NOTES ON THE MOULTING OF MITES AND INSECTS

By A. D. Heriot, Vernon, B. C.

Dyar's law is based on the fact that the head width of insects is constant for each stadium. In certain proven cases the head width increases by a geometrical progression in successive instars. It does not appear that this law is derived from a sequence of events at a particular time, but is merely the generalization of a large number of ascertained facts existing at any time. Since the head is not subject to growth during a stadium, it is manifest that there must be a definite stage during the moult when an increase takes place, and that considerable preparation must be made for this sudden alteration.

By describing the moulting of some of the mites, where the head is very much reduced, then passing on to insects with widely different shaped heads, which bring different movements and contortions into play, when casting the old skin, it may be possible to illuminate what is otherwise obscure regarding Dyar's law.

It will be needless to point out that the moult is not simply a matter of an insect getting too large for its integument and bursting out of it. All kinds of adjustments have to be made relating to the mouthparts and the respiratory and digestive systems, none of which are apparent by merely examining externally an insect when at rest.* This period of rest, so apt to be held responsible for a subsequent transformation, may very well be merely a period for the adjustment and the maturation of parts already well developed during a preceding period of feeding and active movement.

In the mites the head width has little meaning, and moulting is much simplified. Last summer **Eriophyes pini** Nalepa, the largest known species of this genus, was found on yellow pine. Due to the vast number between the needles in the basal sheath, several hundreds of these mites could be rapidly transferred en masse to a slide for examination. It so happened that at this particular time a very large proportion of these mites were in various stages of moulting. It was thus possible to get a consecutive series.

These mites are cylindrical in shape, being broadest across the short cephalothorax and tapering towards the caudal end of the long abdomen. The abdomen itself is not segmented like that of an insect, but has about one hundred little pleats or striae, permitting of a similar extension and contraction.

* The Renewal of the Mouthparts of Sucking Insects has already been published. Further notes on the respiratory and digestive system may throw light on the shrinking and partial recovery of size during the moulting period.

At the approach of the moult the mite stretches itself out to its fullest extent and becomes absolutely at rest. The old cuticle hardens and the new instar shrinks away from its old integument. This shrinkage continues until the mite is small enough to withdraw the legs and palpae from their encasements after which it moves about with considerable freedom within the hardened transparent cylinder of the old skin. At this time the external sexual organs and other characters distinguishing it from the previous instar can be plainly discerned. The new instar is complete, as far as can be judged, in every way except size. It has moreover cast its skin, so to speak although imprisoned within it. Without the aid of a strong reflected light and a high-powered objective it would be quite evident that the mite had remained in continuous inactivity. All that would really meet the eye would be the stiffened old cuticle betraying no indication of the active mite within The next stage appears to be a partial recovery of growth and the mite has only to gather strength to break midway the brittle cylinder enclosing it and emerge from the two halves.

Much the same steps of hardening the cuticle, and shrinking and expanding of the insect, are seen to take place during the moult of the oyster-shell scale. Due to a fixed position on the bark, shrinkage is imperative in order that the insect may separate itself from the hard exuvial skin. This acts as its protective shell until the scale proper is made. As in the mite, so it is to a large extent in the scale. New mouthparts and many of the specific characters of the pygidium, which distinguish the second instar from the first, are evident in the shrunken individual. The head, however, is firmly held in place, preventing the same freedom of movement exhibited by the mite at this stage. Moreover the head of the scale in its cramped position appears to have undergone a change. The rolled stylets in the head instead of being circular, as they are in an earlier stage, are distinctly oval in shape. This might be due to pressure, but as will be seen later is accounted for by the rolled stylets being tilted up. There is a warp in the head of the prospective instar. The shape of the scale, together with the room provided by the shrinkage of the insect, permits the head to slip back and at the same time the flattening out of the warp breaks the thin ventral skin at the anterior end.

This slipping back of the head from out the old head capsule is very noticeable in the caterpillar. Shrinkage of the abdomen in this case is evident by actual loss of weight. The fact that the new instar withdraws its prolegs and moves up within the old cuticle when this ruptures is in many respects a repetition of movements observed in the mite. It is difficult to conceive how the old head capsule could have contained the new head which bulges out the soft integument in the rear.

In the leafhoppers the head itself is the widest part of the insect's body. No amount of shrinkage of thorax and abdomen will permit the head to escape. Until the head capsule breaks, as it must do, the new and wider head is actually contained in the old head capsule. While it is easy to conceive of a larger abdomen with its segments and conjunctiva being squeezed together in a smaller compass than is natural, the segments of the head only exist in a primitive condition and as such are only represented by a few sutures. These would allow at most a certain amount of bending or warping such as has been inferred to take place in the oyster shell scale.

This can be demonstrated in larger insects such as the leafhopper which is now being discussed. Although the head width is constant for each stadium, this does not apply to the length of the body and it is easy to pick out a leafhopper that is about to moult by the comparatively narrow head to the length of the body. Procuring such an individual and having fixed and cleared it, a line is taken across the widest part of the body, namely the head. This line, from the margin of eye to eye, will intersect two prominent setae standing out from the old cuticle. Beneath these setae will be seen, in a well-cleared specimen, faint lines representng the new setae, which are lying compressed beneath the old cuticle. It will, however, be noticed that these new setae are much closer together than either the old setae or those on leafhoppers which have just moulted. This is caused by a deep depression in the head along the line of the median epicranial suture. The head of the prospective instar is something like a half-closed book and only needs to be opened flat to break the head capsule and increase in width. The whole process may be illustrated better by a felt hat with a dent down the middle. If the dent is flattened out the hat will be wider and enable a wider hat with a similar dent to fit inside it.

Careful measurements with the micrometer screw of the microscope indicate that this depression extends to about half the depth of the leafhoppers' head. If the width of the head and depth of this depression are drawn to scale there would be a bent line denoting the latter which if straightened out would give an increase of head width approximating to examples given by Dyar for some lepidopterous larvae. It is also manifest that if the ratio of depth and width is constant that a geometrical progression of head widths in successive instars must ensue.