MODIFICATIONS ADAPTIVE TO AN AQUATIC HABIT IN THE COLEOPTERA.

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Those representatives of the Coleoptera characterized by an aquatic habit show many interesting and remarkable variations from other beetles in their structure fitting them for such a life. Most of the various parts of the insect body are involved to a greater or less extent in these modifications, but the most notable digressions from the structure of the terrestrial beetle are found in the shape of the body,in the manner of breathing,and in the structure of the legs. Adaptations are also noticeable in the length,shape,and position of the antennae, in the number and position of the eyes, and occasionally in the sculpturing of the elytra.

In an article of the length of this it would be impossible to treat all of the various coleopterous insects inhabiting the water even were it possible to obtain specimens for such a treatment. Hence I have decided to limit the subject to a discussion and illustration of the principal adaptations found in the three great families Dytiscidae, Gyrinidae, and Hydrophilidae. Since the individual species of each family do not differ greatly from one another,it will be necessary to use but a single species as indicative of the adaptations found in that family. As the well known family Dytiscidae is generally recognized as first in the order of development, it will properly be taken up first.

THE DYTISCIDAE.

Preliminary to taking up the discussion of the adaptations of Dytiscidae to an aquatic life, it may be well to state briefly what their habits are. The entire family is composed of rapacious diving beetles that obtain their food by the destruction of smaller water insects and occasionally young fishes. The larval and pupa stages are passed in the water and upon moist earth respectively. The imago frequents ponds and pools of stagnant water in which there is a growth of water plants.Most of its time is spent beneath the water but it must accasionally rise to the surface for fresh air and often at nights it comes out and flies to a

new pool or pond.

As a type of the Dytiscid I have taken Cybister Fimbriolatus,one of the commonest as well as largest of the aquatic beetles.

The thing which first impresses one studying this insect is the perfect shaping of the body to a rapid passage through water with the least resistance. The body is of an oval outline,slightly convex above and below and without a single projection to check its passage through a fluid. The head,thorax, and abdomen are compactly and rigidly put together,so as to insure harmony of movement, and the various appendages are situated so as to offer a minimum of resistance to progress. The first two pairs of legs not being used in the act of swimming are drawn close up to the thorax which is itself modified so as to enable their being drawn in out of the way. The antennae are also carried in such a way as not to impede progress .

While the forelegs are not used in swimming they nevertheless show a curious adaptation. The first three joints of the tarsi of the male Cybister are broadly expanded,forming three thin sucking-plates. These plates are not present on the female and their presence on the male is probably to aid him in retaining a hold upon the female. The elytra of the female at the point where the sucking-plates come in contact with them are roughened and full of small porous openings. A fluid has been observed to issue from the plates of the male when pressed and some entomologists believe that there is some connection between this fluid,the porous openings in the elytra of the female,and the act of fertilization. The suctorial plates are most noticeable in the two genera Dytiscus and Cybister,but they are found also in the other members of the family.

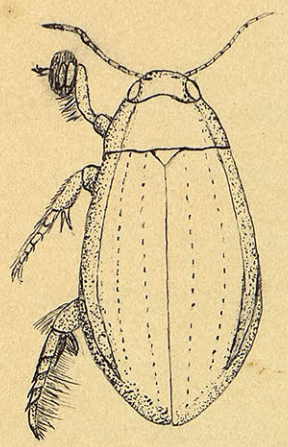
The middle legs of the Dytiscid show but very little variation from those of terrestrial Coleoptera and are probably used,as are the fore legs,in crawling about on land.

The posterior pair of legs which is used as oars for propelling the body about is admirably adapted to perform that function. They are attached to the body

by immovable coxae. The femora and tibiae are flattened and rather stiffly articulated ;the joints of the tarsi are flattened and fringed with long stiff bristles which add greatly to their striking surface; and the whole structure is so articulated with the coxae as to allow the leg when being drawn up for the backward stroke to assume a horizontal position,thus reducing the resistance since the thinness of the various parts causes the water to be parted as by a knife blade. But as soon as the backward stroke begins,the whole leg assumes a vertical position and the whole surface of femur,tibia ,and tarsal joints greatly augmented by the fringe of stiff bristle-like hairs mentioned above is presented broadside to the water. This peculiar but beautiful means of increasing the striking surface,together with the strong muscleing of the legs,gives the insect power to move very rapidly.

Another adaptation of great value to the Dytiscid is that for breathing beneath the surface. The breathing pores or spiracles are situated beneath the wing-covers which are fitted closely together and with the wings form an air-tight and water-tight covering to a cavity of considerable size made by a depression of the dorsal segments of the abdomen. The Dytiscid comes to the surface,protrudes the rear end of the body from the water,slightly raises the elytra,and secures a supply of fresh air which it carries down with it. When its supply is exhausted, it has but to cease swimming,and being lighter than water,it immediately rises to the surface again. The two last spiracles are larger than the others and they are exposed when the elytra are raised. It is beleived that they open into large air tubes running through the body and that when they are exposed these tubes are immediately filled with air thus greatly helping the supply.

The elytra of the male Cybister are nearly smooth (i.e. they show relatively but few punctures,while the females have theirs profusely punctured and striated.) I know of no reason for this other than that the suctorial plates of the male will be more easily attached to a roughened surface than to a smooth one.



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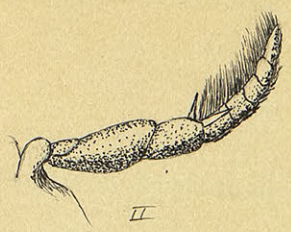

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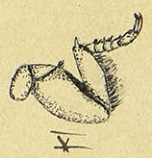

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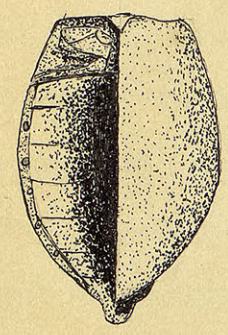


VI

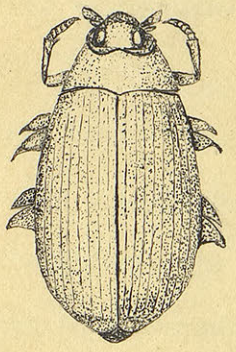
I. Dytiscid (Cybister Fimbriolatus)
II. Posterior Leg.
III. Middle Leg.
IV. Anterior leg of male.
V. Anterior leg of female
VI. Dorsal view with one elytra removed showing cavity.

GYRINIDAE.

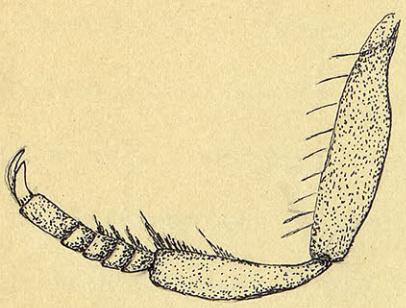
The members of this family are smaller than Dytiscidae and they are not subaquatic in their habits. Most of the time they spend darting and whirling about on the surface of the pond or sluggish stream which they inhabit. Their movements are characterised by great rapidity. Their habit of circling in and out has given them the common name of whirligig beetles. The larvae are water living but the pupa develops on land .The adult when frightened dives quickly,but soon rises again. The winter is passed,so far as is known,in a torpid state at the bottom of the pond which it inhabits.

In some respects the Gyrinidae show the most perfect adaptations of any of the aquatic coleoptera .The shape of the body is much like that of Dytiscidae.The ventral width is greater as compared with the dorsal than that of the preceding family. This fact gives the body more of a boat shape and consequently better fits it for moving on the surface. The body structure,like that of Dytiscidae,is compact and rigid,the head and thorax being joined almost immovably.

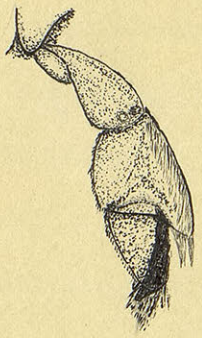
The legs of the Gyrinid show a greater adaptation than do those of a Dytiscid. Instead of having only the rear pair developed for swimming,both the middle and posterior pairs are highly developed. The anterior legs are not used in swimming but are designed as organs of prehension. The tarsi have the soles turned inward instead of downward and are provided with circular sucking plates in the male,presumably for the purpose of clinging to the female. The middle legs are flattened and fringed with long hairs. They are capable of extension though not to the same extent as the third pair. This third pair shows what is probably the most perfect adaptation for swimming to be found among coleoptera. All of its parts are greatly flattened and the tarsi are fringed with hairs. The backward stroke having been dealt with the broadside of the leg,it is at once contracted in a manner similar to a folding fan and at the same time turned edgewise to the water so that it may be drawn up for the new stroke with comparatively little resistance. When



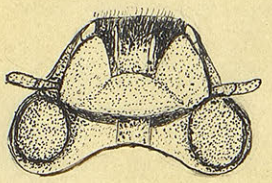
Gyrinidae.



Fore leg.



Posterior leg.



Under side of head

ready for the stroke once more the leg is extended to its full length,in this way enabling the insect to deal a powerful stroke.

The Gyrinidae do not carry air beneath the elytra in the same manner as Cybister. When diving the beetle secures a small bubble of air between the tips of the elytra and the last segment of the abdomen and this it carries down with it,but the amount is so small that it can remain submerged for but a short time.

One curious modification found only in the Gyrinids among aquatic beetles is that of divided eyes. Each individual is provided with four distinct eyes,an upper pair and a lower pair. The use of this arrangement can only be conjectured as it is impossible to observe the insect upon water closely enough to ascertain, but it is supposed,and fairly, that the upper pair is for aerial observation and the lower for making out what is going on in the water below.

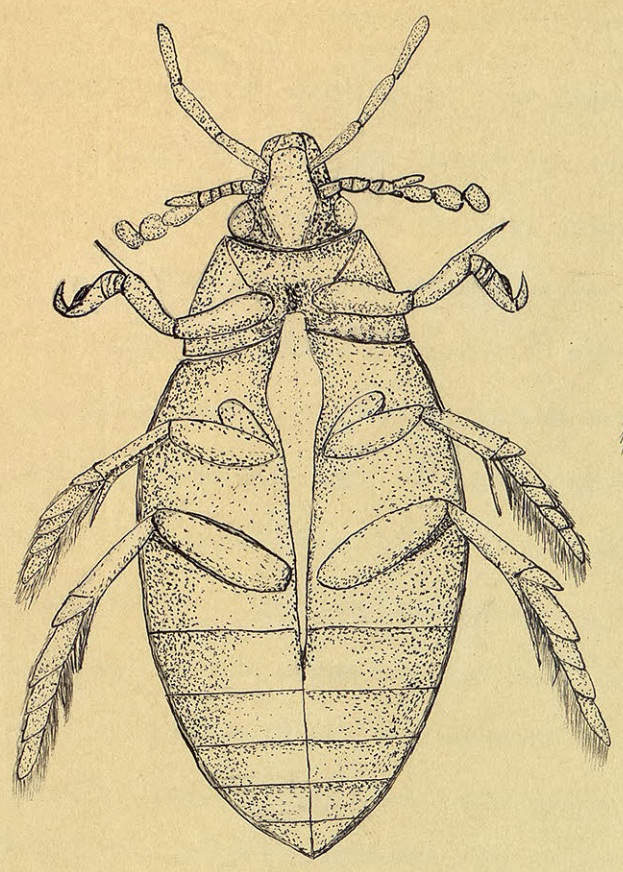
The antennae are curiously modified. The second joint is larger than the first and the third much larger than both of the others,giving the appearance of a small antenna upon the others. The remaining eight joints form a club and its tip is a sensitive organ not found on the Dytiscid antennae. The significance of this type of antenna is not well understood.

The Gyrinids are provided with strong wings and they fly from place to place with ease,although they have some difficulty getting started.

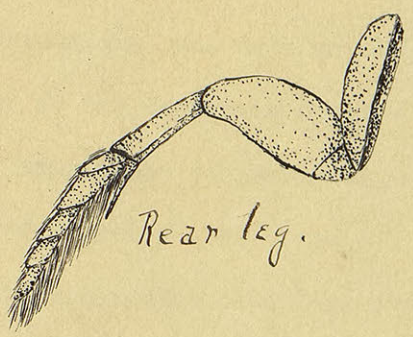
HYDROPHILIDAE.

This family includes the largest as well as some of the smallest of the aquatic coleoptera. They are subaquatic insects whose larva is water living but pupates in moist soil on the bank. They fly about at night and are both vegetable eaters and predaceous. The imago passes the winter by burrowing into the soft mud of the banks of the pond which it inhabits.

In some ways the Hydrophilidae are not so highly adapted to an aquatic habit as are the Dytiscidae or Gyrinidae but in others they are the equals if not superiors of either. They are not nearly as strong as swimmers as either of the

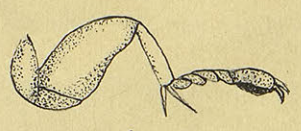


Hydrophilus Triangularis
(Ventral veiw)

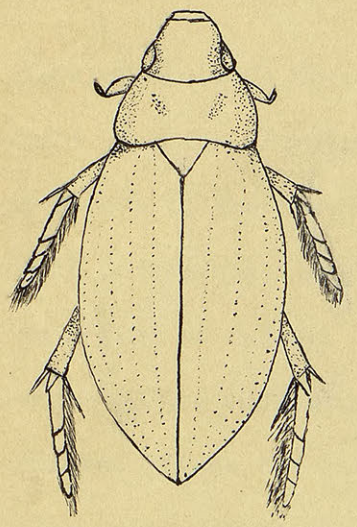


Rear leg.

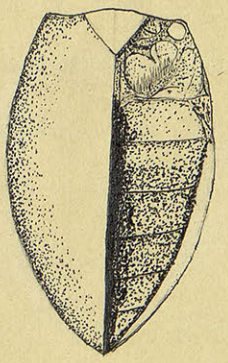
Middle leg.



Fore leg



H. Triangularis (dorsal)



Cavity beneath elytra

C.B.G.

latter, their legs not showing the same degree of modification.

The fore legs of this insect are essentially the same as those of Carabidae except that in the male the last joint of the tarsus is dilated to form a sucking pad. The middle legs show a slight adaptation for swimming, being flattened and having the tarsi fringed with stiff bristles. The coxae are of a half cylindric shape set into a socket in the metathorax. The hind legs are of the same form as the middle only stronger, more flattened, and having a wider fringe of hairs on the tarsi. Most of the propelling surface of both pairs is found in the tarsal joints since the femora and the tibiae are not greatly flattened. The peculiar shape of the coxae together with the articulations of the coxae and femora (which allows of but one movement and that parallel to the body) in the two rear pairs of legs enables them to be drawn up edgewise to the water. But as soon as the backward stroke commences they assume a position broadside to it. Such an arrangement ~~which~~ while quite efficient, is by no means as perfect as that of either Gyrinidae or Dytiscidae, as not nearly the space is obtained for the propelling stroke and more reisistance is met with in drawing up the leg preparatory to the stroke.

The shape of the body does not differ essentially from that of other aquatic beetles except that the metasternum is prolonged backward, forming a long, sharp spine reaching almost to the second segment of the abdomen. The function of this spine is not well understood, though it may be a means of protection or possibly it may serve as a kind of rudder.

The length of the maxillary palpi of the Hydrophilidae is another feature not easily explained. Since the antennae are utilized in a way not found in any other insect, the palpi may be designed to perform their function. Be their use what it may, the palpi are somewhat longer than the antennae.

The provisions of this family for carrying air are more unique than those of either of the other great families. A reservoir is found beneath the elytra as in Dytiscidae and it is filled in very much the same manner. But in addition to this,

certain regions of the ventral surface of the body are covered with mats of very fine velvet-like hair and in the spaces between these hairs the insect carries minute bubbles of air. These regions are situated beneath the thorax and along the edges of the abdomen. When the insect is swimming in clear water, these patches are discernible as silvery white areas. They communicate in some way with the region beneath the elytra in which are situated the spiracles. It is believed by Sharp that the air carried on the lower surface of the body is obtained by use of the antennae. He says; "The terminal joints of the antennae form a pubescent scoop made by some longer hairs into a funnel sufficiently large to convey a bubble of air. The insect rises to the surface and by means of the antennae, which it exposes to the air, obtains a supply with which it surrounds a great part of its body." It was impossible for me to verify this statement except as regards the shape of the antennae.

Of the three families here discussed, the Dytiscidae probably show the highest degree of adaptation to an aquatic life. They do not have as perfect a swimming leg as has the Gyrinidae but it is far superior to that of Hydrophilidae. Their arrangements for carrying air are better than those of the Gyrinidae and compare favorably with those of Hydrophilidae. Nevertheless it is very hard to say that one is positively better equipped to live in water than the other since each of the three possess adaptations which excell those of the others.