AN INSECT GEOMETRICIAN.

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Not less wonderful in its instinctive habits than ants and bees, though of a still more insignificant size and appearance, the *Rhynchites betulæ L.* is without doubt one of the most interesting species of the whole order of Coleoptera. In constructing the cradle for its young this tiny black snout-beetle has for ages been carrying out a problem which, at least in its entirety, was not known to man before the year 1673, when the great mathematical genius, Huygens, published his celebrated "Horologium Oscillatorium."

It may prove of interest to hear some particulars about this little architect, especially since, to our knowledge, its species does not occur among American Rhynchites. Therefore, in the following notes, I shall endeavor to give a brief account of this beetle and its problem, basing my remarks on the investigations and writings of Debay* and of Wasmann,† and upon observations which I myself made some years ago in Holland.

In early spring, as soon as the *Rh. betulæ*‡ has emerged from the ground, it climbs up a birch-tree, where, after mating, the female at once proceeds to construct from the pliant young birch leaves a little house for her offspring. Carefully examining the edge of a leaf, the beetle suddenly stops and begins to cut the outlines of what is to be the cradle for its little ones. It starts at the upper margin of one side of the leaf. Directing its head toward the upper part of the central rib, it cuts with its admirably adapted mandibles an S-shaped curve, whose terminal touches the leaf's central rib. Then after having made a slight incision into the main nerve of the leaf, in order to impair the flow of the sap, it cuts, across the other half of the leaf, a corresponding but more horizontal curve which terminates a little higher on the central rib. Then, after repassing the line of the entire cut to trim the edges and to cut through some nerves still connected, it once more stations itself at the starting-point of the whole operation. With the claws of its legs, whose femurs are powerful levers, it next grasps the edge of the leaf, and walking now downward, now to the middle, it rolls up in less than two minutes the one-half of the leaf into a sort of funnel, opening downward. After a short repast, which very prudently is taken from parts close to the main ribs, our little worker hastens to roll up the other side of the leaf around the funnel just formed, in which operation it uses its legs in a manner just the reverse of the former.

Now, after 30 minutes' work, the main preparations have been completed for depositing the eggs. The beetle crawls into the funnel's interior, cuts out three or four little pockets and introduces an egg into each. After this has been done, nothing remains but to close the precious chamber as firmly as possible. To accomplish this it walks first to the upper end of the funnel and pierces the different layers of the leaf in such a way as to make them adhere to each other. Then it returns to the lower end of the leaf, and grasping its apex, forms a second funnel, with its opening directed upward and fitting exactly into the larger one (Fig. 1).

In doing all this our little architect, otherwise of so timid a nature, exhibits such an interest and fervor that, as I myself more than once have observed, it does not desist from its ingenious work once begun, even though taken into the observer's hand.

Now in what does the real problem of the beetle consist and what has it to do with the conservation of its species?

Unrolling the leaf and spreading it on a plain surface (Fig. 2), we shall find that the exterior margin of the leaf and the S-curve cut by the beetle are in the same relation to each other as the two curves of higher mathematics, the involute and evolute, i. e., *v w, t u, r s, p q, l m* are almost perpendicular to the exterior margin *w, u, s, q, m*, and are equal to the corresponding curves *v y g, t y g, r y g, p y g, l y g*, respectively. In other words, our little mathematician cuts its S-curve so that the length of the cut made and the distance from the exterior margin always remain the same. This problem coincides with the task of higher mathematics, from a given involute to construct the corresponding evolute, and consequently involves a most complicated combination of differential calculus and geometry.

But to what kind of curve does the evolute of *Rh. betulæ* belong? As Prof. Heis first discovered, the evolute is in this case nothing else than an unfinished circle, which has its terminals in the joints, *g* and *y*. Besides, according to the same authority, the more horizontal curve of the second half of the leaf is to be considered as a very appropriate flattening of the first curve, which has a more perpendicular position. For, since the broader exterior windings, *A, B, C*, correspond to the smaller interior, *H, G, F*, without being shortened (i. e., *a b* and *c d* are equal to *l m* and *i k*, respectively), the second S-curve must necessarily lie in a more horizontal position.

This is one part of our little builder's problem. The other consists in the suitableness of the chosen curve to the formation of a funnel. Supposing that the beetle wished to construct from the birch leaf the largest and strongest funnel possible, and that, too, in the shortest time and with the expenditure of the least amount of its limited strength, it could really not choose a more suitable curve.

The funnel may be considered as a surface conically evolvable, which, when spread out upon a plane, coincides with it in all its points. Now such a surface can be rolled up in two ways, so that the lines of convolution meet either in one point or in a row of points, lying in a straight or curved line (Fig. 3). To have them meet in one point is, in our case, altogether out of question. For apart from the fact that the central rib would most probably tear in the course of the operation, it would exceed the strength of our little beetle to handle the whole surface, *o a*, at once. Therefore the second manner of convolution had to be chosen. Yet here again it would not do to have the upper margin in a straight line, for in rolling up the leaf the upper and lower openings would have to become either equal in their respective diameters or not. In the first case we would have no funnel, but only a useless cylinder; in the second the larger opening would be either above or below. If above, the funnel because reversed evidently would not serve its purpose; if below, the length of the side, *o a*, would either not correspond to that of the outer edge, *a g*, or at least the oblique position of the funnel would make it impossible to wind the other half of the leaf around it. The margin, therefore, must be a curved line. But this curved line again would be either convex or concave, or partly convex, partly concave. Of these possible cases, the first two would be impractical; for the merely convex margin has all the disadvantages of a straight one, and, besides, would make the poor beetle do superfluous work in rolling up a part of the leaf (*o b a c*), that is of no use in the formation of the funnel. A funnel with a merely concave margin would have too many windings closely packed at the top, and thus overtax the strength of the builder; and the funnel, which is subsequently to serve also as food for the larvæ, would have, perhaps, dwindled down too much in size.

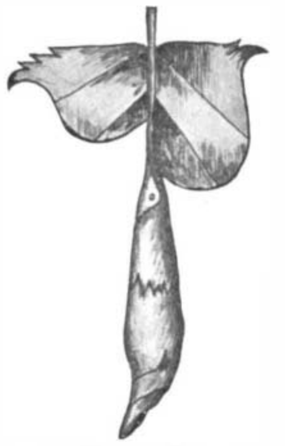

Fig. 1.—The Scientifically Constructed Nest of the Rhynchites Betulae. (After Wasmann.)

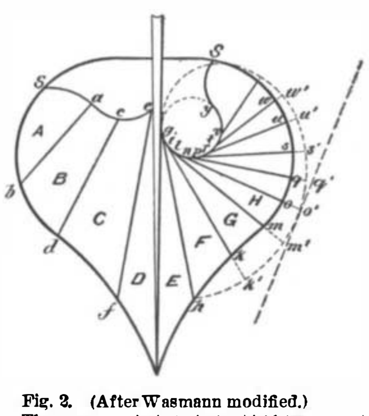

Fig. 2. (After Wasmann modified.)

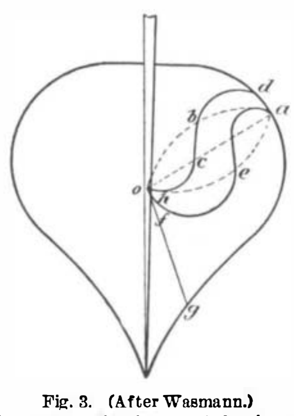

Fig. 3. (After Wasmann.)

The curve g w' u' s' q' o' m' k' h' represents the mathematical involute belonging to the evolute g i l n p r t v y.

Therefore, there only remains the concavo-convex line of section, in which again either the convex or the concave part might be longer. And here, as Wasmann justly remarks, "the technical ingenuity of our architect shows itself in its brightest light." For what would be the result if the convex part were longer? We need but to cut such a funnel from paper and see. First of all, it is not pointed enough. Besides, the part, *h b*, is not in the spiral of the point, as it should be, but along the vertical axis, and thereby the curve, *o c b d*, will no longer have the required length. And the part, *c a b d*, would most unsuitably protrude above the funnel's apex. At any rate, the funnel would be lacking in firmness and could not be closed so tightly as it should be.

But if, as is actually the fact, our architect chooses to make the concave part of the margin longer in the above mentioned proportion to the leaf's outer margin, then all requirements are most admirably met, and not a trace of the disadvantages of the former methods can be discovered. Without wishing to maintain that no other curve might possibly bring about the same result, there is certainly none so simple and yet so wonderfully appropriate.

To understand this still more clearly, we may finally direct our attention for a moment to the purpose which the funnel has. What is the real destiny of this artistic house? To insure the preservation of the species, *Rhynchites betulæ*, it is absolutely necessary that in its larval stage the young progeny should be guarded against all harmful influences resulting from atmospheric changes. Now it has been experimentally proved that every larva, in spite of abundant food, simply dries up when taken out of the tightly-rolled and well-sealed funnel. Moreover, on account of the constitution of its stomach, the larva can feed only on dry leaves, supplied by its habitation. And for making the birch leaf dry in due time, the mother beetle wisely provided by not forgetting to make the incision in the leaf's central rib. Finally, because the number of its progeny is so exceedingly small, it had to guard them well against all insectivorous animals. But who can suggest a hiding-place better adapted to its purposes than a dry, meaningless leaf, rolled up and closed with so great care?

Thus, whether technically or economically considered, the house of *Rh. betulæ*, constructed under normal conditions, is a real masterpiece and in every respect most perfect. Full of admiration, therefore, we look upon this little genius which, having scarcely escaped from its swaddling clothes, and without any education or experience whatsoever, performs a two-fold mathematical and practical problem with the greatest skill and facility. Certainly to explain psychologically such a phenomenon, no automatic machine, as Cartesius believed, will suffice. For it is evident that *Rh. betulæ* is all the time guided by its senses. Neither can there be any question of an intelligence (*sensu proprio*) abiding in the beetle itself. For, first, such an intelligence would by far exceed that of man, and, secondly, it leaves unexplained the great stupidity which the beetle shows when the exterior circumstances are in any way disturbed by man or nature. The sole explanation best adapted to avoid all contradictions and to solve sufficiently all parts of this psychological problem seems to us to be given by instinct, as defined by Wasmann,* "the sum of the specific faculties of the sensitive cognition and appetency, essentially connected with the nervous system and transmitted by the same."

* Dr. Debay, Beitraege zur Entwicklungsgeschichte der Ruesselkaefer aus der Familie der Attelabiden, Bonn 1846.

† Erich Wasmann, S. J. Der Trichterwickler, Muenster 1884.

‡ From betula, birch-tree.

* Wasmann, S. J. Die psychischen Faehigkeiten der Ameisen. Zoologica. Heft 26, Stuttgart 1899, p. 81.

The Mushroom.

The London Lancet says: "The notion has long been held that the mushroom presented the composition of animal flesh, which led to its being called the 'vegetable beefsteak.' It appears, however, that this conclusion has been based on some analysis made many years ago, when analytical methods were not as exact as they are now and when the chemistry of food was not so well understood. In one regard, at any rate, the mushroom does resemble a beefsteak—in that it contains practically the same amount of water. But the dry, solid constituents of the mushroom differ very materially in kind from the solids of meat. The most important difference is due to the rich proportion of proteids—the so-called flesh-formers—in meat as compared with the feeble amount in the mushroom. This fact, as ascertained by recent analyses, hardly justifies the mushroom being regarded as a 'vegetable beefsteak.' It may be a blow to the vegetarian, but he would have to consume at least ten pounds of mushrooms in order to gain the equivalent of a little over one pound of prime beef. Indeed, in the light of modern inquiry there seems to be no reason for believing that mushrooms possess any greater food value than other ordinary fresh vegetable foods, and in many respects they compare unfavorably with them.

"Still, the fresh tender mushroom is undoubtedly easily digestible, and as it contains carbohydrates, in addition to some proteid, it is obvious that it is of some dietetic value. This value is not comparable with that possessed by essential foods, such as meat, milk and eggs. The mushroom, however, contains an unusual proportion of potassium salts. Few will deny that the mushroom is an excellent adjunct to many dishes; it has an appetizing flavor, and this quality alone makes it dietetically valuable."

International Exhibition of Motor Boats.

Count Talleyrand-Périgord informs us that an exposition and competition of motor-driven boats and motors for sailing boats will take place in June, 1902, near Berlin, on Lake Wannsee in the royal forest. Although the exhibition is especially intended for inventors and manufacturers of launches, it is expected that other trades will likewise give it the attention which it certainly deserves. Communications may be addressed to the Secretary, Universitaetsstrasse 1, Berlin, Germany.