta*, although this black mark is not so evident, there is a distinct triangular mark pointing downwards exposed by the opening of the stamens. On each side of the style are two sets of hairs, looking like "whiskers" to the scull-like crest of the style, on which lots of pollen rest. The small insect on entering the flower can hardly help crawling into the cavity at the top of the stigma, for the entrance to the flower is almost completely blocked up by it. On emerging from it it would crawl over the top, which Mr. Hart mentions as seen in *tricolor*, and which I also find in *cornuta*, be guided through the hole by the triangular mark, and so find his way to the nectary. On emerging, covered with pollen, and entering its next flower, it will again be deluded into the *cul-de-sac* in which the stigmatic surface is, where it will deposit its pollen. The details of the structure of the appendaged stamens, as contrasted with those of other *Violas*, fully bear out this view.

As regards the English translation for the German *bestäuben*, I would suggest to Mr. Hart that "pollenate" is an impossible word; *pollen*, *pollinis*, must give the verb to "pollinate," as *fulmen*, *fulminis* gives *fulminate*. But there is a great advantage in a word which speaks for itself, and, if the word "be-pollen" offends scientific ears (Mr. Hart does not tell us why), would the literal translation of the German "to be-dust" be offensive? If not, I think it would tell its own tale. The word "empollen" seems justified by *embalm*, but the prefix generally means to place in or convert into, as in *enthrall*, *emprison*, *embed*. Hence it would at least be ambiguous.

The form of Ground Ivy mentioned by your correspondent S.S.D. grows here abundantly in several spots, seeds freely, and is remarkable for having a much shorter style in proportion to the

tube of the corolla than the common form in which the style and stigmas protrude from the tube.

F. E. KITCHENER

Rugby, June 15

Mr. Kitchener having been kind enough to send me the above letter, I may, perhaps, be allowed to add a few additional notes. Since writing the former paper I have had the opportunity of examining three other species of *Viola*, *V. calcarata*, *elatior*, and *lactea*, all of which present a remarkable contrast to *V. tricolor* in a very curious point of structure. In *V. tricolor* the stigma is brought into close contact with the lowest petal by a very peculiar "knee" in the style, the effect of which is so completely to close up the central cavity of the flower as to render it extremely difficult for any large insect to insert its proboscis into the spur. In all the three species above-named, which I believe to be fertilised by bees, the style is nearly straight, so as to leave a considerable gap between the stigma and lower petal, quite large enough for the insertion of the proboscis of a bee. In none of these is there the least indication of the black triangular streak on the style which I take to serve, in *V. tricolor*, the purpose of guiding the Thrips to the nectary. The ring of anthers is also perfectly closed, as described by Miss Dowson in the case of the Dog and Sweet Violet, there being no opening for the admission of the small insect, as in the pansy. A striking difference in the form of the stigma also favours the same conclusion as to the mode of fertilisation.

ALFRED W. BENNETT

### ON THE ORIGIN AND METAMORPHOSES OF INSECTS\*

#### VI.

THE metamorphoses of insects have always seemed to me one of the greatest difficulties of the Darwinian theory. In most cases, the development of the individual reproduces to a certain extent that of the race; but the motionless, imbecile pupa cannot represent a mature form. No one, so far as I know, has yet attempted to explain, in accordance with Mr. Darwin's views, a life history, such as that of a butterfly, in which the mouth is first mandibulate and then suctorial. A clue to the difficulty may, I think, be found in the distinction between developmental and adaptive changes; to which I have called attention in a previous article. The larvæ of insects are by no means mere stages in the development of the perfect animal. On the contrary, they are subject to the influence of natural selection, and undergo changes which have reference entirely to their own requirements and condition. It is evident, then, that while the embryonic development of an animal in the egg may be an epitome of its specific history, this is by no means the case with species in which the immature forms have a separate and independent existence. If an animal when young pursues one mode of life, and lives on one kind of food, which subsequently, either from its own growth in size and strength, or from any change of season, alters its habits or food, however slightly, it immediately becomes subject to the action of new forces; natural selection affects it in two different and, it may be, very distinct manners, gradually leading to differences which may become so great as to involve an intermediate period of change and quiescence.

There are, however, peculiar difficulties in those cases in which, as among the Lepidoptera, the same species is mandibulate as a larva, and suctorial as an imago. From this point of view *Campodea* and the *Collembola* (*Podura*, &c.) are peculiarly interesting. There are among insects three principal types of mouth—first, the mandibulate; secondly, the suctorial; and thirdly, that of *Campodea* and the *Collembola* generally, in which the mandibles and maxillæ are retracted, but, though far from strong, have some freedom of motion, and can be used for biting and chewing soft substances. This type is intermediate between the other two. Assuming that certain representatives of such a type found themselves in circumstances

\* Continued from p. 107.