PSYCHE.

THE SCALES OF COLEOPTERA.

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The brown scales are lustreless and without cross-bands, while the white scales, as long as they are filled with air, are silvery. This fact and other reasons lead me to believe that the cross-bands are partial separations of the lower lamina of the scale, and are the cause of the silvery lustre of the white scales. I reserve, however, further discussion of the production of silvery surfaces for the last portion of this paper.

To get at the finer structure of these scales transverse sections of some of the brown ones were made; one of these sections is shown in fig. 7, *d*. Altho numerous sections as thin as 0.0025 mm. were examined, I could find no longitudinal canals or passages, but the lower lamina of the scale is somewhat more transparent than the upper lamina; on the latter portion are the longitudinal striae, seen in transverse section in fig. 7, *d*. Sections of the white scales are similar in form, but are so transparent in the fluids in which I was obliged to study them that I could find no air cavities.

Treatment with reagents give positive proof that both the white and brown scales contain air. Alcohol or water rapidly discharges air from cavities within them; glycerin expels it only less rapidly. Scales regain their air readily when dried from water or alcohol. After treatment with any liquid the white scales become very transparent, showing that they contain no coloring matter; when mounted in Canada balsam they are almost invisible.

ELATERIDAE, SPECIES UNDETERMINED.

Fig. 8 represents the scales from an undetermined species of *elateridae*, from Leipzig, Germany. I figure them here because I have found in no other coleoptera scales of similar form. They

Fig. 8. Scales of an undetermined species of *elateridae*: *a*, seen from above; *b*, lateral view. Enlarged 100 diam.

are, however, similar in structure to the brown scales of *Alaus oculatus*, but they have in addition a prolongation of the distal end of the scale into a sort of short filament.

SCALES OF PTINUS ? RUTILUS.

A species of *Ptinus*, probably *P. rutilus*, which was found in great numbers

in a dry-goods store in Leipzig, Germany, furnishes interesting forms of scales. This coleopteron is clothed with brown hairs, one of which is figured (fig. 9, *c*) and among these hairs are scales (fig. 9, *a* and *b*). The relative size of the hairs and scales of this species of *Ptinus* may be seen from fig. 9, where both are drawn enlarged 100 diameters. These scales have from two to seven long apical points, are attached by a little stem at the base, and are 0.06 to 0.09 mm. in length by 0.01 to 0.03 mm. wide. Their color is light brown, which is apparently produced, for the most part, by somewhat irregular longitudinal stripes or thickenings upon the inner surface of the scales. These scales are filled with air.

Fig. 9. Scales and hair of *Ptinus ? rutilus: a* and *b*, scales from elytron; *c*, hair from elytron. Enlarged 100 diam.

SCALES OF CLYTUS ROBINIAE.

Nearly all the yellow stripes upon *C. robiniae* owe their entire coloration to the scales with which they are covered. This can be seen best by scraping all the scales from the insect, after which, with the exception of the legs and a few yellow stripes on the elytra, it is black. Most black parts of the insect are, however, improved in depth of color by being clothed with black scales. The yellow stripes upon the thorax are produced entirely by yellow scales which are set upon a black background. The whole richness of coloration of *C. robiniae* is produced by the scales with which it is clothed, as can perhaps be most strikingly illustrated by removing the scales from one half of a specimen and leaving the other half intact. In the same way the ground color of the European *Saperda scalaris* is black, its beautiful coloration being due to a dense coating of scale-like hairs.

Fig. 10. Scale of *Clytus robiniae*. Enlarged 100 diam.

The black or brown scales from the upper surface of the thorax or from the elytra of *C. robiniae* resemble, at first glance, those of *Alaus oculatus*, but upon closer examination they prove to be quite different. Their form is approximately an elongated parallelogram (see fig. 10), with the shank or point of attachment at one of the acute angles. The striae originate at and near the shank and terminate along the opposite end of the scale, thus differing entirely, in this respect, from the scales of *Alaus*.

The scales of *C. robiniae* are 0.15 to 0.18 mm. long by about 0.02 mm. wide. Under the microscope they are dark brown or light yellow, according to whether they are from the black or yellow parts of the insect. Both the yellow

and the brown scales have the same form and structure, and both contain air, as can be readily seen by the action of water upon them. Neither the brown nor the yellow scales can be bleached by chlorin.

Of the numerous scales of *curculionidae*, the family of coleoptera in which the possession of scales may be said to be almost a rule, I have chosen for especial study the

SCALES OF ENTIMUS IMPERIALIS.

This species has the most brilliant, and, in some respects, the most interesting scales and hairs of any coleopteron which I have examined. Nearly its whole surface, above and beneath, is covered with lines or masses of minute

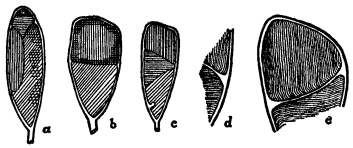

Fig. 11. Scales of *Entimus imperialis:* on *a*, *b* and *c* vertical lines indicate blue, horizontal lines indicate carmine red, and oblique lines yellow; where two kinds of lines cross, one color is tinged with the other; on *d* and *e* the fine lines represent the finer striation of the inner layer of the scales. Enlargement: *a*, *b* and *c*, 100 diam.; *d* and *e*, 300 diam.

scales, glistening by reflected light with the brightest colors, and these colors are heightened by the shining black background which the surface of the insect affords. Hairs and scales cover its legs, and the hairs, as will be seen later, are of the same nature as are the scales.

The form of these appendages is extremely variable. Their greatest width is about 0.06 mm., and from this width gradations may be found down to hairs of a diameter of less than 0.01 mm. The length of such as are typically scales (fig. 11, *a*, *b* and *c*) is 0.15 to 0.18 mm. The hairs attain a length of 1.3 mm.

Both hairs and scales are colored in the same way and with the same colors, chiefly red, blue and yellow, by transmitted light, and green and purple by reflected light. Whatever the color by reflected light, its complementary color appears by transmitted light; predominant is red by transmitted, and green by reflected light. Thus one sees the origin of the green color on the coleopteron itself. Green, yellow, red, blue and purple often appear on a single scale, and these colors change if the light is changed from transmitted to reflected; they are especially brilliant upon a black background. Some scales are of a single color, usually red. On figure 11, *a*, *b* and *c*, I have attempted, as far as is possible without colored figures, to show the distribution of colors in three scales. Even colored figures would have poorly represented some of the brilliant variations which the scales present.

More careful miscroscopical examination sufficed, even with low powers, to show that the scales have the appearance of being filled with pigments, separate colors usually in distinct compartments allotted to them. Sometimes, however, similar colors, like yellow and yellowish red (see basal part of fig. 11, *a*), or like blue and purple, are in the same compartment. Sometimes there is a tinge of color near

the margin of a compartment different from the color of the middle of the compartment, as in the upper part of fig. 11, *b*. The extreme margin of the scales is always transparent and colorless, and sometimes, as if by a flaw, a little transparent spot extends into the colored portion of the scale, as near the base of fig. 11, *c*. At all points along the margin where different compartments meet the marginal transparent portion seems to extend inward, and with higher magnifying powers a very thin, transparent partition can be seen extending between the compartments. This partition is clearly and perhaps too strongly represented on fig. 11, *d* and *e*. If a part of a scale, especially near its base, is broken, two edges can be readily seen, showing the scale to be hollow, and the color sometimes fails near the broken edges. Everything indicates pigment coloration, but experience with the colored scales of *Hoplia* teaches the application of reagents. Treatment with the simplest of all reagents, water, dispels all the illusion in regard to enclosed pigments. Every scale that is not absolutely perfect, becomes, in a few moments, transparent and almost colorless, a slight yellow remaining, the water having entered the cracks and broken places in the scales. Is the pigment dissolved or changed chemically by the water? This is negatived by a few experiments similar to those tried on the scales of *Hoplia*. The scales when redried from volatile liquids regain their original coloration, the same colors and shades in their respective compartments and locations. Chlorin or sulphuric anhydrid (SO_2) fails to bleach the scales; acids and alkalies do not change their colors. Uninjured scales are not penetrated by liquids and remain colored in them. The coloration is surely due, then, to physical causes, that is to some form of interference of light.

The hairs are colored similarly to the scales, although the finer hairs appear to the naked eye, or to a simple lens, as silvery white, even when seen on a black surface. In the hairs the colors often alternate in the same general manner as they do in the scales, but, as is usual in the scales, yellow, or yellowish-red, is generally nearest the basal portion of the hair. The external transparent sheath or wall of the hairs, corresponding, as seen under the microscope, to the transparent margin of the scales, varies much in thickness; in some cases the coloration fills nearly the whole hair, in other cases the channel through the hair is very small and consequently the color line very narrow in the hair. When treated with water or other liquids broken hairs are rendered transparent in the same manner as injured scales.

When filled with water the hairs and scales still show, sometimes quite distinctly, the partitions between their different compartments. In rare cases liquids fail to pass a partition, leaving one part of a scale or hair colored after another part has been rendered transparent. Thus it is evident that, however thin the partitions may be, they are water-tight when uninjured; they are, nevertheless, apparently usually broken through, the scales themselves

being so brittle that few can be removed without breaking. My experiments were all made with scales from a specimen dried at least over ten years; possibly a fresh specimen would have less brittle scales.

Further microscopic examination of narrow scales and hairs reveals a longitudinal striation, the striae of which are from 0.0015 to 0.0020 mm. (or even further) apart. This striation, which for greater distinctness I will call the "coarser striation,' is present on hairs, less marked on elongated scales, and not generally observable on broad scales (such as represented in fig. 11, *b*). This coarse striation is visible after the color has been removed from the scales and hairs by reagents. It is easily seen to be external on the cylindrical hairs, extending beyond the colored portion of the hairs.

Still higher magnifying power brings to view a second striation, which I will call the "finer striation." This striation was much more difficult to see than the coarser striation, the striae being very delicate and only 0.0008 to 0.0009 mm. apart. Unlike the coarser striation, the finer striation is more evident on broad scales and least evident or not discernible, at least with the objectives at my command, on narrow scales and on hairs. The finer striation is further unlike the coarser striation in following no definite direction on the scale, sometimes being in one direction in one portion of a scale and in another direction in another part of the same scale. In any single compartment of a scale the direction of the finer striation is approximately the same, sometimes a little curved, resembling, as seen under the microscope, the furrows of the finger-tips. In adjacent compartments of a scale the finer striae are sometimes at right angles to each other, though oftener in the same direction. I have attempted to represent, on fig. 11, *d* and *e*, the finer striation upon two scales, but the striae, although proportionately about the right distance apart, are themselves relatively coarser than in nature. The finer striation may be at right or at oblique angles (probably also parallel) to the coarser striation. The finer striation is most evident in blue or purplish parts of scales, altho it exists in other parts; probably the darker background makes it more plainly visible on blue portions. The finer striae appear to be formed of rows of dots, but my objectives failed to determine this with certainty. The finer striation is invisible on scales treated with liquid reagents to remove the air.

Both finer and coarser striation are found on the under as well as the upper side of the scales. At the edges of the scales the coarser striation curves and appears upon the transparent border of the scales, the finer striation (see fig. 11, *e*) curves to meet the margins of compartments; the coarser striation is evidently an external, longitudinal plication of the scale-membrane, limited in extent by the size of the scale itself, the finer striation is a plication or figuration of the inner side of the scale-membrane, limited in extent by the outline of the compartment to which it belongs.

(*To be continued.*)