THE BLISTER BEETLE TRICRANIA SANGUINIPENNIS—BIOLOGY, DESCRIPTIONS OF DIFFERENT STAGES, AND SYSTEMATIC RELATIONSHIP.

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INTRODUCTION.

The family Meloidae is distributed all over the world and has been the subject of the studies of several prominent entomologists. Nevertheless, it is a group but insufficiently looked into from the different angles of natural history and especially has the biology of the family and the description of its different larval stages been less worked out than is generally realized.

The metamorphosis was unknown until 1851 and since then only a few important contributions have appeared on this subject, namely, the classical papers of Newport, Fabre, Mayet, Riley, Beauregard, Künckel d'Herculais, and the modern, numerous, very important publications by A. Cros, who has given complete or partial accounts of the biology of many of the hitherto little known or entirely unknown genera and species.

However, as mentioned, much knowledge is still lacking of the life history and structural details of several important forms, this being especially true of our American species. Concerning these little has been written since Riley's famous publications on *Epicauta* and *Hornia*. Thus, the life history of a genus so common as *Macrobasis* has not yet been fully investigated, though F. B. Milliken has recently contributed some valuable information. Of 31 North American genera we have complete biological records of only 1, namely *Epicauta;* and partial records of 2, *Hornia* and *Macrobasis;* the life history of the remaining 29 being unknown or known only through European publications on European species.

This fact is the more amazing when it is considered that at present we know from North America many more genera and species than from any other equally large region of the world, and that the imagines of many of the American genera, for instance *Gynaecomeloe*, *Cysteodemus*, *Megetra*, *Phodaga*, *Eupompha*, and *Calospasta* show the most extraordinary and interesting features.

The present writers consider it their good fortune to be able to reveal the entire life history of the species *Tricrania sanguinipennis* and to describe its different stages, thus adding another complete record of a North American Meloid to the one given by Riley.

In presenting the results of the work the subject has been divided into two coordinate parts, the first dealing with the biology of the insect and the second with the anatomy and systematic description of the different stages, especially the larval stages. J. B. Parker is responsible for the first part, Adam G. Böving for the second.

It has been considered appropriate to include in the second part a brief account, with a key, of a classification, based on larval and pupal characters, of the entire subfamily *Nemognathinae*, and, at the end of the paper, to give an annotated bibliography of literature which refers to this account.

The illustrations are all original and consist of photographs, taken by J. B. Parker, and pen drawings by Adam G. Böving.

The large and unique collection of material of *Tricrania*, from which the descriptions and figures have been made, has been collected by J. B. Parker and has been donated by him to the collections of Coleopterous larvae in the United States National Museum.

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PART 1.

BIOLOGY.

The beetle, *Tricrania sanguinipennis* Say, which belongs to the family Meloidae, is in its larval stage a parasite of the solitary bee, *Colletes rufithorax* Swenk. The adult beetle is about ten millimeters in length, black with blood-red wing covers and, being destitute of true wings, is unable to fly. It passes the winter in the adult stage deep down in the ground in the brood cell of its host.

The nesting site of the host, where these observations were made, is located on the grounds of the Catholic University of America, Brookland, D. C., on a sloping bank facing south. The soil in which the burrows of the bee are placed is a mixture of sand and clay and the depth at which the host places her brood cells varies from eighteen inches to two and one-half feet. The time of the emergence of the adult beetle from the earth in the spring depends upon climatic conditions in which temperature seems to be the chief factor. In

1917 emergence in large numbers occurred on April 12; in 1920, this did not occur till April 21; and in 1921 large numbers were present on April 3 and 4. In each year a few individuals emerged earlier than the dates given above and a few stragglers came out later, but our observations indicate that the time of maximum emergence covers a period of only one or two days.

Mating occurs coincident with emergence and oviposition begins immediately unless delayed by an unfavorable change in the weather. The female crawls beneath some object lying loose upon the ground and fastens her eggs in a mass to the under side of this object. In the present investigation eggs were found chiefly on the under side of bits of dried cow's dung (see fig. 42). They were also found under loose stones and in one case on the under side of a clam shell, *Venus mercenaria* Linnaeus, lying in the field. The eggs (fig. 22) are glistening white and are coated with a sticky substance that causes them to adhere together in a mass. They vary somewhat in size; of those measured in 1920 the average was 0.8 mm. in length by 0.32 mm. in breadth and in 1921, 0.83 mm. in length by 0.315 mm. in breadth. The female being wingless does not wander far from the point of emergence from the ground and having selected a place to deposit her eggs remains, if she is not disturbed, in that place till oviposition is complete, shortly after which death follows, due to exhaustion, since little, if any food is taken in the adult stage.

The number of eggs laid by each female is large and the period of oviposition, as observed in the laboratory, covers about two weeks. Early in the morning of April 21, 1920, two unfertilized females were taken in the field and permitted to mate in the laboratory. They were then put in separate cages suitable for oviposition. Eggs were present in both cages on the morning of April 22, but no count was made till April 27. On this date female No. 1 had deposited 788 eggs and No. 2 had deposited 1,020. From this date forward daily counts were made with the following results:

No. 1 had deposited—	Eggs.
April 28	53
April 29	35
April 30	26
May 1	9
May 2	0
May 3	17
May 4	0
May 5	5
May 9, the beetle died.	

No. 2 had deposited—	Eggs.
April 28	0
April 29	192
April 30	56
May 1–4	0
May 5	27
May 7, the beetle died.	

Thus in the case of No. 1 the beetle deposited a total of 933 eggs in a period of 13 days, perishing 4 days after oviposition was complete. In the case of No. 2, the female deposited 1,295 eggs in the same period of time, perishing two days after oviposition was complete.

On the morning of April 3, 1921, two unfertilized females were taken in the field and after being permitted to mate were placed in cages in the laboratory where daily count of the eggs deposited by each beetle was made and the eggs removed at about 5 o'clock in the afternoon. The results were as follows:

No. 1 had deposited—	Eggs.
April 4	1,017
April 5	392
April 6	165
April 7	118
April 8	87
April 9	60
April 10	27
April 11	28
April 12	26
April 13	1
April 17, the beetle died.	

No. 2 had deposited—	Eggs.
April 4	374
April 5	487
April 6	249
April 7	213
April 8	107
April 9	79
April 10	41
April 11	77
April 12	81
April 13	27
April 14	14
April 15	25
April 16	5
April 17	4
April 18	1
April 19	2
April 21, the beetle died.	

In the case of No. 1. the beetle deposited a total of 1,925 eggs within a period of 10 days, perishing 4 days after oviposition was complete. In the case of No. 2, a total of 1,786 eggs was deposited within a period of 16 days, the beetle perishing 2 days after oviposition was complete. It will be well, however, to note that these results were obtained under laboratory conditions where the environment was very favorable and practically unchanged; consequently, they do not show accurately what transpires in the fields where hot days and cold nights, violent rains and drying winds play a very important part in determining the length of the period of oviposition and the power of the female to deposit the maximum number of eggs .

The period of incubation of the egg is variable, depending upon temperature as the main determining factor. Under laboratory conditions where the temperature varied but slightly above or below 70° F., the time required for the eggs to hatch was from twelve to fourteen days. In the field, where temperature conditions are exceedingly variable at the time the eggs are present, the period of incubation is considerably longer than that required in the laboratory. Out of repeated attempts to carry eggs in the field through the period of incubation only one proved successful. The eggs used were deposited in the laboratory on March 30 and 31, 1921, and were placed in the field on April 1. They began hatching on April 25. These eggs were placed in the field on the under side of a piece of dried cow dung, on which they had been deposited, and then were kept during the period of incubation under conditions as nearly normal as possible. While these eggs were in the field frosts were frequent at night in the early part of April and on one night the ground was slightly frozen.

In 1917 the beetles appeared in the field in large numbers on April 12, indicating that this was the time of maximum emergence, and eggs that year were found hatching in the field on May 12. When these eggs were deposited is not known, but when other facts together with the meager data actually obtained are taken into consideration the probability is great that their period of incubation covered approximately one month. However this may be, enough was learned in these investigations to show that, since the beetles normally emerge and lay their eggs a certain length of time before the host emerges and begins nesting, those factors that retard the hatching of the eggs also retard the emergence of the bees, so that when the first larval instars do appear the bees are providing in their nests the food required by the beetle for its survival as a species.

Just how long this first instar can survive in the field after hatching is not known. When kept confined together in numbers in the breeding jars in the laboratory none survive for a period greater than 11 days. When kept together in a small space the larvae are constantly attacking one another, and, although no case was observed in which one larva killed another outright, there can be no doubt that these constant fights and contentions serve to exhaust the larvae sooner than would be the case if they were allowed to scatter about unmolested, a condition that prevails in the field. Furthermore in the laboratory the larvae were without water or food of any kind. In experimenting with them it was found that the first instars will take water when they come in contact with it and will also eagerly sip honey when they first find it. Their power of resistance to the vicissitudes of their environment is very great. It is next to impossible to drown them in water. The means for overcoming this danger, probably the greatest they have to face in the field is found in the development of the last pair of spiracles as will be explained in the discussion of the morphology of the larvae. (See p. 17.)

Just how the first instar gets down into the nest of the host has not been positively learned. The eggs are laid in the immediate vicinity of the nesting burrows of the host and when the larvae emerge from the eggs they immediately scatter about over the ground in every direction. Under these conditions it is possible that the larva simply finds the mouth of a burrow and crawls down into the nesting cell of its host. Observations, however, indicate that this is not the way entrance is effected. Repeated attempts to induce larvae reared in the laboratory to enter the burrows known to be occupied by the host invariably failed. If placed at the mouth of a burrow the larvae refused to enter it; if placed down on the walls of the burrow inside it, they invariably scrambled out and wandered away. It is our conviction that the first instar succeeds in attaching itself to the host, and when she enters the burrow rides down to the nesting cell upon her. The mandibles of the parasite (fig. 13) are notched on the inner margin, which fits them admirably for seizing and holding on to the hair of the host, and if a bee is placed in a breeding jar among active larvae every one that comes in contact with her will seize hold of a hair or spine with the mandibles and hold on so tenaciously that both bee and parasites can be killed in a cyanide bottle without the parasites releasing their hold (fig. 24). Likewise, if a camel's-hair brush is brought into contact with them they will seize the hairs with their mandibles and hold on tightly so long as the brush is moved vigorously about or rubbed against some object in an effort to dislodge them. So soon, however, as the movement of the brush is stopped the larvae will release their hold and scramble off the brush. If the brush is free of contact with another object the larva will release its hold with the mandibles and crawl about over the brush; but if it is dislodged while moving about it can attach a thread to the brush and thus let itself down by spinning a thread as do the larvae of many Lepidoptera. In this operation the larva goes down head first. What advantage the larva derives from this power to spin a thread has not been learned.

On May 20, 1920, males of *Colletes rufithorax* were abundant about the nesting site eagerly searching for the females, which on that date were emerging freely. A number of both males and females was captured and killed in a cyanide bottle and, after being taken to the laboratory and placed on pins, were examined for first instars. Sixty per cent both of males and of females were found infested, the different individuals carrying from one to four *Tricrania* larvae. On the males, all the larvae, with the exception of one, were found clinging to hairs on the posterior, ventral part of the head. On the females, however, although a few were found adhering to hairs on the ventral parts of the thorax, the great majority of the larvae were clinging to hairs on the posterior, dorsal part of the head or on the vertex.

Beauregard, quoting from the researches of Fabre, writes that the female of *Sitaris humeralis* places her eggs in the entrance of the burrow of the host (*Antophora pilipes*) and that the first larval instars, which on hatching from the eggs find themselves at the opening of the burrow, attach themselves to the males of the host, which emerge first and are carried about by the males till the females appear and then during copulation transfer themselves to the females and in this manner finally reach the brood chamber of the host. It seems highly probable that *Tricrania sanguinipennis* makes use of similar methods in gaining access to the brood cells of *Colletes rufithorax*. The eggs of the beetle are laid in a cluster as stated above in the vicinity of the burrows of the host and the larvae when hatched scatter about actively in all directions and this dispersal takes place normally at the time when the males of the host are most active in searching out the females. In their efforts to find the females, the males range hither and thither over the nesting site, spending much of their time crawling about over the ground and dodging in and out of burrows. The parasites are thus given far greater opportunities to attach themselves to the male than to the female, for the latter is seldom on the ground save when entering or leaving a burrow. When to these facts we add the data given above, that, on infested males and females of *Colletes* taken in the field at a time when matings were in progress, the majority of the parasites on the males were found on the ventral side of the body whereas on the females they were found on the dorsal side, it would all seem to indicate that the male of the host is an active agent in enabling the parasite to attach itself to the female.

But there is evidence to show that the parasite is not wholly dependent upon the male to find its way to the female of its host. In opening the burrows for cells of the host containing parasites, it was invariably found that where nests were opened in an area on which a clutch of the eggs of the parasite had hatched or on which a large number of the parasites hatched in the laboratory had been turned loose, the percentage of infested brood cells of the host was always greater than was the case in places more remote from such centers of dispersal of the parasite. If the parasite depended entirely upon the male to gain lodgment on the female this difference in degree of infestation in different parts of the nesting area would be hard to explain, since the males roam freely and uniformly over the extent of the nesting area in search of the females. Furthermore, cells infested with parasites were found that were constructed long after all males had disappeared from the field, cells that were constructed by bees whose previously constructed cells did not contain the parasite. In addition, some females of *Andrena perplexa* Smith (of which species the males perish before the young of *Tricrania* hatch), taken at the time the parasite was active in the field, were found with first instars attached to them. These parasites must have attached themselves directly to the bee and, in spite of the fact that *Andrena* crawls about over the ground to a greater extent than does *Colletes*, if the parasites can reach the female of *Andrena* by their own efforts there is no very good reason for believing that some of them can not reach the female of *Colletes* in the same way.

It may be well to report at this time some other observations made in connection with the study of the life history of this beetle. Another solitary bee, *Andrena perplexa* Smith, also nests in great numbers on this same sunny slope and the nests of the two species are intermingled promiscously over the nesting site. *Andrena* emerges earlier in the season than *Colletes* and the nesting operations of the former are in full swing when the latter first appears on the scene, but for a considerable length of time the nesting activities of the two species go on side by side. If our conclusion is correct, that the parasites get down into the nests of *Colletes* by obtaining a hold upon the host and riding down to the brood cell in this position, then there can be no doubt that a great many go down into the nests of *Andrena;* for this bee alights usually at a short distance from her burrow and crawls over the ground to the entrance, whereas *Colletes* alights directly in the mouth of her burrow, which is always left open, and disappears within immediately.

This beetle can not parisitize *Andrena*, however, and the explanation lies in the nesting habits of this species. *Andrena perplexa* Smith constructs as a brood chamber, at the end of a vertical tunnel, a cavity whose walls are smoothed and made waterproof by means of a waxy substance. At the bottom of this chamber the bee places a mass of pollen upon which she deposits an egg (fig. 39). The egg is placed on end and never in contact with the wall of the brood chamber. Then upon this pollen-mass, upon which the egg rests, she places a quantity of thin, watery honey that completely surrounds and almost submerges the egg. Hence, the cell when completed is so arranged that the parasite can not reach the egg without first falling into this watery honey. A large number of nests of *Andrena* were brought into the laboratory in the course of our investigations and placed in breeding receptacles into which first instars of the beetle were introduced. In every case, without a single exception, the parasites got into the honey and perished. We repeatedly placed the larva directly upon the egg, but in every instance the larval beetle sooner or later got into the honey and perished. A larva may become mired in the honey furnished by *Colletes* and later struggle out and survive, but once it becomes mired in the honey supplied by *Andrena* it never gets out and perishes in a short time.

In the case of *Colletes rufithorax* Smith, the bee, in constructing a brood chamber, excavates, at the end of a tunnel, a cavity, and within it, closely applied to its walls, she constructs a cell of thin, tough, homogeneous, transparent substance that in chemical composition seems closely related to chitin (fig. 36). In the bottom of this cell the bee places a quantity of food composed of honey and pollen mixed into a sticky semi-fluid mass. Then within the cell she deposits an egg attaching it by one end to the side of the cell wall above the food mass (fig. 36.) The parasite within the cell can, therefore, readily reach the egg without coming in contact with the food at all.

When the Meloid larva gains entrance into the cell of *Colletes* it attacks and devours the egg of the bee. This is the normal proceedure but it is not absolutely necessary that the parasite, in order to survive, make its first meal upon the egg of the host. For we reared one parasite in the laboratory from egg to adult wholly upon the food (pollen and honey) provided by the bee for her offspring. By devouring the egg of the host the parasite in addition to obtaining a nutritious food performs an act of self-preservation; for if the egg of the host were permitted to hatch and the young survive, the quantity of food available would be insufficient for the two larvae and both would perish. If the beetle is to survive, the egg of the host must be destroyed. The food thus derived from the egg of the host is sufficient for the development of the first instar. During this period of development the larvae expands greatly so that the chitinized rings of the abdomen are widely separated and its length increases to nearly double that of the instar on its emergence from the egg (fig. 37). After the first moult the body of the larval beetle assumes a boat-shaped form with the spiracles placed dorsally, for the larva, which normally while in its first stage remains on the side of the cell, now rests directly upon the food mass and its shape is such that it floats safely upon the semi-fluid food in much the same manner as a duck floats on water (fig. 38). This same position with relation to the food mass is maintained by the following third instar (fig. 40), but by the time the fourth instar is reached so much of the food has been consumed and the larva has grown to such size that it may now safely assume any position in the cell that may be necessary to enable it to obtain all the food remaining (fig. 41).

On the morning of June 9, 1920, a number of brood cells of *Colletes* was obtained from the nesting ground each of which contained a parasite in the first stage. In six of these the parasites were still feeding on the egg of the host and these molted for the first time as follows: 2 on June 14; 1, June 15; 2, June 17; and 1, June 20. In regard to six others the egg of the host had already been completely devoured and molting took place as follows: 1, June 9 (at 4 o'clock in the afternoon); 1, June 11; 1, June 12; 1, June 14; and 2, June 17. From the data given above it is evident that the time required to complete the first stage in development varies. Of two parasites taken from the ground in the act of devouring the egg of the host, one required 11 days to reach the second instar while another required but 5.

It frequently happens that two or more first instars gain entrance into the same cell, but in every case observed, either in the field or in the laboratory, only one survived. In removing the brood cells of *Colletes* from the ground on June 9, 1920, one cell was crushed out of shape, but no rupture occurred in its walls. When examined in the laboratory a first stage Meloid larva was discovered submerged in the disturbed food mass. The side of the cell was opened, the parasite fished out, given a bath in water to remove the honey from it, and was restored to the cell, which was placed in a breeding vial. The egg of the host could not be discovered in the cell and the larva showed by its appearance that it had taken food before the cell had been removed from the ground. On the morning of June 14 it was found that this larva had molted and was lying dead on the food mass and that a second larva in the first stage was present in the cell.. The dead larva and its cast skin were removed from the cell at once and the second parasite left in the cell. On June 19 this second parasite molted. On the morning of June 20 a third parasite in first stage appeared in the cell. This third one had killed the newly molted second instar and was feeding on its body. The cast skin and the dead body of the second instar were removed from the cell and the third parasite left in possession. This third parasite, a first instar, molted on July 2.

Now, all three of these parasites were in the cell when it was taken from the ground, for *Colletes* seals her brood cell up after she deposits her egg so that nothing can get in without rupturing the cell wall. All three must have been submerged in the food mass when the cell was crushed out of shape in its removal from the ground, but all three survived in spite of the fact that only one was discovered and had the honey removed from it. How the egg of the host was destroyed, whether by the three jointly or by the first alone (which is most probable) is not known. But that the first larva to molt was killed by the second and the second by the third is quite evident. Here then is a case where a first instar introduced into a cell of *Colletes* prior to June 9 and later messed up in the food survived and completed this first larval stage July 2, a period of more than 23 days.

In the development of the larval beetle there are in all six instars and consequently six cast skins before the pupal stage is reached. Aside from that relating to the first larval stage the data obtained dealing with the length of time required to complete the other larval stages have not been found satisfactory, owing to failure in many cases to discover the exact time of the second molt and to the necessity of killing many of the larvae in different stages to provide material for morphological study. Out of eight larvae that were permitted to complete their larval development six had transformed to the pupal stage by August 23, 1920. All six were taken from the ground in cells of the host in the first stage on June 9, 1920. They completed the fourth larval stage—that is, the period of feeding—on dates ranging from July 4 to July 19. In other words the approximate time of feeding in these cases varied from 26 to 41 days under laboratory conditions. On August 31, 1920, two cells of *Colletes* were taken from the ground each containing the parasite; in each case the beetle was in the pupal stage. Both of these beetles as well as all those permitted to reach the pupal stage in the laboratory had transformed to the adult stage by September 17, 1920.

In the development of the larva the skins of the first three instars are cast off free of the insect, but the fourth cast skin is not ruptured at all, the larva simply shrinking away from its skin and remaining within it. Likewise the fifth skin is not ruptured but is cast off within the fourth in the same manner as the fourth is cast off. The skin of the sixth instar, however, which immediately precedes the pupal stage, is ruptured and pushed down to the posterior end of the pupa where it may be found adhering to the ventral side of the pupa within the fifth larval skin. Thus the fourth and fifth larval skins serve as a protecting case for the pupa within which the beetle finally transforms to the adult stage and from which it emerges the following spring to begin anew the life cycle of the species.

To Edward S. Reinhard we are indebted for the following interesting observations on the life-history of this beetle. On April 24, 1921, he obtained from a burrow of *Colletes inequalis* Say near Poughkeepsie, New York, a brood cell containing the larva of this beetle that had completed its fourth stage and perhaps its fifth also. At least the larva was lying free within the fourth cast skin. The beetle was removed from the brood cell of the bee but was not otherwise disturbed. On July 29, 1921, Mr. Reinhard found that this larva had broken through the wall of its protective covering composed of its cast fourth and fifth skins and was lying naked in the breeding receptacle. On August 12 it transformed to the pupal stage and on September 5 to the adult condition.

From this data obtained by Mr. Reinhard it is evident that this individual for some unknown cause failed to complete its transformations in the summer of 1920 and, consequently, passed the winter of 1920–21 in the larval condition and completed its transformations as noted above. In our investigations no case of this kind was observed.

In every case in our study of the life-history of this insect, where we followed out the transformations of the individual from egg to adult, these transformations occurred within a period of time extending from April to September, and in every case also the beetle did not rupture its protecting case composed of its cast fourth and fifth skins till it emerged as an adult insect. Whether so slight a change in the normal course of events as that caused by the removal of this individual from the cell of the bee before it had reached the pupal stage was responsible for the unusual behavior of this larva, or whether this departure from what seems to be the normal course of events in the process of development represents a return to a more primitive stage in the insect's life-history, we are unable to say.

PART 2.

MORPHOLOGY AND TAXONOMY.

A. EGG.

On page 3 an account has been given of the way in which the egg masses are distributed and cared for by *Tricrania*, the number of eggs deposited has been given, as well as the size, shape and color of the individual egg.

In the *Nemognathinae* the act of caring for the safety of the egg masses is more neglected than in the other blister beetles whose females dig a 3–5 mm. deep thimble or bell-shaped cavity in the soil and deposit one or two egg masses at the bottom of it. Thus *Sitaris muralis*, *Apalus bimaculatus*, and *Stenoria analis* lay their eggs as an uncovered pile in some little groove in the galleries of the host bee, and *Sitaris rufipes*, *Sitaris solieri*, *Nemognatha chrysomelina*, and *Zonitis bilineatus*[1] deposit their sometimes rather numerous egg masses on the leaves or stems of different large herbs. To place the egg masses under small stones or dry cow dung, as *Tricrania* does, is the simplest way recorded in this group of caring for them.

The total number of eggs laid by a single female varies much in the Meloids, ranging from about 50 in some of the species of *Zonabris* to about 2,000 or more in genus *Meloe*. The *Nemognathinae* deposit as many as *Meloe*.

The proportional size of the single egg depends on the number of eggs laid, being comparatively large, from 2–3 mm. in forms

[1] Two egg masses of *Zonitis bilineatus* were collected by A. N. Caudell, Bureau of Entomology, on underside of one leaf of *Verbesina occidentalis* growing near Fletcher's boathouse, south side of Georgetown Canal, Washington, D. C., Aug. 14, 1917. Other egg masses identical to these, from which larvae hatched Sept. 1, 1917, were collected at the same place and on the same plant species about 1½ inches from a spent female of *Zonitis bilineatus*, by H. S. Barber, Bureau of Entomology, Aug. 24, 1917. All egg masses are preserved in the U. S. National Museum.

which deposit a small amount of eggs and comparatively very small, only ½–1 mm., in forms which lay many eggs. The absolute size, of course, depends also on the size of the species.

The shape of the egg is cylindrical with both ends rounded, but it varies in the different forms from short and wide with embryo bent double, as in many species of *Zonabris*, to rather elongate with embryo straight with bent head as in all *Nemognathinae*.

Contrary to what is found in *Tricrania*, it has been recorded that in many blister beetles the same female deposits her eggs at different periods and in different places. Two, or three, or four separate ovipositions with the interval of one or two weeks frequently occur, and in the forms which oviposit on plants, the female places her eggs in several packages, each containing about 100 eggs or more. Further, it has been recorded that in several Meloids the female copulates more than once to effect two or more consecutive deposits, and the males do not die after the first copulation.

B. DESCRIPTION OF THE SIX INSTARS OF LARVA.

FIRST LARVAL INSTAR.[2]

Figs. 1–6, 9, 13, 23–25.

Length, 1—1.5 mm. Width, about 0.4 mm.

Color, head shining, ochraceous, with a black round spot surrounding the eyes; tergal shields and legs shining, sepia brown, with base of legs and hind margin of shields darker; intersegmental membranes grayish.

Setae, in general few and small; antenna, maxilla, legs and ninth abdominal segment carrying a single, or a few long or fairly long setae (macrochaetae), possibly with tactile function.

Body form, rather short, fusiform with metathorax the broadest segment; thoracic segments of subequal length; head and thorax together half the size of entire body. Medio-dorsal longitudinal suture almost fully developed on prothorax; fully developed on meso- and metathorax. Legs long; tarsus slender, conico-falciform with two rather strong setae at base. Abdomen subconical, with one short machochaeta terminally on each side of ninth segment.

Head, (figs. 3, 13) large, almost one-fifth the length of the body, length from anterior margin of head capsule to dorsal margin of occipital foramen approximately equal to extreme width. Porrect

[2] The terms "stage" and "instar" have been applied as used by David Sharp and as formulated by J. W. Folsom in his Manual, 1913, p. 128: "During the growth of every insect, the skin is shed periodically and with each moult, or ecdysis, the appearance of the insect changes more or less. The intervals between the moults are termed *stages* or *'stadia.'* To designate the insect at any particular stage, the term *'instar'* has been proposed and is growing in favor; thus the insect at hatching is *'the first instar,'* after the first moult the *'second instar,'* and so on."

and extended; subtriangular, gradually narrowing behind ocellar area toward the large, posteriorly placed foramen occipitale; collum distinct; dorsal surface convex, sloping apically and laterally. Smooth with minute, few and scattered setae.

Frons, (fig. 3) anteriorly without clypeal suture, laterally not sharply limited by distinct frontal sutures, posteriorly acute, not reaching occipital foramen; angulus frontalis not developed.

Clypeus and labrum, immovably united and fused with anterior margin of frons into a nasale.

Nasale, (figs. 3, 13) convex, shaped like an eye shade, anterior margin broadly arcuate, laterally deflexed, forming the roof above a short cylindrical, horizontal space which in size corresponds to a bee's hair; lower half of the space framed in by the mandibles when closed (fig. 4).

Epicranial halves, large, meeting dorsally along a short, not sharply defined epicranial suture, laterally and posteriorly bulging, with ocellar area almost on top. Antennal foramen (figs. 5, 13) anteriorly continuous with the foramen for the mandible; oval; length about one third of the lateral length of epicranium; ventral margin of epicranium between mandibular condyle and posterior end of maxilla oblique, about as long and extending as far back as the antennal foramen; behind the end of maxilla, longitudinal, almost straight and anteriorly with a triangular, slightly depressed enlargement.

Gula, (fig. 13) narrow, longitudinal, subrectangular, about four times as long as wide, smooth, without setae.

Ocelli, (figs. 3, 5) two on each side, anteriorly placed in the bulging lateral region of epicranium, rather distinct, with well developed lenses and surrounded by a round, blackish, pigmented spot.

Antenna, (fig. 13) slender, one fourth the length of head, distally almost reaching the anterior end of the head, three jointed, with basic articulating membrane extremely large, permitting a very free motion of the entire antenna; articulating-membrane reaching from external part of base of mandible more than half way to the ocellar spot; basal joint short, cylindrical, with width about twice the diameter of the mandibular condyle, and length about half the width; second joint cylindrical, three fourths the width of basal joint, three times as long as wide, distally and externally with a very low, round, convex supplementary appendix and a few minute setae; apical joint half as thick and almost as long as the second joint, distally with a few short setae and one macrochaeta, which is about twice as long as all antennal joints together.

Mandible, falcate, basically enlarged, gradually attenuate, strongly incurved, about half as long as the lateral outline of head from the mandibular condyle to the occipital foramen. Axis (an imaginary line) between the dorsal and the ventral mandibular articulation almost longitudinal and horizontal, hence the plane of movement perpendicular; no molar structure; inner edge from middle to apex with a series of six tooth-like transverse ridges; the position, the shape and the dentation of the mandibles enable the larva readily to seize and keep a firm hold of one of the hairs of the host by pressing it against the hollow underside of nasale (figs. 4, 24).

Maxilla, with cardo reduced (or fused with stipes). Stipes developed as an immovable, slightly convex plate, with suboval outline, framed in by the bracon, by the anterior portion of the ventral margin of epicranium, by the triangular enlargement of the epicranial margin, and by the posterior, lateral part of mentum.[3] Stipes with one small seta and one macrochaeta of same shape and extraordinary length as the terminal antennal seta. Maxillary mala single, small, semiglobose, fleshy, set with several medium long or short setae. Palpus, three jointed, almost twice as long as stipes, slender, straight, apically obliquely truncate; with few and minute setae; basal joint small, cylindrical, about as wide as mala, somewhat shorter than wide; second joint cylindrical, somewhat narrower than the basal joint, and three times longer; apical joint as long as basal and second joints together, clavate, terminally truncate, somewhat narrower than the second joint.

Submentum and mentum, fused into a single approximately pentagonal region which is broad in front, attenuate behind, and within the posterior corner marked on each side by a narrow, bow-like chitinization; anterior margin concave, as wide as labium; each anterolateral margin concave, half as long as the anterior margin; each postero-lateral margin twice as long as the anterior margin; entire region slightly chitinized, flat medianly, longitudinally depressed, probably offering a convenient resting place for the hair of the bee-host when it carries the larvae to its nest. One pair of medium long setae at middle of mentum.

Labium, a semicircular region, about one third as long as one of the maxillary stipites; posteriorly limited by a bow-shaped chitinization which carries one pair of punctures (or possibly minute setae). Palpigers chitinized; each occupying one fourth of the entire ventral labial region. Palp two-jointed, small, as long and half as wide as palpiger; basal joint cylindrical, hardly one third as long as entire

[3] A slightly chitinized narrow arm extends from the triangular enlargement of epicranial margin, passes along the posterior lateral part of mentum to the anterior free part of mentum and fuses here with the rod-like chitinous thickening, or bracon, of the buccal membrane between the ventral mandibular articulation and the hypopharynx. Thus the base of the maxilla is completely surrounded by a chitinous ring, which consists of the same anatomical elements as in the *Staphylinini* and the Melandryidae.

palp; apical joint subclavate, about two thirds of palp. Ligula short and thick, with two small setae.

Paragnathae (="Maxillulae"="Paraglossae"), not developed.

Hypopharynx, membranous.

Epipharynx, with a single granulated transverse plate, the ends of which are swollen, more heavily chitinized and rounded. The plate probably assists in keeping the hair to which the larva clings in proper and steady position during the period of transportation. Epi- and Hypopharyngeal rods, long and thin.

Bracon, present, forming a bridge in front of the maxillary stipes.

Tentorium, slender, with ventral tentorial pits immediately outside the gular sutures.

Prothorax. (fig. 3, 5) Prothoracic tergal shield subtrapezoidal, about two thirds the length of head; anterior width about the same as posterior width of head; posteriorly ¼ wider than head and more than twice as wide as the length of the segment; postero-lateral angles sharp; medio-dorsal suture fully developed posteriorly, occupying about four fifths of the length of the segment, but not reaching anterior margin of segment. Setae of shield few, minute. Prosternum not distinct, probably included in not divided sternal region. Hypopleural chitinizations distinct but small. Setae of segment scattered, minute.

Meso- and metathorax, similar in shape; metathorax slightly the larger, and also the largest of all the body segments. Tergal shield subtrapezoidal, twice as wide as long with latero-posterior angles sharp; medio-dorsal sutures fully developed; setae of shields few and minute. Hypopleural chitinizations present in both segments, but small. Sternal regions not divided. Setae of segments scattered, minute. Intersternal bands present, but not distinct.

Legs, slightly and gradually increasing in length from first to third, about one and one-half times as long as the width of the corresponding segment. Coxae widely separated, free, inclining, obconical, about twice as long as wide at base, about one-fourth the length of entire leg; without groove for the reception of femur; one long seta and a few of medium size. Trochanter distinct, shaped like a signet ring; with one seta as long as coxa and with a transverse series of small circular spots. Femur slightly longer than coxa, half as thick, elongate, slightly clavate, distal end oblique; with a few small setae and one seta as long as femur and coxa together. Tibia as long as femur, about half as thick, subcylindrical, distally somewhat attenuate, almost straight; setae rather small, scattered. Tarsus (fig. 6.) half as long as tibia, claw-shaped, slender, falcate, apically attenuate; near base of tarsus with two slender, slightly curved setae, about four-fifths as long as tarsus, distally as far from tarsal tip as proximally from tarsal base. Tarsus moved by a flexor and a retractor, (m_1 and m_2, fig. 6) but no muscles attached to the two setae at the base.[4]

First to seventh abdominal segments, with tergal shields subtrapezoidal; first abdominal segment about four times wider than long; segments gradually decreasing posteriorily in length and width; seventh abdominal segment about half as long and not much more than one-fourth as wide as the first one; latero-posterior angles of tergal shield in all segments almost rectangular, carrying a short terminal seta.

Eighth abdominal segment, subquadrate. From posterior margin of the tergal shield one pair of falciform, distally attenuate, flat processes extends backward about as far as the segment is long; they are diverging, their convexities opposed, at base as far apart as half their length and distally twice as far or more; each is adjacent to the inner and upper side of an equally long but somewhat wider and conical hook, which projects slightly below the falciform process. Apically and facing the process each hook carries the annular peritreme of the eighth abdominal spiracle, and inwardly contains the elongate, ovoid spiracular atrium (fig. 2). Undoubtedly the object of these structures is to facilitate the breathing under extraordinary and difficult conditions. The function of the adjacent processes may possibly be that of holding a supply of air between themselves and the ends of the hooks to prevent water from penetrating into the tracheal system at the period when the larva is free living in the field (see p. 5). Later on, when the larva has invaded the cell of *Colletes*, the air supply may prevent honey from obstructing and clogging the spiracular opening, if accidentally the larva should become temporarily submerged.[5]

Ninth abdominal segment, cylindrical, two-thirds as wide, twice as long as the eighth abdominal segment; terminally on each side, with one rather short macrochaeta of same length as the segment.

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[4] These setae in the Meloid larvae have been interpreted and termed as "claws" by most authors; but erroneously, because true claws, as developed for instance in Carabid larvae, are provided with individual muscles.

[5] The interpretation of the object of the hooks and processes, given by Fabre, Mayet, and Beauregard, who consider them as locomotory and grasping organs, has already been abandoned by Cros in several of his masterly papers, for instance on page 59, in his study on *Nemognatha chrysomelina* (Bull. Soc. Hist. Nat. Afrique du Nord, vol. 10, 1919). Cros calls the organs "appareil respiratoire erectile dorsale" and probably looks upon their physiology and use as here described. He has, however, avoided proposing any definite theory on this subject, unless such is found in his study on *Hornia nymphoides* (Bull. Soc. Hist. Nat. Afrique du Nord, vol. 5, 1913), which is not available to the present writers. To this study Cros refers in his "Larves primaires des Meloidae," (Ann. Soc. Ent. France, 1919, p. 262) as follows: "In my paper on *Hornia nymphoides* Escal., I have discussed at great length the structure and the functions of these organs to which J. H. Fabre has assigned, but by no means proven, the rôle of fixation and locomotion; in reality they are but modified spiracles."

When Cros mentions the organs as "erectile," the present writers must admit that they never have been able to see them make actual motions.

Tenth abdominal segment, terminal, cylindrical, almost as long as ninth, one-third narrower; anterior half slightly chitinized, and posterior half membranous with round anal opening.

Spiracles, annular; one thoracic and eight abdominal pairs. The thoracic spiracle, in the mesothoracic preepipleurum, about as large as tibia in cross section. The first seven abdominal spiracles placed in the middle of the ventral surface of the lateral expansions of the tergal shields. The eighth abdominal spiracle on top of the spiracle bearing hook. The first abdominal spiracle as large as the thoracic one; the rest much smaller and rather minute (fig. 1).

Spinning glands on ninth or tenth abdominal segments not found, but microtomical sections have not been made; the first instar, however, has been observed by the present writers (see p. 6) to spin a thread, lowering itself with head turned downward, but it was not definitely determined from what part of the body the thread originated; possibly it is an exudation from the malpighian tubules and comes out through the anus.

Differentiating characters.—The genus *Tricrania* belongs to the subfamily *Nemognathinae*, as borne out by the biological and morphological characters of both imago and the six larval instars. The first instar of this subfamily is always carried by a bee-host to its nest. It has spiracle-bearing elevations on the dorsal side of the eighth abdominal segment, a head with labrum, clypeus and frons fused together, two ocelli on each side and dentate mandibles which move in a plane transverse and vertical to the body; tarsus, as a rule, is conicofalcate and ninth abdominal segment has either two fine and short caudal setæ, or none.

In this subfamily the first instar of genus *Hornia* is distinguished by mandibles with seven or eight teeth; *Hornia minutipennis*, also by low, rather soft spiracle-bearing elevations on eighth abdominal segment. First instar of *Stenoria* has spathulate tarsus and both tarsal setae almost as long as tarsus itself; it approaches *Tricrania* closely by possessing six teeth on the mandible, all the rest of the genera of the *Nemognathinae* having but two or three teeth. *Sitaris* and *Apalus* have fine and short tarsal setae. *Nemognatha*, *Zonitis*, *Leptopalpus*, and *Sitarobrachys* which are well limited from all the other genera by having the sixth instar adherent to the exuvium of the fifth instar are not easily characterized as a group by their first instars. In *Nemognatha* first instar is without caudal setae, the medio-dorsal suture is present on all thoracic segments and continued on the head into the epicranial and frontal sutures, and the tarsal setae are two and almost as long and strong as tarsus. In *Zonitis bilineatus* the spiracle bearing hooks are short and distant, and this character applies according to Cros' description, also to the genus *Leptocephalus*, but in all the old world species of *Zonitis*, investigated by Cros, the hooks are found normal in size and position. In *Leptopalpus*, *Nemognatha*, and *Sitarobrachys* the tarsal setae, one or two in number, are always weak.

SECOND LARVAL INSTAR.

Figs. 7, 8, 14, 26, 27.

Length immediately after first moult, 2.25 mm.; before second moult, 2.75 mm. Width after first moult, 0.5 mm.; before second moult, 1.2 mm.

Color, whitish. All segments soft.

Setae, none, but body densely set with minute, pointed asperities.

Body form, in the beginning of the stage rather slender and spindle shaped with comparatively long legs stretched out like oars, later on distended, more ovate, dorsally flat and ventrally very convex (figs. 26, 27). Thoracic segments of about equal length; prothorax much narrower than mesothorax and the latter slightly narrower than metathorax. Ten distinct abdominal segments; first to third abdominal segments the largest. Spiracles located on the flat dorsal surface at a short distance in from its lateral margin, freely exposed to the atmosphere and permitting easy and safe breathing. Below the wide overlip fleshy and supple mouth parts work as exquisite tools of the gluttonous larva.

Head, porrect and extended; length from free margin of labrum to occipital foramen almost one-eighth of entire body length. Width of head about the same as the length. Form of head, with labrum included, quadrate-rotundate; anteriorly rounded, sides straight and parallel, posterior corners rounded. Short collum. Occipital foramen wide, broadly oval and posterior. Dorsal and ventral surfaces of head capsule slightly convex and smooth.

Frons (fig. 7), rather distinct, posteriorly rounded, not reaching the occipital foramen. Frons and clypeus fused.

Labrum, large, immovable but separated from clypeus by a fine line; shaped like an eyeshade, covering the other mouth parts completely.

Epicranial halves, dorsally meeting along a well-developed epicranial suture.

Antennal foramen, anteriorly continuous with mandibular foramen; almost circular, diameter about one-fourth the length of the epicranium from mandibular condyle.

Hypostomal margin between mandibular condyle and posterior end of maxilla (fig. 14), transverse, semicircularly emarginate.

Margin between end of maxilla and occipital foramen, fused with intermediate gular region.

Gular region, longitudinal, subrectangular, about three times as long as wide.

Optic spot, horizontal, dorso-lateral, blackish pigmented and reniform; length about equal to diameter of antennal foramen; ocelli not distinguishable by the presence of lenticular convexities.

Antenna, thick and conical, about one-eighth the length of head, distal end not reaching middle of mandible, three jointed with basal membrane well developed; basal joint cylindrical, about half as long as wide, diameter about three times as long as diameter of mandibular condyle; second joint cylindrical, about half as wide as basal joint, somewhat shorter than wide; supplementary appendix very small; a few sensorial papillae; apical joint papilliform, pointed, as long as second joint and one-fifth as wide; no macrochaeta.

Mandible, rather soft, almost equilateral, triangular, length and width about equal. The exterior side-margin half as long as head from mandibular condyle to occipital foramen; axis between dorsal and ventral articulations approximately perpendicular to the length of the body, hence mandibles operate horizontally; terminal third part of mandible slightly set off from the rest, with inner margin obliquely truncate, somewhat concave, and minutely serrate; rest of mandible flat, broad, without molar portion or any other particular structures.

Maxilla, free, protracted, fleshy, subcylindrical, twice as long as wide, palpus not counted. Stipes indistinctly divided into a distal and a proximal part of equal size.[6] Cardo absent, or more probably fused with the proximal part of stipes. Mala single, low and indistinct, fleshy and without spines or long setae. Palpus three jointed, short, one-fourth the length of the entire stipes, thick and conical; the joints are in shape and proportion similar to the antennal joints.

Mentum (possibly including submentum) and Stipites labii, fused into a free, thick, fleshy, subcylindrical organ which acts like a spoon; it is twice as long as wide, and as long and one-fourth as wide as one of the stipites maxillae.

Labial palp, two jointed, same size as the two combined terminal joints of the maxillary palp.

Ligula, indistinct.

Paragnathae (=Maxillulae=Paraglossae), not developed.

Hypopharynx as well as the anterior portion of the floor of the buccal cavity, fleshy, soft and covered with fine pubescence.

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[6] An interpretation of these maxillary components as being stipes and cardo might be possible. Such an interpretation, however, does not present itself as quite so valid as the one given above because it does not concur with the maxillary development in the first instars of Meloid larvae of the more unchanged types, like *Zonabris*. Neither would it agree with the interpretation given below of the maxillary parts in the third and fourth stages. Briefly expressed, the maxilla of the second instar of a Meloid larva seems more comparable to the maxilla of a Carabid larva as *Amara*, than to the maxilla of a Staphylinid larva like *Philonthus* or *Ocypus*.

Bracon and Tentorium, not observed.

Prothorax, without shield, subtrapezoidal, somewhat shorter than head, anteriorly not wider than head, posteriorly about twice as wide, postero-lateral angles obtuse; presternum not distinct; no hypopleural chitinizations; sternal regions simple.

Meso- and metathorax, same general shape and development as prothorax, but wider; metathorax the widest thoracic segment.

Legs, inserted widely apart, of ambulatory type, but weak and not fitted for walking, all of about the same medium size; in the young second instar, about half as long as posterior margin of metathorax, in the full fed and wider larva, proportionally shorter. Coxa free, with length about one-fourth the entire length of the leg, and twice as wide as long. Trochanter well developed, ring-shaped. Femur subcylindrical, about as long as coxa, about one-third as wide as long. Tibia same length as femur, slightly narrower, conico-cylindrical. Tarsus claw-shaped, triangular, somewhat curved, about twice as long as the width at base.

First to third abdominal segments, subequal in length, each segment as long as one of the thoracic segments; transverse, subrectangular, four times as wide as long; second abdominal segment slightly wider than the two others and also wider than metathorax. Fourth to eighth abdominal segments, of about same individual length as previous segments; in the young second instar the segments decrease gradually but considerably in width, measuring from about as wide as third abdominal segment to one-fourth as wide; but in the full-grown instar the segments decrease less in size, the eighth segment being about half as wide as the third. Ninth and tenth abdominal segments, rather small, about equal in length, and each about half as long as the eighth abdominal segment; in the young second instar the ninth and tenth segments are about as wide as long, but in the mature instar the ninth and tenth segments are respectively three times and twice as wide as long.

Anus, terminal. Anal slit rather well developed, vertical and ventrally bifurcate.

Spiracles, annular, one mesothoracic and eight abdominal ones present. All of about same size, rather small, about as wide as second antennal joint.

Differentiating characters.—Second instar in all *Nemognathinae* stays in the same bee-cell into which it was carried as first instar and feeds on the honey; it liberates itself completely from the exuvium of first instar. The head capsule, mouthparts, and body are thinly chitinized and rather soft in all genera of the subfamily and prothorax is always without prothoracic shield, but the shape of the body varies somewhat, from ovate-fusiform and straight to subcylindrical and slightly curved. However, it does not seem possible to find any definite character by which the second instars of the different genera of *Nemognathinae* can be separated.

THIRD LARVAL INSTAR.

Figs. 28, 29.

Length of larva immediately after second moult, about 3 mm.; before third moult, about 5.5 mm. to 6 mm. Width after second moult, about 1 mm.; before third moult, about 2 mm.

Color, whitish.

Setae, very few and short on head parts and legs; body set with dense, minute asperities.

Body, very similar to that of second instar, soft, thick, straight, subovate, a little more fusiform than in the mature second instar, but like this instar dorsally flat, ventrally convex and built for floating on the surface of the honey-paste which gradually becomes harder and more solid.

Head, seminutant; at first large in comparison with rest of body, that is, as wide and twice as long as prothorax; later on in fully fed larvae only of moderate size, the body having grown immensely, the head but slightly, and in this last period of the third stage the width of head in comparison with the width of prothorax is as one is to one and one-half, and the lengths of the two structures are about equal.

Head capsule, slightly chitinized; nasale not fully as large as in the second instar; ventral side of head capsule transverse and shaped like a dumb-bell; gula short with posteriorly converging sides.

Ocellus, represented only by a small round point of dark pigment.

Antenna, more cylindrical than in second instar.

Mandible, broad, triangular, with chitinous, finely denticulate tip and with chitinized ventral condyle; tip of mandible reaching somewhat beyond the nasal margin.

Maxilla, retracted, well developed, very slightly chitinized, the different maxillary parts a little more slender, more distinct and more individually movable than in the second instar.

Labium, free.

Thorax, occupying about one-fourth or less, of body.

Legs, three pairs, of same shape as in second instar but comparatively smaller in proportion to rest of body, not well fitted for locomotion.

Abdominal segments, 10; the four anterior ones widest.

Spiracles, dorsal, annular, very large, all of same size, the eighth abdominal pair apparently not developed.

The anatomical details of the head and the rest of the body are similar to those of the following fourth larval instar, only smaller. To avoid identical descriptions of these details in the two instars they will be recorded only for the fourth larval instar in which they are more easily seen and investigated.

Differentiating characters.—The third instar in the *Nemognathinae* has been recognized by very few authors as representing a definite stage. Cros, however, has recorded it in most of the genera of the subfamily and Beauregard [7] has given a rather full description of it in *Sitaris muralis* Foerster. In all the genera it seems to be identical; not a single distinguishing difference has been found, be it in habits, size, or shape.

FOURTH LARVAL INSTAR.

Figs. 10, 15, 16, 30, 31.

Length of larva, immediately after third moult, about 7 mm.; before fourth moult, about 12 mm. Width, after third moult, about 3 mm; before fourth moult, about 5 mm.

Color, pale cream; chitinizations light brownish.

Setae, fine and short on head-parts and legs; body densely set with fine asperities (fig. 10).

Body, soft, fusiform-ovate, with both dorsal and ventral surfaces convex. Epipleural areas large, but not forming a swollen lateral ridge. Prothorax, dorsally slightly longer than either of the two other thoracic segments and carrying a pair of light brownish chitinous patches corresponding to a tergal shield.

Head, seminutant, extended, with head capsule and appendices thinly chitinized, but slightly thicker than in third instar.

Head capsule, dorsally about 1 mm. long; length and width almost equal; developed as in third instar; dorsal and ventral surfaces slightly convex and smooth.

Frons, indistinct; laterally fused with epicranium, anteriorly with clypeus.

Labrum, rather short and broad; immovable, posteriorly distinct, but almost fused with clypeus. Antennae, maxillary palps and distal part of mandibles projecting in front of its anterior margin. Setae short, mostly set along the free anterior margin.

Epicranial halves, fused dorsally, no median epicranial suture; antennal and mandibular foramina combined, about one-third the length of cranium from the mandibular condyle.

Hypostomal margin between mandibular condyle and posterior end of cardo, oblique and very concave, half as long as side of cra-

[7] Insectes vésicants, p. 341.

nium. Margin between cardo and occipital foramen convex, separated by a well defined suture from intermediate gular area.

Gular area, almost fan-shaped, broad in front, attenuate behind: anterior margin convex; lateral margins concave; anterior and lateral margins of about same length, and equal to that of the hypostomal margin.

Optic spot, dorso-lateral, reduced to a blackish pigmented point, placed behind the antennal foramen in a distance that is almost equal to the length of the basal antennal joint.

Antenna, conico-cylindrical, distal end reaching about to the anterior third of the mandible; basal membrane large; basal joint largest and about as wide as long; second joint half as long and somewhat narrower; apical joint very small and carrying a minute seta; supplementary appendix minute; sensorial papillae few and minute; medium-long setae at the base of basal and second joints.

Mandible, triangular, with length and width about equal, exterior lateral margin about as long as the hypostomal margin; axis between the dorsal and ventral mandibular articulations almost perpendicular to the dorsum of the body. Terminal third heavily chitinized, triangular, with inner surface somewhat concave; edge serrate. Median part of mandible thinly chitinized, light colored, wide and with inner margin very convex. Basis and particularly the ventral condyle heavily chitinized and dark.

Maxilla, free, protruding, slightly chitinized, rather slender, three times as long as wide (palpus not counted), divided into two almost equal parts; the posterior part probably formed by a fusion of a proximal section of stipes and the cardo; the anterior part is a distal section of stipes. Mala single, fleshy and rounded, with short setae. Palpus three-jointed, somewhat shorter than the distal section of stipes; rather slender, conico-cylindrical; the joints almost equally long, apical joint about one-third, and second joint about half as wide as the basal joint; short setae on all joints; tactile palpillae on tip of apical joint.

Submentum, transverse, anteriorly convex with median incision, posteriorly concave.

Mentum, transverse, trapezoidal, about twice as wide as long, broadest anteriorly.

Stipites labii, fused; the joint formation transverse, anteriorly and medianly somewhat incised, as wide as posterior margin of mentum; no distinct palpiger. Labial palp two-jointed.

Ligula, absent.

Paragnathae, not developed.

Bracon, indistinct but present.

Tentorium, not observed.

Prothorax, subtrapezoidal, before moult with posterior margin medially almost effaced. On each side of middle line of tergum with one light brownish, subtriangular plate, about half as large as ventral side of epicranium. Prothorax somewhat longer than and about twice as wide as head. Hypopleural chitinization small and linear.

Meso- and metathorax, subtrapezoidal; in first period of stage somewhat shorter, in last period somewhat longer, than head. Posterior width of mesothorax in proportion to its length, as three to one, of metathorax as four to one. Epipleural area large, not distinctly separated from tergum. Hypopleural chitinizations small and linear, same size as in prothorax. Sternal region simple.

Legs, inserted widely apart; ambulatory type, but small and unfitted for locomotion. All of same size, about as long as side of head-capsule from base of antenna backwards. Coxa large, conical, with oblique base, about one-third of the length of the entire leg and somewhat longer than the mandible. Trochanter well developed. Femur subcylindrical, a little shorter than coxa, about half as wide as long. Tibia conico-cylindrical, almost as long as femur, but somewhat narrower. Tarsus short and claw-shaped.

Abdominal segments, with dorsal and ventral sides convex; laterally with large, but not protruding or ridge-forming epipleural areas; ventro-lateral suture not sharp in the last period of the stage. First to seventh abdominal segments alike: third and fourth segments somewhat wider than others; abdomen tapering anteriorly, and still more posteriorly toward the terminal complex of the eighth to tenth abdominal segments, which together form a cone of equal length and width. Tenth segment not much shorter than the ninth.

Anal opening, perpendicular, ventrally bifurcate.

Spiracles, placed dorsally, annular; one mesothoracic and seven abdominal, extraordinarily large, gradually decreasing somewhat in size posteriorly; seventh abdominal spiracle about half as wide as the anterior spiracles: eighth abdominal spiracle very minute.

Differentiating characters.—The fourth instar is known in more Meloid genera than the third, partly because the third stage has been overlooked or not recognized as a distinct stage, different from the fourth, partly because the cast skin of the fourth instar either is attached to the end of the fifth instar as in *Zonabrini*, *Epicautini*, and *Lytini*, or partially envelops it, as in the *Meloini*, or completely surrounds it as in all the *Nemognathinae*, and this fifth instar is more easily and frequently found than the previous instars.

The genera of the subfamily *Nemognathinae* of which the fourth instar is known are: *Hornia*, *Allendesalazaria*, *Stenoria*, *Sitaris*, *Apalus*, *Sitarobrachys*, *Leptopalpus*, *Zonitis*, and *Nemognatha*. In most of these genera the instar does not need to change from one cell to another as the content of honey in one cell is large enough to supply the parasite with food for its whole feeding period; it therefore remains as in *Tricrania* in the same cell in which it has been parasitizing during the preceding stages; but in *Zonitis* and, according to Cros, probably also in *Nemognatha* the fourth instar leaves its first cell and enters another, devouring the whole content, bee-larva as well as honey, before it changes into fifth instar. The fourth instars of the two last genera are characterized by small but distinct spiracles on the eighth abdominal segment, all the other genera possessing either minute eighth abdominal spiracles, as *Sitaris*, or apparently none, as *Apalus*. In *Nemognatha* the instar is described by Cros as very curved ("fortement curvée en arc"), in the other genera it is fusiform-ovate as in *Tricrania*.

The chitinizations, present on the prothoracic tergum in *Tricrania*, are not developed in all genera, for instance not in *Apalus* and *Sitaris;* in *Hornia*, on the contrary, a complete, rather large, but thin prothoracic shield is present.

FIFTH LARVAL INSTAR.

Figs. 11, 17, 18, 32, 34.

Larva inclosed in and entirely surrounded by the unbroken and not shed exuvium of fourth instar.

Length of larva, about 10.25 mm.; width, about 4.25 mm.; consequently smaller than the previous full-grown instar.

Color, yellowish.

Setae, none; body covered with fine asperities.

Body, with thin, pellucid but rather rigid skin; almost regularly ovoid, dorsally and ventrally convex, ventrally slightly flatter; mouth parts and legs very reduced and tuberculiform; segments plainly indicated; main areas distinguishable, terga transversely divided into two folds, epipleural areas not forming any continuous lateral ridge above the distinct ventro-lateral suture; ninth and tenth segments rather short, flatly rounded; anus oval, facing downwards.

Head, nutant, somewhat retracted, vaguely formed. Head-capsule transversely oval; length medio-dorsally about 1 mm., slightly shorter than in fourth stage; laterally only half as long as in fourth stage; width the same in both stages, about 1 mm.; ventral side behind the ventral mouth parts very short, developed as a transverse, narrow, laterally somewhat enlarged band. Dorsal and ventral surfaces of head slightly convex.

Antenna, mandible, maxilla and labium, short, thick, tuberculiform, without segmentation, recognizable only by their relative positions.

Ocellus, merely represented by a single, transverse dash of dark pigment, somewhat larger than in fourth stage.

Legs, represented by three pairs of low, broad, poorly segmented tubercles.

Spiracles, dorso-lateral; the mesothoracic and first seven abdominal ones somewhat salient and cupuliform, all alike and of medium size; the metathoracic and eighth abdominal spiracles present but minute.

Differentiating characters.—The fifth instar is found in the same comparatively large number of genera of the subfamily *Nemognathinae* as is the fourth. In all of these the instar is completely enveloped by the unbroken exuvium of fourth instar, but the shape of the body and the texture of the surface is somewhat variable.

In *Hornia minutipennis* Riley, the instar is curved, subovate, with distinct segmentation, shining, thin skinned, rather soft and gradually becoming shrunken and almost triangular prismatic; however, it recovers its original swollen shape before the transformation into the next stage. Mouth parts and legs less reduced than in *Tricrania*, *Stenoria* (*analis* Schaum), and most others.

In *Stenoria*, *Apalus*, and *Sitaris* the instar is straight, ovoid, with shining skin; in *Stenoria* rigid and never deformed, in *Apalus* and *Sitaris* soft and periodically triangular prismatic as in *Hornia.*

In *Zonitis* and *Nemognatha* the larva is curved, almost regularly cylindrical with bluntly rounded ends, rigid and, seen from the side, velutinous due to the development of short hairs on the finely shagreened skin; body opaque. Skin of sixth instar in these two genera adherent to the inside of the skin of the fifth. In *Sitarobrachys*, which possibly belongs near *Zonitis*. the surface is shining as in *Stenoria.*

All *Nemognathinae* have one pair of mesothoracic and seven pairs of abdominal spiracles, all well developed, of medium size or larger; the eighth pair of abdominal spiracles vestigial; the comparative size both of the normal and vestigial spiracles somewhat varying according to the different genera; thus the normal spiracles are smaller in *Tricrania* than in *Hornia* (*minutipennis*) but in both much smaller than in *Stenoria* (*analis*); on the contrary the vestigial eighth abdominal pair is smaller in *Stenoria* than in the two other genera.

SIXTH LARVAL INSTAR.

Figs. 12, 19, 20, 32, 35.

Sixth instar inclosed in, but not adherent to, the unbroken and not shed exuvia of the fifth and fourth instars.

Length of larva, about 10.25 mm. Width, about 4.25 mm.

Color, pale cream.

Setae, few and short; body densely set with fine asperities.

Body, ovate, ventrally slightly less convex than dorsally; eighth, ninth, and tenth abdominal segments short, together forming an obtusely rounded, downward-bent end of body, and not, as in fourth instar, an attenuate, straight and conical one; anus round, facing obliquely forward, not posteriorly as in the fourth instar; segments distincly limited, with most of the segmental areas distinguishable, not effaced as in fourth instar, but more similar to the conditions of the fifth instar; tergal areas transversely divided into two folds; epipleural areas rather large with epipleural lobes round and distinct, not forming a continuous lateral ridge above the ventro-lateral suture; this latter is sharply set off; ventral areas all represented. Legs, three pairs of equal size, as long as in fourth instar, but much thicker, soft, not fitted for locomotion; femur and tibia distinct; tarsus less so; coxa indistinct and trochanter lacking.

Head, rather large and flat, nutant and directed backward, somewhat retracted; head-capsule and appendices obese but distinct, very similar to the same structures in fourth instar; all soft, except tip and condyle of mandible, which are darkly chitinized.

Head-capsule, dorsally with slightly convex surface and rounded outline; length, about 1 mm.; width, 1.25 mm.; ventral side, behind maxillae and submentum, very short, medianly about 0.12 mm. long, half as long as in fourth instar and much shorter than in second instar; lateral side of head about 0.75 mm. long.

Frons, small, anteriorly wide, posteriorly attenuate, lateral margins convex, rather distinctly set off from epicranium by frontal sutures; also a definite indication of a fronto-clypeal suture; separated from foramen occipitale by a distance about half as long as the frontal area itself.

Clypeus, large, anteriorly about half as wide as posteriorly, lateral margins convex.

Labrum, transverse, subtrapezoidal, with almost straight anterior margin; the mandibles, maxillae and labium, but not the antennae, projecting in front of labrum.

Epicranial halves, large, laterally and posteriorly rounded, medianly meeting along well developed epicranial suture; hypostomal margin very concave, half as long as side of cranium; margin between cardo and foramen occipitale short.

Gular area, short, half as long as in fourth instar, somewhat similar in shape; laterally limited by two gular sutures.

Ocellus or pigmented optical spot, absent.

Antenna, conical, distally extending over posterior third of the mandible, three jointed, basal joint much larger than in fourth instar, somewhat longer than the two other joints together, about as wide as long; apical joint small; supplementary appendix same size as apical joint. A few setae on all joints.

Mandible, triangular, with about equal length and width. Imaginary axis between dorsal and ventral articulations located as in fourth instar. The tip and the condyle slightly harder than the rest, but not well chitinized as in fourth instar; the tip also much shorter and its inner surface less developed than in that instar.

Maxilla, free, protruding, turgid and plump, about as wide as long (palpus not counted). Stipes divided into a distal and proximal part; the distal part with rounded fleshy setose mala, and short, thick, conical three-jointed palpus. Basal, second, and apical palpal joints somewhat smaller than the corresponding antennal joints, but of same shape and relative proportions; short setae on all joints.

Submentum, mentum, and stipites labii, with two-jointed labial palps, very similar to the same structures in fourth instar.

Ligula, absent.

Thoracic and abdominal segments, similar in size and development to the corresponding features of fifth instar.

Legs, short, thick, conical, protruding, and immovable; with same general appearance but larger than antennae. Coxa indistinct, flat and wide. Trochanter not developed. Femur rather distinct, conico-cylindrical, short, three times as wide as long. Tibia, like femur, rather distinct, subcylindrical, as long as femur, but considerably narrower. Tarsus indistinct, very short, apically rounded without claw-like end.

Spiracles, lateral, circular, of medium size; development and size as in fifth instar; one mesothoracic and seven abdominal pairs present; seventh abdominal pair somewhat smaller than rest; eighth abdominal pair wanting.

Differentiating characters.

The sixth instar is known from the same genera of the *Nemognathinae* as are the fourth and fifth instars. In all of these genera the sixth instar rests inactive inside the unbroken exuvia of the two preceding instars. In *Zonitis* and *Nemognatha* the integument adheres to the inner wall of the skin of the fifth instar and is not shed by the pupa, but surrounds it completely together with the two previous exuvia: in the other genera it is free, is shed by the pupa, pushed backwards, and found attached to the end of the pupal abdomen.

C. PUPA.

The process of the pupation inside a capsule formed by the exuvia of the fourth and fifth larval instars, has been described in Part 1. During the moult, the exuvium of the sixth instar opens along the back, is slowly moved behind by contractions of the young pupa, and pushed together into a little flat mass or pellicle, which is loosely attached to the end of the pupa. This pupa is pale yellowish, completely glabrous, and has a swollen abdomen. It does not differ in any respect from the pupae of

Sitaris and *Stenoria*, figured and described by Valéry Mayet and Beauregard, nor from the pupa of *Hornia* which, according to Riley is like that of *Sitaris*. Therefore a detailed description is considered unnecessary.

A different pupal type with slender abdomen and hair or spines on the dorsal side of the head and the posterior margins of prothorax and abdominal segments is characteristic for *Meloid* with errant fourth larval instar and with the pupa developing in the ground, for instance the genera *Zonabris*, *Cerocoma*, *Epicauta*, *Macrobasis*, *Lytta*, and several species of genus *Meloe*.

FIG. 1.—TRICRANIA SANGUINIPENNIS SAY. PUPA WITH EXUVIUM OF SIXTH INSTAR ATTACHED TO POSTERIOR PART OF BODY.

D. IMAGO.

The genus *Tricrania* LeConte has been divided into two genera by Wellman,[8] namely, the old genus *Tricrania* LeConte s. str. with *Tricrania sanguinipennis* Say as the type species and *Tricraniodes* Wellman with *T. stansburii* Haldeman as type species. The genus *Tricrania* s. str. is characterized as follows:

Body rather hairy. Head triangular. Labrum small, short, and triangular, anteriorly rather obtuse. Mandible long, strong, projecting, armed with a low, almost obsolete tooth below the middle of the inner edge. Maxilla with stipes proper, subgalea, the lacinia-carrying intermaxillare and lacinia itself amalgamated into a single piece; maxillary palp with apical joint distally obtuse, a little longer than the following joint. Labium small. Antenna serrate; antennal joints obconical, slightly compressed. Head and thorax slightly narrower than the base of the elytra. Hind wings absent. Tarsi rather robust; those of the anterior and middle legs about as long as their tibiae; tarsus of hind leg not more than two-thirds of the length of tibia. Tarsal claws double, with a pectinate and thicker upper portion, and an equally long, simple, and bristle-shaped lower one; upper portion distally with a single, proximally with a double row of short teeth.

According to Wellman *Tricraniodes* differs from *Tricrania* by possessing hind wings and by having a single row of long, regular teeth both distally and proximally on the upper portion of each double claw.

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[8] Wellman, C.—On the classification of the Lyttidae, Ent. News, vol. 21, 1910, p. 219.

The first description of the present species *Tricrania sanguinipennis* is by Say, who treats it under the name of *Horia sanguinipennis*. It is as follows: [9]

Body black; elytra sanguineous, immaculate. Inhabits Pennsylvania. Body short, robust, deep black, scabrous, with dense punctures; head lobate at the basal angles, with a slightly elevated longitudinal, glabrous line on the front; antennae impunctured; third joint as large or larger than the first; terminal joint acuminated from its middle; mandibles glabrous and with the palpi impunctured; thorax transverse-quadrate, very obtusely rounded behind; scutel conspicuous, rounded behind, punctures more minute than those of the thorax; elytra very flexible, sanguineous, immaculate; feet punctured (nails denticulated on the middle, tip, and base simple).[10] Length more than two-fifths of an inch.

SYNOPSIS OF THE TRIBES AND GENERA OF SUBFAMILY NEMOGNATHINAE.[11]

The following synopsis, given in the form of a key, summarizes the contents of the above-given descriptions of the egg, larval, and pupal stages of *Tricrania* and the comments on the corresponding stages of other genera of *Nemognathinae*. The key is based, partly on the present authors' personal examinations of the North American and some of the European species, partly on the texts and figures of other authors, but especially on Cros' very important publications about European and African forms.

The sequence in which the tribes and genera are arranged in the key expresses our conception of their natural grouping.

CHARACTERIZATION OF SUBFAMILY NEMOGNATHINAE.

The subfamily *Nemognathinae* is differentiated from the other members of the family *Meloidae* by the following characterization:

FIRST INSTAR: Head subtriangular or subcordate, labrum fused with head capsule into a nasale which is hollowed longitudinally on ventral surface. Epicranial margins behind ends of cardines, parallel or posteriorly converging. Gular area distinct.

Ocelli two on each side, sometimes close together.

Mandibles not projecting in front of labrum; axis between fossa and condyle of mandible, horizontal and mandible consequently moving in a vertical plane; with from 2 to 8 distinct teeth.

Labial palp two-jointed.

Thorax about of the same size as abdomen.

Tarsus, except in *Stenoria* in which spathulate, slender and conico-falcate, with one or two either small and fine, or long and strong setae laterally at base.

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[9] Journ. Acad. Nat. Sci., Philadelphia, vol. 3, 1823, p. 279.

[10] Say's description of the claws is not correct; compare the generic description above.

[11] The term "*Nemognathinae*" takes here the place of the more commonly used "*Zonitinae*," which has long been applied to a subfamily of Mollusca; see T. D. A. Cockerell, Ent. News, vol. 21, 1910.

Ninth abdominal segment with or without two, fine, short caudal setae.

First abdominal spiracle about as large as the mesothoracic spiracle and much larger than rest.

Eighth abdominal tergum with spiracle-bearing chitinous hook, or a low, soft elevation.

SECOND, THIRD, AND FOURTH INSTARS: Body ovate or cylindrical, often slightly or, in *Nemognatha*, strongly curved.

Head-capsule and mouthparts thinly chitinized.

Prothorax, never with strongly chitinized shield.

FIRST, SECOND, AND THIRD EXUVIA shed. FOURTH AND FIFTH EXUVIA not shed; fifth instar covered with one exuvium and sixth instar with two closed exuvia.

SIXTH EXUVIUM completely shed, except in tribe *Nemognathini* in which it is adherent to inside of exuvium of fifth instar.

FIRST TO SIXTH INSTARS parasitizing on bees, feeding on the egg and honey of a single bee cell or, in the *Nemognathini*, feeding on the contents, egg, larva, and honey of two cells.

FIRST INSTAR carried by bee host; attached to bee hair by mandibles alone.

FOURTH INSTAR always sedentary.

KEY TO TRIBES AND GENERA.

1. FIRST instar with mandible carrying 6 to 8 teeth. SIXTH instar not adherent to fifth exuvium. SIXTH exuvium shed ---------- 2

   FIRST instar with mandible carrying 2 to 3 teeth. SIXTH instar either not adherent or adherent to exuvium of fifth instar ---------- 5

2. FIRST instar with mandibles carrying 7 to 8 teeth; anterior nasal margin obtuse, almost truncate; head comparatively short and broad; tarsus conico-falcate, long and slender with two, not equally long, slender tarsal setae, none of which are as long as tarsus; spiracle-bearing elevation either short or well developed. FIFTH instar with thin skin; gradually becoming triangular-prismatic ---------- 3

   FIRST instar with mandible carrying 5 or 6 teeth; anterior nasal margin subconical, not truncate; head comparatively elongate; medio-dorsal suture on thoracic segments varying; tarsus variable in form, always with well developed tarsal setae; spiracle-bearing elevation well developed, and as long as ninth abdominal segment. FIFTH instar more or less rigid; never deformed ---------- 4

3. FIRST instar with mandible with 8 teeth; spiracle-bearing elevation low, rather soft, much shorter than length of ninth abdominal segment; one well developed, almost ventral tarsal seta; medio-dorsal suture on all thoracic segments complete; one pair of fine and very short caudal setae ---------- **SITARINI-HORNIIDES.**
   Genus Hornia.

   FIRST instar with mandible with 7 teeth; spiracle-bearing elevation well developed and hook-shaped ---------- **SITARINI-HORNIIDES.**
   Genus Allendesalazaria.

4. FIRST instar with spathulate tarsus; both tarsal setae almost as long as tarsus ---------- **SITARINI-STENORIIDES.**
   Genus Stenoria.

   FIRST instar with conico-falcate tarsus; tarsal setae somewhat shorter than tarsus ---------- **SITARINI-TRICRANIIDES.**
   Genus Tricrania.

5. FIRST instar with two fine and short tarsal setae; spiracle-bearing hook well developed; caudal setae present. FIFTH instar ovate, smooth and soft skinned, gradually becoming deformed and almost triangular-prismatic. SIXTH instar free; exuvium of sixth shed.......... **SITARINI-APALIDES.**
Genera Sitaris and Apalus.

FIRST instar either with fine and short tarsal setae and spiracle-bearing hook shorter than half the length of eighth abdominal segment, or with strong and long tarsal setae and spiracle-bearing hook well developed, about as long as eighth segment. FIFTH instar, except in *Sitarobrachys*, finely shagreened and set with fine minute hairs, opaque and rigid. SIXTH instar adherent to exuvium of fifth; exuvium of sixth not shed......... 6

6. FIRST instar without or with fine and short caudal setae. Epicranial and frontal sutures not distinct and the median dorsal suture on prothorax either not present, in *Leptopalpus*, or, present only posteriorly, in *Zonitis;* always present on meso- and metathorax. Tarsal setae weak, one or two in *Zonitis*, two in *Leptopalpus;* seta on trochanter either long, in *Zonitis*, or normally developed, in *Leptopalpus*. Spiracle-bearing hook short and distant in *Leptopalpus* and in the North American species *Zonitis bilineatus;* normal in other species of *Zonitis*......... **NEMOGNATHINI-ZONITIDES.**
Genera Zonitis, Leptopalpus, and possibly Sitarobrachys.

FIRST instar without caudal setae. Epicranial and frontal sutures distinct, medium suture fully developed on all thoracic terga. Tarsal setae almost as long and strong as tarsus, two present; trochanter with a long seta. Spiracle-bearing hook well developed.
NEMOGNATHINI-NEMOGHATHIDES.
Genus Nemognatha.

RECORDED SPECIES OF THE SUBFAMILY NEMOGNATHINAE, REPRESENTED BY ALL, SOME OR ONE INSTARS.[12]

Subfamily NEMOGHATHINAE.

Tribe SITARINI.

Hornia minutipennis Riley (3, 4, 54, 55).
Allendesalazaria nymphoides Escalera (13, 21).
Stenoria analis Schaum (3, 18, 42, 43, 44, 45, 58).
Stenoria apicalis Latreille (2, 3, 19, 43, 58).
Tricrania sanguinipennis Say (30).
(*Sitaris colletis* Mayet=*Stenoria analis* Schaum.)
(*Sitaris humeralis* Fabricius=*Sitaris muralis* Foerster.)
Sitaris muralis Foerster (1, 3, 4, 8, 9, 19, 24, 25, 26, 28, 43, 47, 58, 63).
Sitaris rufipes Gory (14, 19).
Sitaris solieri Pecchioli (15, 19, 51).
Apalus bimaculatus Linnaeus, var. **lecontei** Pic (3, 8, 13, 16, 33, 58, 61).

Tribe NEMOGNATHINI.

(*Zonitis analis* Abeille de Perrin=*Zonitis praeusta*, var. Fabricius.)
(*Zonitis fenestrata* Pallas=*Zonitis praeusta*, var. Fabricius.)
Zonitis immaculata Oliver (3, 4, 19, 34, 58).
(*Zonitis mutica* Scriba=*Zonitis immaculata* Olivier.)

[12] Numbers in parenthesis refer to the guide-numbers in the bibliography (p. 34) indicating the papers in which the species is mentioned.

Zonitis praeusta Fabricius (3, 19, 25, 27, 58).
Leptopalpus rostratus Fabricius (13, 18, 64, 66).
Sitarobrachys brevipennis Reitter (19).
Sitarobrachys buigasi Escalera (10, 19, 20).
Nemognatha chrysomelina Fabricius (11, 12, 17, 19).

COMMENTS TO THE SYSTEMATIC ARRANGEMENT OF THE SYNOPSIS.

The main taxonomic results recorded in the above given synopsis may briefly be presented as follows:

The subfamily *Nemognathinae* consists of two tribes:

a. SITARINI and *b*. NEMOGNATHINI.
a. SITARINI with four subtribes:
1. Horniides, 2. Stenoriides, 3. Tricraniides, 4. Apalides.
b. NEMOGNATHINI with two subtribes:
1. Zonitides, 2. Nemognathides.

The genus *Stenoria* is placed in a subtribe *Stenoriides* next to *Horniides* and apart from subtribe *Apalides* which comprises *Sitaris* and *Apalus*, two closely related genera, entirely distinct from *Stenoria*. Genus *Tricrania* has been placed by Wellman and Borchmann in tribe *Horiini* together with *Horia* and *Cissites* and by Leng in his tribe *Zonitini* immediately after *Zonitis* and *Nemognatha* and right before *Horia*. In this paper, however, *Tricrania* is considered very close to *Stenoria* and *Hornia* and listed accordingly.

BIBLIOGRAPHY WITH NOTES.

1. 1835. Audouin, J. V.—Bull. Soc. Ent. France, vol. 4, p. 77.
Sitaris muralis; believes that larva feeds on *Anthophora*-larvae; interprets 4th and 5th exuvia of *Sitaris* as skin of bee-larva.
2. 1884. Beauregard, H.—Compt. rend. acad. sci. Paris, vol. 99, p. 148.
(*Stenoria apicalis*, 5th and 6th instars.)
2*a*. 1884. ———.—Le naturalist, vol. 2, 1882–1884, p. 546.
(Same article as No. 2.)
3. 1890. ———.—Les insectes vésicants, pp. i–xiv and pp. 1–544, pls. 1–19 (on title-page wrongly given as 34 plates), text-figs. 1–44, Paris.
Anatomy. Physiology and Pharmacology. Geographical distribution. Habits. Copulation and Oviposition. Development. Description of the stages.—*Sitaris muralis, Stenoria analis, Stenoria apicalis, Zonitis praeusta, Zonitis immaculata, Hornia minutipennis, Apalus bimaculatus.*
4. 1887. Brauer, F.—Verwandlung d. Meloiden. Verh. d. k. k. Zool-bot. Gesellsch. Wien, vol. 37, pp. 633–647.
Sitaris muralis, Hornia minutipennis. Classification built on form of tarsus in first instar, thereby establishing main groups on a character which can even vary in different species of same genus.
5. 1917. Brockmann, F.—Meloidae, Cephaloidae, W. Junk; Coleopterorum Catalogus, pt. 69, pp. 1–208.
Several incorrect citations of larval literature.
1853. Candèze, E.—See Chapuis and Candèze.
6. 1840. Castelnau, F. L. L.—Histoire naturelle et iconographie des Coléop tères, vol. 2.

7. 1889–1893. CHAMPION, G. C.—Biologia Centrali-Americana. Coleoptera, vol. 4, pt. 2, Heteromera (part). Meloidae. pp. 364–450, pls. 17–21.

Descriptions and figures of many of the most interesting American genera.

8. 1853. CHAPUIS, F., and CANDÈZE, E.—Catal. Larv. Coleopt.—Mem. Soc. Roy. Sci. Liège, vol. 8, pp. 529–533.

9. 1910–13. CROS, A.—Notes préliminaires sur les Meloés. Bull. Soc. Hist. nat. Afrique Nord. (1910; pp. 164–176. *Sitaris muralis.*)

Publication not available to authors of the present paper.

10. 1912. ——.—Contribution a la biologie des Méloides Algériens, note prelim. Feuille jeun. natural., vol. 42, pp. 131–132.

First instar of *Sitarobrachys buigasi.*

11. 1912. ——.—Entomologie algérienne; *Nemognatha chrysomelina* F. Variétés, évolution. Zeitschr. f. wissensch. Insektenbiologie, vol. 8, pp. 137–141.

Fourth to sixth instars.

12. 1912. ——.—Sur l'évolution du *Nemognatha chrysomelina* F. Bull. Soc. Hist. nat. Afrique Nord. vol. 4. p. 9.

Oviposits on flowerstands of *Echinops spinosus.* Publication not available to authors of the present paper.

13. 1913. ——.—*Hornia (Allendesalazaria) nymphoides*, Moeurs; évolution. Bull. Soc. Hist. nat. Afrique Nord, vol. 5, Nos. 2–5, 40 pp.

Also with short notes on *Apalus bimaculatus* and *Leptopalpus rostratus.*

14. 1913. ——.—Sitaris rufipes. Moeurs; évolution. Feuille jeun. natural., vol. 43, pp. 173–177 and pp. 187–193.

Eggs on leaves of *Ballota hirsuta;* description of first instar, differentiating characters.

15. 1914. ——.—*Sitaris Solieri.* Feuille jeun. natural., vol. 44, pp. 38–40.

Eggs, depositing habits, seasonal history of known species of *Sitaris.*

16. 1917. ——.—*Apalus bimaculatus*, var. *comtei*, Bull. Soc. Hist. nat. Afrique Nord, pp. 125–132.

Almost complete evolution; no first instar found.

17. 1919. ——.—*Nemognatha chrysomelina* F. Sa larve primaire. Bull. Soc. Hist. nat. Afrique Nord, vol. 10, pp. 55–61.

Egg masses on flowerheads of *Echinops spinosus;* biology of larva in different stages; probably feeds on contents of more than one bee-cell, devouring eggs, larvæ, and honey of bee; characters of first instar; comparison with first instars of other Nemognathinæ. Capsule formed by fourth to sixth exuvia similar to that of Zonitis.

18. 1920. ——.—Notes sur larves primaires des Meloidae (1[re] série) Ann. Soc. Ent. France., vol. 88, pp. 261–279.

Leptopalpus rostratus, Stenoria analis, Cissites testaceus.

19. 1921. ——.—Notes sur larves primaires des Meloidae (2m série) Ann. Soc. Ent. France. vol. 90, pp. 133–155.

Zonitis praeusta, var. *analis, Zonitis immaculata, Sitarobrachys brevipennis, Sitarobrachys buigasi, Stenoria apicalis, Sitaris solieri.*

20. 1909. ESCALERA, .—Bol. Espan. Hist. Nat., vol. 9, p. 241. (*Sitarobrachys buigasi*)

Publication not available to the present authors.

21. 1910. ——.—Bol. Espan. Hist. nat., vol. 10, p. 379.

(*Allendesalazaria nymphoides*) Publication not available to the present authors.

22. 1894. ESCHERICH, K.—Naturgesch. d. Meloiden=Gattung *Lytta.* Verh. Zool. Bot. Gesellsch. Wien, vol. 44.

Suggests on p. 256 the terms "Cyste" and "Cystestadium" for the fifth instar and stage.

23. 1897. ——.—Bestimmungstabelle d. europaischen Coleopteren.

Divides the Blister beetles into the *Meloidae* and the *Zonitidae*, corresponding to the *Meloinae* and *Zonitinae* of Ganglbauer 1907, the Lyttinae and Zonitinae of Wellman 1910, the Lyttinae and Nemognathinae of Borchmann 1917, and the Meloinae and Zonitinae of Leng 1920.

24. 1856. Fabre, J. H.—L'instinct et métamorphose des Sphégiens. Ann. Sc. Nat., ser. 4, Zool., vol. 6, pp. 187–188.

Sitaris muralis, different instars.

25. 1857. ——.—Mem. sur l'hypermetamorphose et les moeurs des Méloides. Ann. Sc. Nat., ser. 4, vol. 7, pp. 299–365, pl. 17, figs. 2–8

Life history of *Sitaris muralis*, description of different instars; on pp. 311–312, the author describes the hooks on dorsum of eighth abdominal segment of *Sitaris* as movable and retractile; the spiracle on top is not seen; an adhesive liquid forming a thread is said to be exuded from anus. Figures of larval instars of *Sitaris muralis* and *Zonitis praeusta*.

26. 1882.——.—Nouv. souvenirs entomologiques, 2 edition.

On pp. 262–303, *Sitaris muralis;* pp. 323–349, metamorphosis of *Sitaris* and *Zonitis mutica;* p. 277, description of hooks of first instar of *Sitaris;* p. 287: "The *Anthophores* do not appear to be bothered at all by their presence."—Compare: *Assmuss, Ed.*, 1865. Die Parasiten des Honigbiene. Berlin, pp. 18–19, and *Cros, A.* 1914. "Meloe autumnalis." Bull. Soc. nat. Afrique Nord, vol. 6, pp. 105–106; both of these authors state that first instars of Meloe species are nourished from the carrying bees.

27. 1886. ——.—Souvenirs entomologiques; 3 ^{me} série, pp. 253–282; 3 figures.

Zonitis praeusta; no first instar found.

28. 1898. Friese, H.—Über *Sitaris* and *Meloe;* Ill. Zeitschr. f. Entom.; vol. 3, pp. 97–100.

Development of *Sitaris muralis*.

29. 1913. Folsom, J. W.—Entomology (second edition) Philadelphia.

P. 128: Definition of terms "instar" and "stage."

30. 1912. Frost, C. A.—Note on *Tricrania sanguinipennis* near burrows of *Colletes compactus*. "Psyche" p. 208.

No eggs found. A few adults beneath dry cow dung and one beneath a small stone. *Colletes* were flying close to the ground, occasionally alighting.

31. 1907. Ganglbauer, L.—Verh. Zool.-bot. Gesellsch. Wien.

32. 1870. Gemminger, M. and Harold, E.—Catalogus Coleopterorum, vol. 7.

No subdivisions of family; 42 genera recorded.

33. 1831. Gené, J.—Mémoir pour servir à l'historie naturelle de l'Apalus bimaculatus et des Cantharides en général. Ann. Sci. Nat., vol. 23, p. 138–144.

Reared first instar of *Apalus bimaculatus* from egg; no description of larva. The publication mentioned in Westwood's Classification of insects, vol. 1, p. 299.

34. 1866. Giraud, J.—Ann. Soc. Ent. France, ser. 4, vol. 6, p. 494.

Zonitis mutica-immaculata; good description of capsule formed by the skin of fourth to sixth instars.

35. 1888. Hahn, E.—Berl. Ent. Zeitschr., vol. 32, Sitzber. pp. 6–8.

Life history of different Meloids. Compilation of little scientific value.

36. 1906. Heyden, L. von; Reitter, E.; Weise, J.—Catalogus Coleopterorum Europae. Second edition by Edmund Reitter.

37. 1893–1905. Künckel d'Herculais, J. P. A. — Invasion des Acridiens en Algérie. Gouvernement general de l'Algérie. Alger-Mustapha, vol. 1, p. 2, pp. 618–632.

38. 1865. LACORDAIRE, J. T.—Hist. nat. d. Ins. gen. des Coleopt. Paris. vol. Meloids.

39. 1853. LECONTE, J. L.—Synopsis of Meloides of the U. S. Proc. Acad. Philadelphia, vol. 6. pp. 328–350.

40. 1883. LECONTE, J. L. and HORN, G. H.—Classification of the Coleoptera of North America, Washington, D. C. The Smithsonian Miscellaneous Collection, vol. 26, No. 507.

41. 1920. LENG, C. W.—Catalogue of the Coleoptera of America, North of Mexico; New York. pp. 1–470.

42. 1873. LICHTENSTEIN, J.—Bull. Soc. Ent. France, ser. 5, vol. 3, p. 20.

Sitaris colletis, short note giving *Colletes* as host of the species.

43. 1879. ———.—Bull. Soc. Ent. France, p. 25. First instar of *Sitaris muralis*, *Stenoria analis*, *Sitaris colletis*, *Stenoria apicalis*.

44. 1873. MAYET, V.—Bull. Soc. Ent. France, pp. 20 and 139.

Small notes on larva of *Sitaris colletis* and *Stenoria analis*.

45. 1875. ———.—Moeurs, métamorphose du *Sitaris colletis*. Ann. Soc. Ent. France. ser. 5, vol. 5, pp. 65–92, pls. 3, 4.

Reviews previous literature on habits and metamorphosis of Meloids. Description of different stages of *Sitaris colletis* (=*Stenoria analis*) from egg to adult; like Fabre, has not seen that the "larve seconde" represents three stages; mentions that first instar of this species, contrary to *Sitaris muralis* described by Fabre, attaches itself to outgoing bee after only 5–6 days rest in the gallery where it was hatched.

46. 1921. MILLIKEN, F. B.—U. S. Dept. Agric. Bull. No. 967. Professional paper; pp. 8–21.

47. 1857. MULSANT, E.—Histoire naturelle de Coléoptères de France, Lyon, vol. 8. Monographie des Vésicants de France. pp. 1–201.

Pp. 14–27: Summary of classification of Meloid covering period from 1758–1857. Reared eggs of *Sitaris muralis;* found full-grown fourth instars in nests of *Anthophora;* evidently believes that *Sitaris* larva feeds on bee's larva; compare Audouin 1835.

48. 1851. NEWPORT, G.—On the natural history, anatomy, and development of the oil beetle *Meloe*, more especially of *Meloe cicatricosus* Leach. First memoir. Trans. Linn. Soc. London. vol. 20, pp. 297–320.

49. 1851. ———.—Second memoir. Trans. Linn. Soc. London, vol. 20, pp. 321–357. pl. 14, figs. 3–5. and 10–19.

50. 1853. ———.—Third memoir. Trans. Linn. Soc. London, vol. 21, pp. 167–183. pl. 20, figs. 1–16.

51. 1839. PECCHIOLI and AUDOUIN.—Bull. Soc. Ent. France, vol. 8, p. 47.

Eggs of *Sitaris solieri* with full-grown embryos in white glutinous material on the flowers of *Rosemary*.

52. 1904. PIERCE, W. DWIGHT.—Univ. Studies Nebraska, vol. 4, pp. 4 and 18.

Key to first instars of *Epicauta*, *Lytta*, *Meloe*, and *Sitaris*.

53. 1877. RILEY, C. V.—On the larval characters and habits of the Blister-beetles belonging to the genera *Macrobasis* and *Epicauta*, with remarks on other species of the family Meloidae. Trans. Acad. Sci. St. Louis, vol. 3, pp. 544–562, pl. 5, figs. 1–12 and text figs. 35*a–i*.

Historical review; oviposition; life-history and descriptions. *Sitaris*, *Apalus*, *Zonitis*, *Horia*.

54. 1877. ———.—*Hornia minutipennis* Riley infesting Mason bee cells.—U. S. Trans. Acad. Sci. St. Louis, vol. 3, pp. 563–565.

55. 1878. ———.—On the transformations and habits of the Blisterbeetles, Amer. Naturalist. vol. 12, pp. 213–219 and pp. 282–290, pl. 1, figs. 1–12

Text adapted from article No. 54, text figures and plate identical.

56. 1878. Riley, C. V., Packard, A. S., and Thomas, C.—First Ann. Report U. S. Ent. Commiss. Dept. Interior, U. S. geol. Survey, 1877, pl. 4, figs. 4–7.
57. 1880. Rupertsberger, M.—Biologie d. Käfer Europas, pp. 194–196 and p. 281.
58. 1894. ——.—Biol. Literat. ii. die Käfer Europas von 1880 an; pp. 195–199 and p. 293.
59. 1903. Schwarz, E. A.—Proc. Ent. Soc. Wash., p. 137.

Nemognatha nigripennis LeConte came out of a ball of pine resin, collected by the author in Arizona, which proved to be the nest of bee genus *Anthidium*.

60. 1905. Silvestri, F.—Descrizione di un nuovo genere di Rhipiphoridae. Redia, vol. 3, pl. 20, figs. 17 and 18.

Compare characters and figures given in paper by Silvestri with characterization of subfamily *Nemognathinae* in the present publication.

61. 1863. Strauch, A.—Ann. Soc. Ent. France, ser. 4, vol. 3, p. 481.

Letter to Reiche on *Apalus* adults, found in galleries of a subterranean hymenopteron.

62. 1910. Wellmam, C.—On classification of the Lyttidae (Meloidae s. Cantharidae auctt.) Ent. News, vol. 21, pp. 211–222.
63. 1839. Westwood, J. O.—Introduction to modern classification of insects. London.

Figures (vol. 1, fig. 34, nos. 4–9) the first instar of *Sitaris muralis* and recognizes it. on p. 298, as such.

LATE REFERENCES.

64. 1913. Cros, A.—*Leptopalpus rostratus*, Bull. Soc. Hist. nat. Afrique Nord No. 7, p. 175
65. 1917. ———.—Forme des ongles des larves primaire des Meloidae; Terme "Triongulin," Ann. Soc. Ent. France, vol. 86, p. 159.
66. 1923. ———.—*Leptopalpus rostratus* Fabr. Moeurs; larve primaire. Bull. Soc. Hist. nat. Afrique Nord, vol. 14, pp. 327–337.

EXPLANATION OF PLATES

(All figures refer to *Tricrania sanguinipennis* Say.)

Plate 1.

Larval instars.

Fig. 1. *First instar.*—*Ventral view*, showing hypopleural chitinizations with articulation for coxa; the thoracic and seven abdominal spiracles.
2. *First instar.*—Hook with eighth abdominal spiracle on top and atrium inside. Scale adjacent to hook.
3. *First instar.*—Dorsal view.
4. *First instar.*—Anterior part of head, showing excavation of nasale and completely closed mandibles. Compare fig. 24.
5. *First instar.*—Lateral view.
6. *First instar.*—Claw-shaped tarsus with two basal setae; m_1, and m_2. muscles of claw-shaped tarsus.
7. *Second instar.*—Dorsal view. Eight pair of abdominal spiracles.
8. *Second instar.*—Lateral view.
9. *First instar.*—End of abdomen, showing tracheal system and spiracles.
10. *Fourth instar.*—Lateral view. Seven large abdominal spiracles. Posterior view of anal segment shown separately.
11. *Fifth instar.*—Lateral view. Seven abdominal spiracles of medium size.
12. *Sixth instar.*—Lateral view. Seven abdominal spiracles of medium size.

PLATE 2.

Head Structures.

FIG. 13. *First instar.*—Ventral view.

14. *Second instar.*—Ventral view.
15. *Fourth instar.*—Ventral view; *m*, mentum; *sm.* submentum; *gu.* gula.
16. *Fourth instar.*—Dorsal view.
17. *Fifth instar.*—Ventral view. First pair of vestigial legs shown; *a*, antenna; *la*, nasale=the fused labrum, clypeus and anterior margin of frons; *leg.*, leg; *li*, labium; *md*, mandible; *mx*, maxilla.
18. *Fifth instar.*—Dorsal view.
19. *Sixth instar.*—Ventral view.
20. *Sixth instar.*—Dorsal view; *cly.* clypeus; *hy.* hypopharnyx; *la*, labrum.

PLATE 3.

Eggs and Larval Instars.

FIG 21. Cell of the bee *Colletes rufithorax* Swenk with fourth larval instar of *Tricrania* inside. Notice the unbroken covering of the cell and the great amount of excrement-pellets of the Meloid larva. The honey supply is exhausted.

22. Eggs of *Tricrania*. Cement spots on the egg-shells.
23. *Colletes rufithorax*, female, with first instars of *Tricrania* just having attached themselves to its hair. Drawn from a specimen in captivity; in nature the larvae are found mainly clinging to hairs on the posterior, dorsal part of the head or on the vertex.
24. *First instar* of *Tricrania* grasping a bee's hair with its mandibles, the legs having nothing to do with this performance. Compare fig. 4.

Different instars of Tricrania.

All figures and the interposed millimeter-scales drawn with the same magnification to demonstrate the growth of the larva and to indicate the real size of the instars. *md.*=mandible.

FIG. 25. *First instar.*

26. *Second instar*, first period.
27. *Second instar*, second period.—Notice that head and legs have the same size as in fig. 26.
28. *Third instar*, first period.—Lateral and ventral views; *c. s. 2*, cast skin of second instar. Compare the size of head and spiracles with the size of the same structures in figs. 27 and 29.
29. *Third instar*, second period.
30. *Fourth instar*, first period; *c. s. 3*, cast skin of third instar. Notice the dorsal sclerite of prothorax, not developed in third instar.

PLATE 4.

Various instars.

FIG. 31. *Fourth instar*, second period.

32. *Sixth instar* (*6*), enveloped by the exuvia of fifth (*5*) and fourth (*4*) instars. In nature both exuvia are unbroken and placed against each other and against the sixth instar; in the figure they are cut open, pulled out and partly separated.

FIG. 33. Imago inside capsule formed by the exuvia of fourth and fifth larval instars. *1*, imago; *4* and *5*, exuvia of fourth and fifth instars; *6*, the shed and crumbled exuvia of sixth instar and of the pupa pushed to the bottom of the capsule; *e*, unfertilized very small eggs abnormally deposited inside unbroken capsule.

34. *Fifth instar.*—Lateral view of head.

35. *Sixth instar.*—Lateral view of head.

PLATE 5

Eggs of bees and instars of Tricrania.

FIG. 36. Brood cell of *Colletes rufithorax* Swenk in its natural position in the soil, slightly enlarged. The egg of the bee in its normal position above the food mass is shown through the transparent wall of the brood cell.

37. *First Instar* of *Tricrania* resting on the edge of the food mass in the brood cell of the bee, immediately preceding the first moult. × 16.

38. *Second Instar* of *Tricrania*, resting on the food mass in brood cell of bee. × 3.

39. Brood cell of *Andrena perplexa* Smith showing egg of bee in its normal position on the mass of pollen in the bottom of the cell. In this case no honey had yet been placed in the cell about the egg. Slightly enlarged.

40. *Third Instar of Tricrania* resting on food mass in cell of bee. × 3.

41. *Fourth Instar* of *Tricrania* feeding in brood cell of bee from which the wall has been cut away.

42. Female of *Tricrania* ovipositing on the under side of a mass of dried cow's dung. Enlarged about two diameters.

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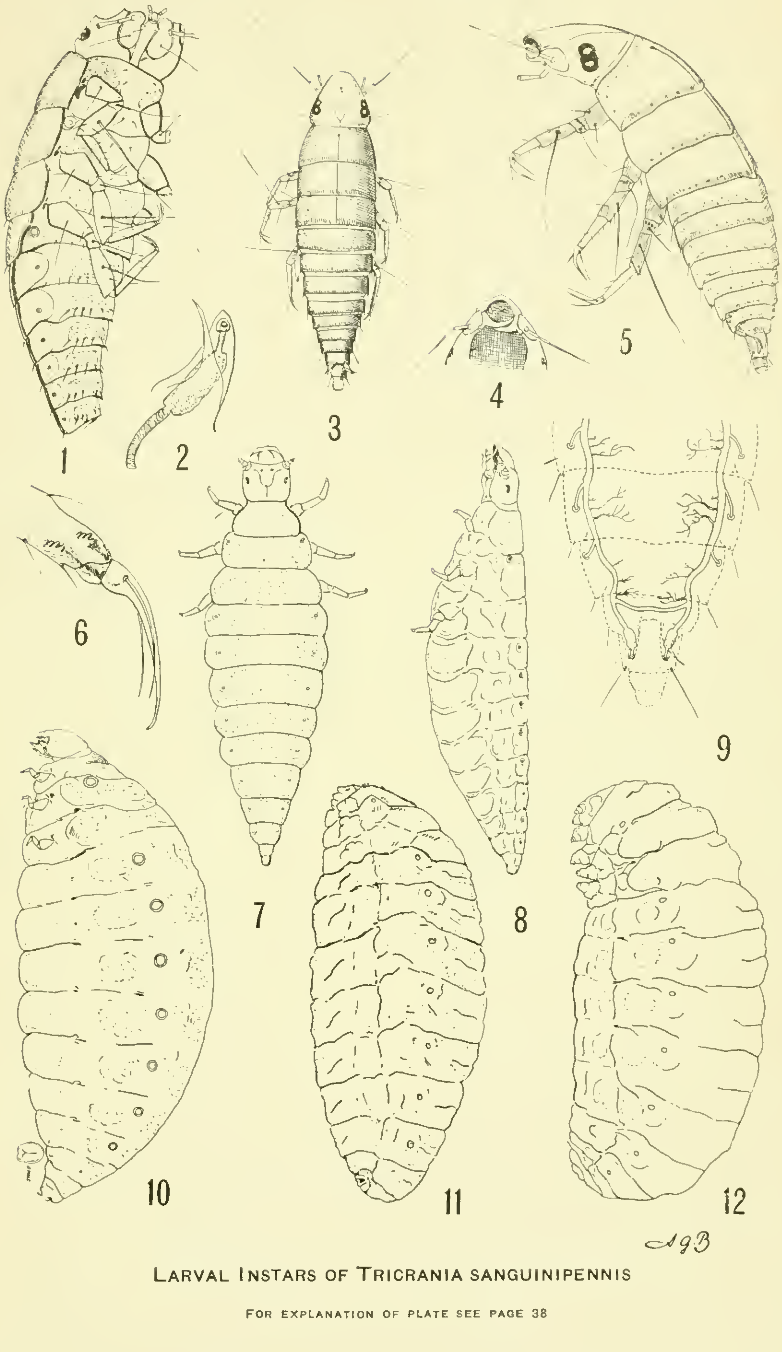
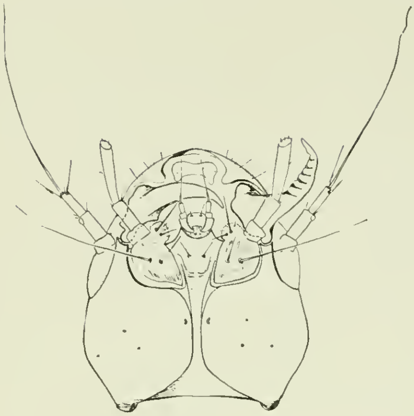


LARVAL INSTARS OF TRICRANIA SANGUINIPENNIS

FOR EXPLANATION OF PLATE SEE PAGE 38



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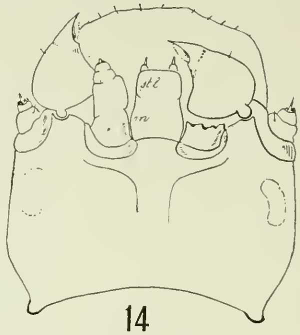

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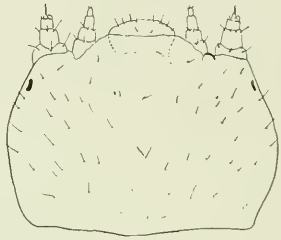

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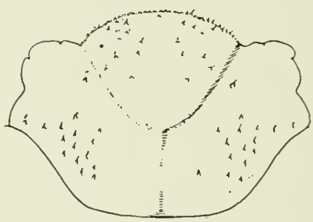

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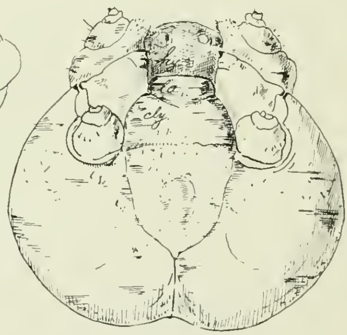

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HEAD STRUCTURE OF TRICRANIA SANGUINIPENNIS

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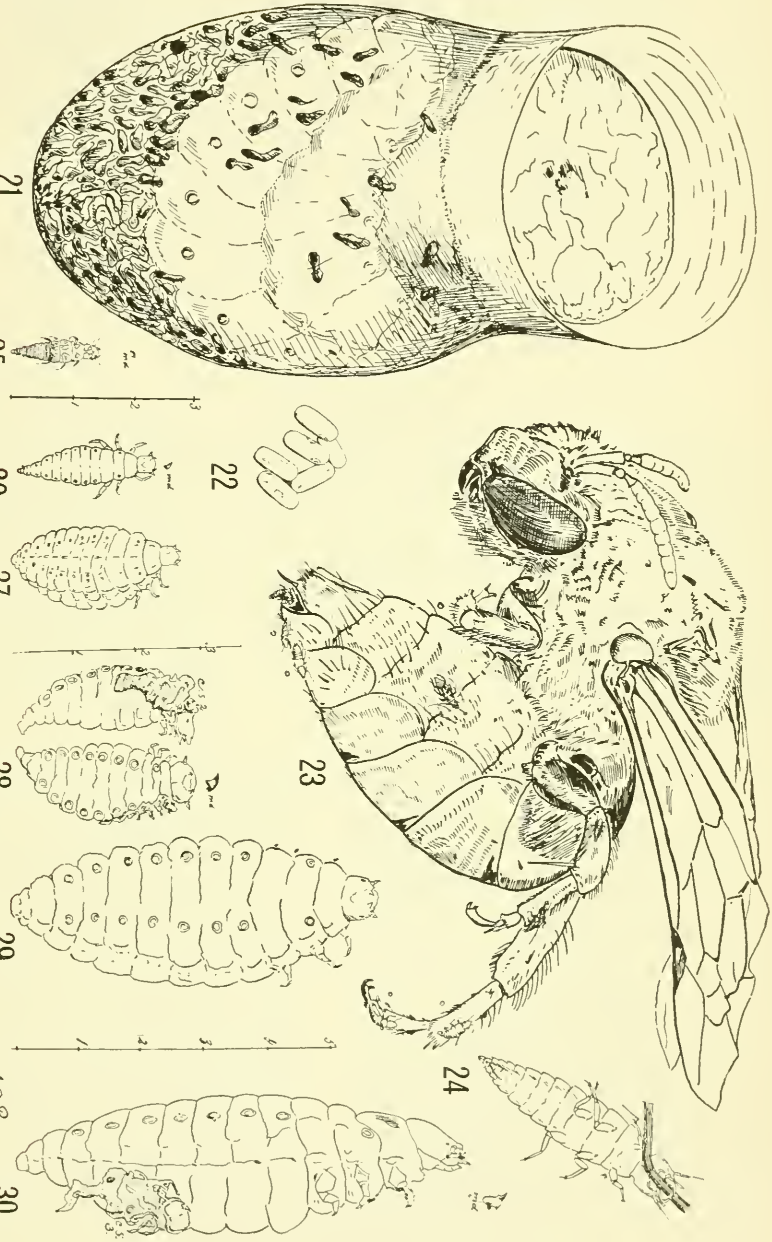

EGGS AND LARVAL INSTARS OF TRICRANIA SANGUINIPENNIS

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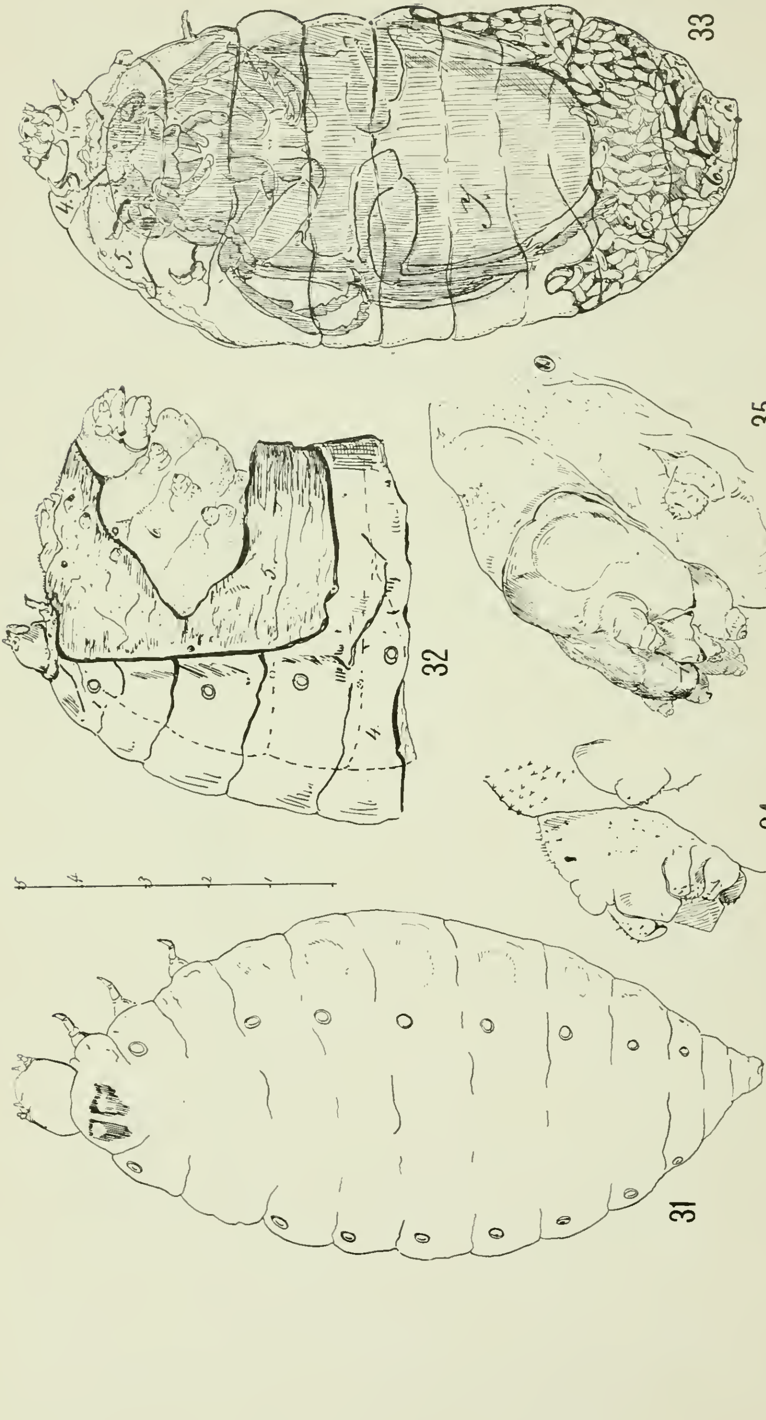

VARIOUS INSTARS OF TRICRANIA SANGUINIPENNIS

FOR EXPLANATION OF PLATE SEE PAGES 39 AND 40

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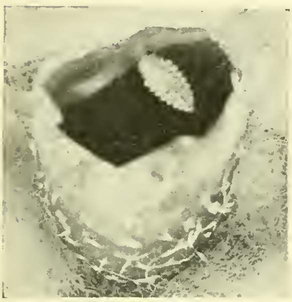

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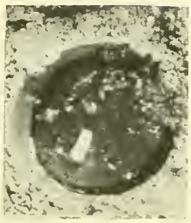

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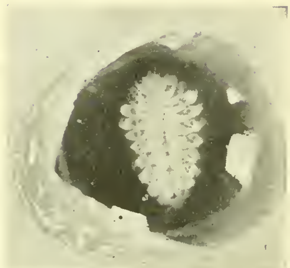

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EGGS OF BEES AND INSTARS OF TRICRANIA

FOR EXPLANATION OF PLATE SEE PAGE 40