On the Larval Characters and Habits of the Blister-beetles belonging to the Genera Macrobasis *Lec. and* Epicauta *Fabr.*; with Remarks on other Species of the Family* Meloidæ.

By Charles V. Riley.

[Read Nov. 5, 1877.]

The larval habits of the European Cantharis of commerce, as also those of its congeners in our own country and in other parts of the world, have hitherto remained a mystery, notwithstanding the frequency with which the beetles occur, their great abundance at times, and their commercial value and interest. The same remark holds true of the allied genera *Macrobasis*, *Epicauta*, and *Henous*, the species of which have the same valuable vesicatory properties as *Cantharis*. Some of these species are very common in the United States and quite injurious to vegetation, swarming at times on potato-vines, beans, clematis, and other plants. Their great numbers and destructive habits make it all the more remarkable that so little has hitherto been discovered of their early life. Harris, who evidently had hatched the first larva of the Ash-gray Blister-beetle (*Macrobasis unicolor* Kirby), says: "The larvæ are slender, somewhat flattened grubs, of a yellowish color, banded with black, with a small reddish head, and six legs. These grubs are very active in their motions, and appear to live upon fine roots in the ground; but I have not been able to keep them till they arrived at maturity, and therefore know nothing further of their history." (*Ins. inj. to Vegetation*, p. 138.) Latreille, according to Westwood, states that the larvæ live beneath the ground, feeding on the roots of vegetables (*Intr.*, vol. i., p. 301), but the statement is evidently founded on conjecture. Ratzeburg, who well describes the method of oviposition of the European *Cantharis vesicatoria*, and roughly figures the first larva (*Forst Insecten*, II., Col. Taf. ii., Fig. 27

* As stated by Dr. Horn (Rev. of the Sp. of several Genera of Meloidæ of the U. S.—*Am. Phil. Soc.*, Feb. 21, 1877), these two genera are very closely brought together by connecting species. There is certainly nothing in the adolescent habits or characters to separate them. Yet the same thing may be said of almost any two allied genera when comprehensively considered, and I follow LeConte's separation because it facilitates study, and because the species considered in this paper illustrate very well the differences on which the genera in question are founded.

B), believed that it was a plant feeder in the immature state. Olivier describes what is possibly the second larva as a soft, yellowish-white, 13-jointed grub, with short, filiform antennæ, and short, corneous, thoracic legs—"living in earth" (*Traité Elém.* etc., M. Girard, Col., p. 618); but his account is very loose, and may apply to any number of other coleopterous larvæ. Audouin, who studied the Cantharides intently, making them the subject of his thesis in his medical examination, was obliged to confess that absolutely nothing was known of their larval history; and Mr. William Saunders, of London, Ont., in a paper on the same subject read at the 1876 meeting of the American Pharmaceutical Society, could add nothing more definite.

This is about all we learn from the older writers, and the opinion was general among them that, like their parents, the blister-beetle larvæ in question were vegetable feeders. In 1874 Laboulbène mentioned the fact (*Ann. Soc. Ent. de France*, 1874, lxxxiii.) that some one (name not given) had seen the European *Cantharis vesicatoria* issuing from ground in the neighborhood of which there were wasps (*guêpes*—no specific reference given), and rashly concludes that the former were parasitic on these. Still more recently, M. J. Lichtenstein, of Montpellier, France, has endeavored to discover the larval habits of this species, and in 1875 he succeeded, after many fruitless attempts, in causing the first larva to feed on honey kept in a glass tube, and to undergo one molting. While spending a few days with him, I had the pleasure of making a sketch of this second larva as it swam on the honey. It subsequently died. He afterwards reared two others in the same way until they had passed through three molts, and is of the opinion that *Cantharis* develops in the nests of *Halictus*. These facts, as well as analogy, pointed to a parasitic life and partly carnivorous, partly mellivorous diet for our own allied species, since the life-history of two genera in the Family, viz. *Meloë* Linn. and *Sitaris* Latr. has been fully traced. Indeed the young of all vesicants belonging to the *Meloidæ*, so far as anything has yet been known of them, develop in the cells of honey-making bees, first devouring the egg of the bee and then appropriating the honey and bee-bread stored up by the same. They all are remarkable, in individual development, for passing through seven distinct stages, viz. the egg, the first larva

or *triungulin*, the second larva, the coarctate larva or pseudo-pupa, the third larva, the true pupa, and the imago.

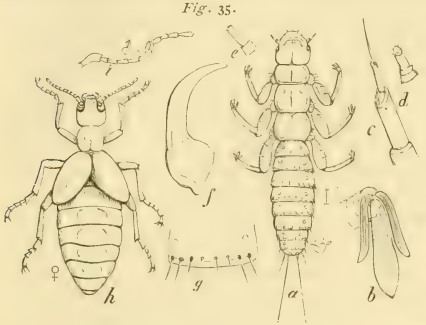
HISTORY OF MELOË.

The history of *Meloë* may be briefly summed up as follows:—The newly hatched or first larva (now generally called *triungulin*) was first mentioned in 1700 by the Holland entomologist Gœdart, who hatched it from the egg Frisch and Réaumur both mistook it for a louse peculiar to bees and flies. De Geer, who also obtained it from the egg, mentions it in 1775 as a parasite of Hymenoptera. Linnæus called what is evidently the same thing, *Pediculus apis;* Kirby in 1802 described it as *Pediculus melittæ*, and Dufour in 1828 named it *Triungulinus andrenetarum*. Newport in 1845 (*Trans. Linn. Soc.*, vol. xx. p. 297) first rightly concluded that it was carried into the nests of bees, and described. in addition, the full-grown larva from exuvial characters, and the coarctate larva and pupa which he found in the cells of *Anthophora retusa*. He failed, however, to fill the gap between the first and full-grown larva; and this Fabre first inferentially did in 1858 (*Ann. d. Sc. Nat.*, Zool. t. ix. p. 265) by tracing the analogous stages of *Sitaris*.

The female *Meloë* is very prolific. She lays at three or four different intervals, in loose irregular masses in the ground, and may produce from three to four thousand eggs. These are soft, whitish, cylindrical, and rounded at each end. They give birth to the triungulins, which, a few days after hatching—the number depending on the temperature—run actively about and climb on to Composite, Ranunculaceous and other flowers, from which they attach themselves to bees and flies that visit the flowers. Fastening alike to many hairy Diptera and to Hymenoptera which can be of little or no service to them, many are doomed to perish, and only the few fortunate ones are carried to the proper cells of some *Anthophora*. Once in the cell, the triungulin falls upon the bee egg, which it soon exhausts. A molt then takes place and the second larva is produced. Clumsy and with locomotive power reduced to a minimum, this second larva devours the thickened honey stored up for the bee larva. It then changes to the pseudo-pupa with the skin of the second larva only partially shed; then to a third larva within the partially rent pseudo-pupal skin, and finally to the true pupa and imago. These different changes of

form are known by the name of hypermetamorphoses, the term first given them by Fabre to distinguish them from the normal changes from larva to pupa and imago, experienced by insects generally. The triungulin or first larva (Fig. 35, *a*) is characterized by a prominent labrum, very stout thighs, unarmed shanks, three broad and subspatulate tarsal claws, feeble and reduced trophi, untoothed jaws, 3-jointed antennæ* ending in a long seta, and four anal setæ, the two inner ones longest. When the abdomen is shrunken the general aspect is very much that of *Pediculus*, and it is hardly surprising that some of the early describers so determined it.

Fig. 35.



MELOE:—*a*, first larva; *b*, claws; *c*, antenna; *d* maxillary palpus; *e*, labial palpus; *f*, mandible; *g*, an abdominal joint; *h*, imago ♀; *i*, antenna of ♂.

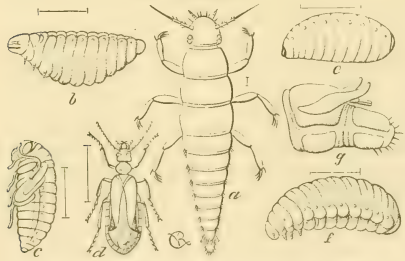
---

* My figure is from specimens affecting the mature honey-bee at San Diego, Cal. It corresponds very closely with Newport's original figure and description of that of the European *M. cicatricosus*, and belongs doubtless to one of our Pacific coast species, probably *M. barbarus*, Lec. It is 2 mm. long. The head is produced in front, with a strong labrum, beyond which the smooth jaws do not reach; the antennæ are 3-jointed, and similar to those of *cicatricosus*; the mouth parts are diminutive, the maxillary palpus 3-jointed, the 3d joint longer than the others together and tipped with a few short, weak points; the labial palpus is 2-jointed; the coxæ are armed with a few very strong spines; the femora are very stout and faintly imbricated; the tibiæ are unarmed, and the tarsal claws subspatulate, the middle one pale, ⅓ longer and twice as broad as the two outer ones, which are dark, articulate close together and curve slightly outward. The first pair of stigmata are distinctly dorsal and on the mesothoracic joint. The dorsal hind border of the abdominal joints is armed with 8 spinous hairs, the 4 intermediate ones only half as long as the others. Newport is evidently wrong in considering the jaws articulate in themselves, while Candèze is wrong in describing the antennæ as 5-jointed (*Mem. de la Soc. Roy. des Sc.*, viii. p. 530, Liège, 1853). Packard's figure of what is in all probability *M. angusticollis* Say, fails to indicate the characteristic mesothoracic spiracles, and probably makes the two outer anal setæ too short — these anal appendices being in reality nothing more than prolonged spinous hairs, such as occur on the other joints. The form of the abdomen varies, contracting somewhat with age. Newport remarks on the similarity of the triungulins of *Meloë violaceus*, *M. proscarabæus* and *M. cicatricosus* being so great that he could discover no differences. Judging from figures sent me by M. Lichtenstein, very slight differences occur in the relative length of the antennal joints, and none other.

HISTORY OF SITARIS.

The history of *Sitaris* is also well known and agrees very closely with that of *Meloë*. Its first larva was figured many years ago by Westwood (*Introduction*, etc., Fig. 34, 5) from specimens obtained from Audouin, who found the female *Sitaris* in the cells of *Anthophora* enclosed in its thin pseudo-pupal and second larval skins, which Audouin erroneously took to be the pellicle of the devoured bee-larva. But the complete life-history of the genus was first given by Fabre in 1857 (*Ann. d. Sc. Nat.*, Zool., t. vii. p. 299; t. ix. p. 265), who studied the *S. humeralis* Fabr., while that of *S. colletis* V.-M. has been more recently given by M. Valery-Mayet, of Montpellier, France (*Ann. Soc. Ent. de Fr.* 1875, p. 65), from whom I have specimens in all stages. The former species infests the nests of *Anthophora*, the latter those of *Colletes*. In the former the newly hatched larvæ hybernate in huddled masses in the galleries of the bee; in the latter they hybernate in the bee-cell, slowly feeding while the temperature permits; but such differences doubtless depend on the relative earliness in the autumn that the eggs are laid. The first larva or triungulin (Fig. 36, *a*) agrees very much in the head, tarsal and general characters with that of *Meloë*, but differs in several important particulars and especially in having a pair of pre-anal spinnerets, from which is secreted a serous sticky fluid, which aids the animal in holding firmly to the bee that is to carry it into the nest. A pre-anal pair of claspers also assists in this work.* The hypermetamorphoses are very similar to those of

Fig. 36.



SITARIS:—*a*, first larva; *g*, anal spinnerets and clasps of same; *b*, second larva; *e*, pseudo-pupa; *f*, third larva; *c*, pupa; *d*, imago ♀ (after V.-Mayet).

* The small size (about 1 mm. long) and the hairless and spineless nature of this larva contrast strongly with the other triungulins considered in this paper. The tarsal claws are somewhat narrower than in *Meloë*, and unicolorous. A few soft lateral hairs are represented on the abdominal joints in the figure, but they are scarcely perceptible under the

Meloë. The triungulin after absorbing the contents of the bee egg, molts, and thereafter floats upon and devours the honey—the pseudo-pupa, third larva and true pupa all forming in due time within the second larval skin. The female does not feed, and on account of her heavy abdomen travels but a short distance from the bee-burrows where she developed.

It is generally stated by writers on the Hive-bee that the Oil-beetle (*Meloë*) is one of its parasites. The posssibility that our more common blister-beetles were similarly parasitic on bees, taken in connection with the frequent complaints from apiarians of the wholesale death of bees from causes little understood, led me, some years since, to pay attention to the biological characteristics of the blister-beetles, in the hope of ascertaining whether or not they really bear any connection with bee mortality. From these investigations I am satisfied that *Meloe* is only parasitic on the perfect Hive-bee as it is on so many other winged insects that frequent flowers; and that it cannot well, in the nature of the case, breed in the cells of any social bee whose young are fed by nurses in open cells.

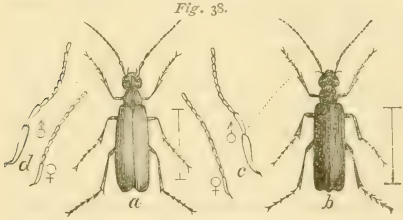
I have had no difficulty in getting the eggs or the first larva of several of our vesicants, and described some of them at the Hartford (1874) meeting of the Am. Ass. Adv. Sc.; but these young larvæ refused to climb on to plants furnished to them, or to fasten to bees or other hairy insects. Nor would they nourish upon honey, bee-bread, or bee larvæ on which they were placed. They showed a proclivity for burrowing in the ground, and acted quite differently from those of *Meloë* or *Sitaris*, which not only readily attach to bees in confinement, but which, in the case of *Meloë*, I have known to so crowd upon mature hive bees as to worry them to death and cause extended loss in the apiary. Explorations into the nests of Solitary bees gave no clue, and, in fact, the immense numbers in which the more common blister-beetles occur rendered a parasitic life upon such bees highly improbable. In

EPICAUTA VITTATA: normal form.

strongest microscope. Nor do any hairs or spines appear in any of the subsequent stages, even on the true pupa. The pseudo-pupa lacks the prominent lateral ridge so striking in the others. The stigmata are so faint in the triungulin that Mayet could not resolve them; but with proper light and specimens rendered transparent I have discerned them in the same positions as in *Meloë*. The mandibles are toothed.

sweeping plants and flowers with the net. I had never met with any of the first larvæ with which I had become familiar, as already indicated; while I had on several occasions, in digging ground where there was no trace of bee nests, met with the curious pseudo-pupa so characteristic of the Family. While analogy and the law of unity of habit in species of the same family pointed, therefore, to a parasitic life, I began to conclude, from the facts just stated, that the parasitism was of another kind, having satisfied myself by various experiments that the triungulins did not feed on roots. Few discoveries are stumbled upon. We find as a rule that only which we anticipate or look for. Late last Fall, in digging up the eggs of the Rocky Mountain Locust (*Caloptenus spretus*) at Manhattan, Kansas, the pseudo-pupæ were not unfrequently met with. The thought at once occurred to me that locust eggs might be the proper food for these blister-beetle larvæ, and it was encouraged by the fact that the Meloids abound most in those dry western regions where the Acrididæ most prevail, and by a pretty distinct recollection, which my notes support, that the years when the vesicants were most injurious to potatoes had been preceded by dry Falls, during which there had been much locust injury and, necessarily, unusual locust increase. The suspicion thus raised that these blister-beetles preyed in the preparatory states upon locust eggs was confirmed last spring by finding the larvæ of different ages within the egg-pods and devouring the eggs of *Caloptenus spretus*. Mr. A. N. Godfrey had, also, no difficulty, under my directions, in finding them last May at Manhattan; while they were sent to me among other locust-egg parasites by Mr. Seth H. Kenney of Morristown, Minn., and from St. Peters in the same State by Prof. Cyrus Thomas, who had no suspicion of their nature.

Fig. 38.



MACROBASIS UNICOLOR:—*a*, normal gray form; *b*, black (*murina*) form; *c*, *d*, male and female antennæ of either.

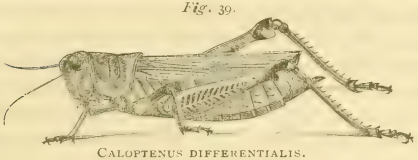
From such larvæ preying on the eggs of *spretus* I have reared

the unicolorous form of *Epicauta cinerea* (Forster), or the Margine Blister-beetle* ; the *Epicauta pennsylvanica* (DeGeer),† or the Black Blister-beetle ; the *Macrobasis unicolor* (Kirby),‡ or the Ash-gray Blister-beetle ; and the form of it described as *murina* by LeConte, or the Black-rat Blister-beetle.

Since then I have found it very easy to trace the larval habits and development of the two more common potato-feeding species around St. Louis, viz. the Striped Blister-beetle (*Epicauta vittata*, Fabr.)§ and the Margined Blister-beetle (*marginata* Fabr.) just alluded to.

Careful examination of locust eggs in the vicinity of potato fields frequented by these beetles show a varying proportion of the egg-pods affected, and in some locations nearly every pod of the Differential Locust (*Caloptenus differentialis*) will contain the *Epicauta* larva. The eggs of this locust are laid in large masses of 70 to about 100. The pod is but slightly bent, rather compact outside, while the eggs are irregularly arranged, and capped with but a shallow covering of mucous matter. It is the egg-pod of this species which the larvæ of the two Blister-beetles in question prefer ; for while they will feed upon those of other species in confinement, I have so far found

Fig. 39.



CALOPTENUS DIFFERENTIALIS.

* The black, gray-margined form, very appropriately described by Fabricius as *marginata*, is referred to *cinerea* Forster by modern systematists, and specifically united with it by Dr. Horn. Yet the fact remains that the two are not ordinarily, if ever, found commingled. The margined form is very common in potato fields in Missouri. It shows little variation and is found almost invariably in conjunction with *vittata*, but not with the unicolorous form in question, which is most common farther west and occurs abundantly without the margined form—all which is against the specific union of the two.

† = *atrata* Fabr.

‡ = *cinerea* Fabr., *Fabricii* Lec., *murina* Lec., *debilis* Lec. I accept Dr. Horn's conclusion that the last two are but poorly developed forms of this species. Yet the *murina* form is not due to rubbing or injury, but issues from the pupa without a trace of gray scales on the elytra.

§ = *lemniscata* Fabr. Dr. Horn retains *lemniscata* as a distinct species in his Revision already referred to. The outer stripe in the bi-vittate specimens divides up in others so as to give the tri-vittate character on which *lemniscata* is founded. Both extremes and every possible variation between them occur constantly together in the same potato field in Missouri, and there are no other differences of specific value.

none in the deeper-necked, narrower, more compact egg-pods either of *Caloptenus femur-rubrum*, *C. Atlantis*, or *Œdipoda sulphurea*, in which the eggs are regularly and quadrilinearly arranged as in those of *C. spretus*. Not only have I found a large proportion of the egg-pods of *C. differentialis* naturally infested with these *Epicauta* larvæ, but I have succeeded in hatching and rearing numbers in-doors, and have them even at this writing (Oct. 30th) by hundreds in all stages from the first larva to the pseudo-pupa. Referring the reader to the end of this paper for detailed descriptions, let me illustrate the larval habits of the genus by reciting those of one of the species in question, viz., *vittata*.

From July till the middle of October the eggs are being laid in the ground in loose, irregular masses of about 130 on an average —the female excavating a hole for the purpose, and afterwards covering up the mass by scratching with her feet. In confinement she sometimes omits both these instinctive acts and oviposits on the surface of the ground. She lays at several different intervals, producing in the aggregate probably from four to five hundred ova, judging from examinations made on the ovaries of some that were gravid. She prefers for purposes of oviposition the very same warm sunny locations chosen by the locusts, and doubtless instinctively places her eggs near those of these last, as I have on several occasions found them in close proximity. In the course of about 10 days—more or less, according to the temperature of the ground—the first larva or triungulin hatches. The hatching takes place without the aid of any *ruptor ovi*, for the egg-shell is so delicate that it easily splits, from mere expansion, along the back near the head, and breaks and shrivels up with the escape of the larva. These little triungulins (Pl. V., Fig. 2), at first feeble and perfectly white, soon assume their natural light brown color and commence to move about. At night or during cold or wet weather all those of a batch huddle together with little motion, but when warmed by the sun they become very active, running with their long legs over the ground, and prying with their large heads and strong jaws into every crease and crevice in the soil, into which, in due time, they burrow and hide. Under the microscope they are seen to fairly bristle with spinous hairs, which aid in burrowing. As becomes a carnivorous creature whose

prey must be industriously sought, they display great power of endurance, and will survive for a fortnight without food in a moderate temperature. Yet in the search for locust eggs many are, without doubt, doomed to perish, and only the more fortunate succeed in finding appropriate diet. Upon the slightest disturbance they curl up in a ball with the head bent pretty closely on the breast.

Reaching a locust egg-pod, our triungulin, by chance, or instinct, or both combined, commences to burrow through the mucous neck, or covering, and makes its first repast thereon. If it has been long in the search, and its jaws are well hardened, it makes quick work through this porous and cellular matter, and at once gnaws away at an egg, first devouring a portion of the shell, and then, in the course of two or three days, sucking up the contents. Should two or more triungulins enter the same egg-pod, a deadly conflict sooner or later ensues until one alone remains the victorious possessor. By the time the contents of an egg are consumed, the body of the parasite has perceptibly increased so that the white sutures between the segmental plates show conspicuously, especially as there is a tendency on the part of the animal to curve its body, and bring the sutures more into relief. A second egg is attacked and more or less completely exhausted of its contents, when a period of rest ensues, the triungulin skin splits along the back and there issues the *Second Larva* (Pl. V., Fig. 4)—white, soft, with reduced legs and quite different in general appearance from the first. This molt is experienced about the eighth day from the first taking of nourishment. The animal now naturally lies in a curved position (Pl. V., Fig. 4, *d*), but, if extracted from the egg-pod, will stretch itself and move with great activity, reminding one very strongly of many Carabid larvæ, for which reason I would designate this as the *Carabidoid* stage of the second larva. After feeding for about another week, a second molt takes place, the skin, as before, splitting along the back and the new larva hunching out of it until the extremities are brought together and released almost simultaneously. This kind of molting, which is characteristic of our blister-beetles up to the pseudo-pupal state, is exceptional among insects, the skin being ordinarily worked backward from the head. The modification at this molt is slight. The mouth-parts and legs

become rudimentary and the body takes on more fully the clumsy aspect of the typical Lamellicorn larva, for which reason I designate this as the *Scarabæidoid* stage of the second larva.

Another six or seven days elapse and the scarabæidoid skin is rent and shed with but slight modification in the form and characters of the animal.* In this, the *Ultimate* stage of the second larva (Pl. V., Fig. 5) the creature grows apace, its head being constantly bathed in the rich juices of the locust eggs, which it now rapidly sucks or more or less completely devours. The color is more yellowish than it was before, and the power to stretch and travel on the venter on an even surface is still retained. In another week it forsakes the remnants of the pabular mass, and, by burrowing a short distance in the clear soil, avoids the deleterious decaying influences of these egg remnants. In the soil it forms a smooth cavity, within which it lies stretched on one side, motionless and gradually contracting. The skin separates and becomes loose at the end of the third or fourth day, when it splits on the top of the head and thoracic joints and is worked toward the extremity, but never fully shed. The mouth-parts and legs are now quite rudimentary and tuberculous, and the soft skin rapidly becomes rigid and of a deeper yellow color, and we have what has been called the semi-pupa (Pl. V., Fig. 8). The term pseudo-pupa given it by Fabre is more appropriate, and I should prefer myself to call it the *Coarctate Larva*, for it is nothing but a rigid and dormant larval stage, having its counterpart in the well-known "flaxseed" stage of the Hessian-fly larva and in the so-called coarctate pupa of the Diptera generally. A similar dormant but less rigid larval stage occurs with many Tenthredinidæ in Hymenoptera, and, in fact, the summer dormancy of certain Lepidopterous larvæ and the winter dormancy of others is analogous. We find something similar, therefore, in all the Orders undergoing complete transformations, but in no insects is the change so marked and exceptional or the freeing of the subsequent larva from the coarctate larva so striking as in these Meloidæ. The

* None of the observers of *Meloë* or *Sitaris* mention the two molts which the second larva undergoes, though these doubtless occur in those genera as they do in *Epicauta*. Only by the most careful watching from day to day of a number of specimens have I been able to observe these molts; for the exuviæ are generally devoured as soon as they are cast, and this fact doubtless accounts for their not having been observed in the two genera first mentioned.

insect has the power of remaining in this coarctate larval condition for a long period, and generally thus hybernates.

In spring the coarctate larval skin is, in its turn, rent on the top of the head and thorax, and there crawls out of it the *Third Larva*,* which differs in no respect from the ultimate stage of the second larva already mentioned, except in the somewhat reduced size and greater whiteness. The coarctate skin, when deserted, retains its original form almost intact. The third larva is rather active, and burrows about in the ground; but while there seems to be no reason why it should not feed, nourishment is not at all essential, and all my specimens have, in the course of a few days, transformed to the true pupa without feeding. In the transformation to pupa (Pl. V., Fig. 9) the third larval skin is worked into a wrinkled mass behind, as is also the skin of the true pupa when shed. The pupa state lasts but five or six days, and before the wings of the imago are fully expanded, or the abdomen contracted, the general aspect of *Epicauta* forcibly recalls the mature *Henous*.

Like all parasitic† insects that nourish on a limited amount of food and possess no power to secure more, the blister-beetles vary greatly in individual size in the same species, and the larvæ have the power of accommodating their life to circumstances, and of assuming the coarctate larval form earlier or later according to the size of the egg-mass which they infest. I have had some interesting illustrations of this in my experiments with them In an average sized egg-pod of the Differential Locust, however, there are more than enough eggs to nourish the largest specimen of *E. vittata*, and a few are usually left untouched.

The period of growth, from the first feeding to the coarctate larva, averages, as will be gathered from the foregoing, about a month; yet in the month of September, out-doors, under screens where I have had the Differential Locust oviposit for the experiment, I have known the full larval growth of *vittata* to occupy

* The coarctate larva is, properly speaking, the third and that following it the fourth; but just as I have preferred to designate as special stages of the second larva the stages between the first and fourth molts, so I prefer to call the last larva the third, to conform to the nomenclature now generally employed.

† An insect is not properly parasitic that simply feeds on eggs, but the term is permissible and even necessary to characterize and distinguish those species which develop within and are confined to a locust egg-pod from the predaceous species that are not confined but pass from one pod to another.

but 24 days. As this species occurs in the beetle state as early as June in the latitude of St. Louis and as late as October, there are possibly two annual generations here and farther south.

Larval Habits of Macrobasis and Henous.

The characteristics of the triungulins of the blistle-beetles, represented by *Epicauta* and *Henous*, are remarkably similar, and point to unity of habit. The slight differences of some are given in the appended descriptions. The same holds true of the characters of the second, coarctate and third larva and of the pupa of *Epicauta* and *Macrobasis*. They are precisely alike; so that, while appreciable differences may be found in the triungulins, it is doubtful whether the subsequent developmental stages will indicate specific or even generic differences in species of similar size in these three genera.

That the eggs of *Epicauta* may exceptionally hybernate is possible, but, from their delicate nature, improbable. That the triungulins frequently do so there can be no doubt, especially in species like the Black Blister-beetle, which is found on the flowers of Solidago, Eupatorium, etc., till the end of October, and continues laying till frost. I have at the present time many of these last that are quietly huddled together, and, with winter temperature, will doubtless remain so; while others have worked in between the locust eggs, there evidently to remain without feeding till spring opens. I have also found as many as five triungulins of this species curled up in the deep red mucous matter that surrounds the eggs of *Œdipoda phanœcoptera*—all numb and torpid, and evidently hybernating.

Conclusion.

From the foregoing history of our commoner blister-beetles, it is clear that while they pass through the curious hypermetamorphoses so characteristic of the family, and have many other features in common, yet *Epicauta* and *Macrobasis* differ in many important respects from *Meloe* and *Sitaris*, the only genera hitherto fully known biologically. To resume what is known of the larval habits of the family, we have:

1st—The small, smooth, unarmed, tapering triungulin of the prolific *Sitaris*, with the thoracic joints subequal, with strong

articulating, tarsal claws on the stout-thighed but spineless* legs, and, in addition, a caudal spinning apparatus. The mandibles scarcely extend beyond the labrum; the creature seeks the light, and is admirably adapted to adhering to bees but not to burrowing in the ground. The second larva is mellivorous, and the transformations from the coarctate larval stage all take place within the unrent larval skin.—We have:

2nd—The more spinous and larger triungulin of the still more prolific *Meloë*, with long caudal setæ, but otherwise closely resembling that of *Sitaris* in the femoral, tarsal and trophial characters, in the subequal thoracic joints, in the unarmed tibiæ, and in the instinctive love of light and fondness for fastening to bees. The second larva is also mellivorous, but the later transformations take place in the rent and partly shed skins of the second and coarctate larvæ.—We have:

3rd—The larger and much more spinous triungulins of the less prolific *Epicauta*, *Macrobasis*, and *Henous;* with unequal thoracic joints, powerful mandibles and maxillæ, shortened labrum, slender femora, well-armed tibiæ, slender, spine-like, less perfect tarsal claws—combined with an instinctive love of darkness and tendency to burrow and hide in the ground. The second larva takes the same food as the first, its skin is almost entirely cast from the coarctate larva, while the subsequent changes are independent and entirely free of the shell of this last.

Larval Habits of Cantharis.

The question naturally arises here, whether *Cantharis*, in its larval habits, will most agree with *Meloë* and *Sitaris* or with *Epicauta*. The triungulin, except in becoming almost black, has much in common with *Meloë*, in the subequal thoracic joints, the toothless mandibles, and the long antennæ; also in its habit, observed by Lichtenstein, of fastening to bees. The fact that it can nourish on honey, though it does not appear to do so freely, would also indicate that it breeds in the nests of solitary bees. Nevertheless, in the slender thighs and the caudal and abdominal

* The larva of *S. humeralis* appears to differ from that of *S. colletis* in having hairs on the femora and tibiæ.

characters it agrees more nearly with *Epicauta*, and in the stage following the first molt the legs are still quite long and the general aspect much like the carabidoid stage of that genus. I should not be surprised, therefore, if *Cantharis* also nourished on locust eggs, and I hope that my friends in South France will not fail to make the test.

What is known of the Larval Habits of other Meloid Genera.

Mylabris, Fabr. (*nec* Geoff.), according to V.-Mayet, is much less prolific than any Meloids so far observed. The egg is 2.5 mm. long and ½ as wide, with a tolerably thick shell and the embryo more fully bent within it. The triungulin has many of the characters of *Epicauta*, judging from the published description (*Ann. Soc. Ent. de Fr.*, 1876, p. cxcvi.), which is, however, not sufficiently detailed as to the trophi. I doubt not that the genus will be found to infest locust eggs.

Horia, Fabr., from what little is known of it, would seem to have a similar partial parasitism to *Meloe*, but on Carpenter bees.

Tetraonyx, Latr. was found by Guérin-Meneville in places frequented by Bumble-bees.

The eggs of *Apalus* Fabr., as well as its triungulin, are said to resemble those of *Meloë*.

Zonitis, Fabr. is known to develop in the cells of *Osmia* and *Anthidium*, and to have a coarctate larva much like that of *Sitaris*.

DESCRIPTIVE.

Epicauta vittata.—*Egg.*—Average length 1.6 mm., diameter rather more than ¼ the length. Elongate, cylindrical, rounded at extremities, the anterior end being very slightly larger than the posterior. Rarely a little curved. Color very pale whitish-yellow. Smooth and shiny—the shell somewhat stiff, bearing considerable finger and thumb pressure and cracking with some noise. Laid loosely in the ground in irregular batches of 130 and upward. Embryo lying straight, with head bent on breast.

Larva: First Larva or Triungulin.—Elongate, subcylindrical, the venter being flattened. Average length when just from the egg, 3 mm. Width across prothoracic joint not quite ⅓ the length; tapering thence gradually to anus. Head prominent, well separated from neck, flattened, slightly depressed, as broad as, or slightly broader than joint 1; with the ordinary Y-shaped suture superiorly and with an elongate medial triangular piece inferiorly, attenuating to thorax; also, a suture inferiorly starting from near the middle and curving toward base of antennæ; with a few spinous

hairs from the sides and on the horny mouth-parts; mandibles long, prominent, sickle-shaped, the outer edge having a slight elbow about the middle, and the inner edge armed along terminal half with about 11 blunt, quadrate teeth, and slightly produced basally; labrum short, slightly excavated at middle, studded with very minute short hairs and with 4 stouter spinous hairs around border. Antennæ not extending as far as do the mandibles, 3-jointed, the basal joint bulbous and stout, the 2nd more slender and about as long, the 3rd as long as the other two together and surmounted with two fleshy tubercles, the outer unarmed and fusiform, the inner more elongate and tipped with 4 or 5 stiff hairs. Maxillæ short with a strong 3-jointed palpus, the basal joint less long than wide, the 2nd twice as long and the 3rd four times as long, fusiform and slighly flattened and armed with short spines on the inner terminal third—the chitinous covering on all joints showing regular imbrications (the maxilla proper is composed of two pieces not more than twice as wide as the palpus, so as to look rather like two stout basal joints). Labium composed of a short basal piece and a heart-shaped terminal piece, surmounted each side with a 2-jointed palpus, the terminal joint thrice as long as the basal and with short stiff apical hairs. Eyes round, dark, not prominent, and on the side, just behind antennæ. Body with the normal 12 joints and subjoint; with a corneous covering superiorly, laterally, and across joints 11 and 12 ventrally, the fleshy sutures distinctly separating the plates; joint 1 (prothoracic) somewhat longer than joints 2 and 3 together, broadening posteriorly somewhat thicker than the others and with a few stiff hairs at sides; joints 2 and 3 subequal, with a transverse row (8 superior and several lateral and subventral) of spinous hairs; joints 4–12 gradually diminishing in width but increasing in length, each with a transverse row of superior short conical spines, and of longer spinous hairs at posterior border, a few more slender ones nearer the middle, and a ventral row of still more slender ones across the middle; anal joint with 2 longer setous hairs, about as long as the 3 terminal joints together. Legs long; coxæ stout, swollen in middle and ⅔ as long as femora; trochanters small and short; femora slender; tibiæ still more slender and somewhat longer; tarsi rudimentary and with three long spinous claws of unequal length: all parts beset with spinous hairs, and the tibiæ with four regular rows of more slender ones. Stigmata subdorsal, with difficulty distinguished, from being concolorous, the first pair mesothoracic, the rest on joints 4–11 inclusive. Color yellowish-brown, with more or less black on the lower corners of joints 1, 4, 5, 10 and 11; borders of head, thorax and of joints also somewhat more dusky; tips of jaws and eyes dark brown; legs and venter paler. A pale medial longitudinal line observable especially on joint 1; the fleshy sutures and venter white: the lobes of anus, ventrally, may swell so as to appear like fleshy tubercles or pseudopods, but they are not used in running.

Second Larva; Carabidoid Stage. — With the first molt the whole aspect changes. The head is now narrower than the prothoracic joint and this again narrower than the three succeeding joints, so that the body

tapers both ways; the legs are shortened and thickened, the corneous plates give way to fleshy wrinkles; the dorsal spinous hairs to a few weaker ones; the lateral ones are still stout and the anal setæ are lost. Prothoracic joint faintly corneous; antennæ with basal joint longest, 2nd joint short, and the unarmed apical tubercle longer than the other: the maxillæ are totally changed, having a rudimentary 2-jointed palpus and an inner lobe; the labium is not much altered, but the two inferior claws of tarsus have become tibial spines. The color is white and the skin is seen to be finely granulated under a strong power, while the stigmata are more easily discerned. *Scarabæidoid Stage*— With the second molt the trophi are still more shortened, the legs more rudimentary, the wrinkles of body more pronounced, and the general aspect is that of the typical Scarabæid larva. The head is faintly mottled. The jaws have anteriorly a large obtuse tooth, which still shows, more or less distinctly, the minute teeth of the first larva. The body is cream-white in color, and devoid of strong or spinous hairs, but sparsely covered instead with short setaceous points. A third molt takes place with little change, except that the dorsal wrinkles are evenly beset with tolerably dense, closely shorn, fulvous, setaceous hairs. *Ultimate Stage*—A fourth molt produces little change in general appearance, except that the color becomes more yellowish. The full-grown larva presents the following characteristics: Body soft, curved, largest in middle, tapering slightly toward head, more rapidly toward anus; heavily wrinkled transversely, and with a prominent lateral submonoliform fold; the soft parts evenly covered, except at sutures and on venter, with dense, ferruginous, setaceous points. Head slightly retractile, about half as wide as joint 1, with no distinct sutures, but with two U-shaped impressions on the face, and one running a short distance from base of mandibles, relieving the cheeks: color pale yellow, shaded with spots of a deeper yellowish-brown, which spots are most intense in the depressions, and in some specimens relieve a distinct, pale, Y-shaped line. Trophi much as in second larva, except that they are shortened, thickened, and less perfect. A slightly chitinised cervical shield, with a few faint ferruginous spots along middle, relieving a pale line. Legs with no distinct claws, and covered with the similar dense setaceous points that occur on other parts. A brown, horny, convex breastplate (already noticeable in the second larva) runs from the head on the front part of joint 1 ventrally. Stigmata light brown, the first pair on an anterior mesothoracic fold, the others, on joints 4–11 inclusive, just above the lateral fold.

Coarctate or Quiescent Larva.—Length 7 to 8.5 mm. Dorsum regularly arched, the transverse segmental sutures but faintly indicated. Venter convex, with transverse sutures still more faint; bulging at thoracic joints. Lateral outline elongate-ovate. Depth at joint 6 (from dorsum to venter) rather less than $\frac{1}{3}$ the length, diminishing thence slightly to anal joint. Width at joint 6, $\frac{1}{3}$ the length. A prominent longitudinal, lateral, rounded ridge, faintly constricted at segmental sutures and reaching from base of joint 4 to end of joint 11. Head small, well separated ventrally

but not dorsally, the mouth-parts — consisting of a bow-shaped labrum, conical mandibles and maxillæ, and exarticulate antennæ — brown, rudimentary, and tuberculous; eyes small, imperfect, and scarcely raised. Six brown conical tubercles in place of the thoracic legs. Stigmata as in full-grown larva, but more conspicuous, being darker brown and raised. Anus rounded and unarmed. Color gamboge-yellow. Chitinous covering firm, and very faintly corrugate. The larval skin adheres, in shrivelled mass with its dark mandibles ventrally, to the end of the body, and sometimes extends to the middle.

Third Larva. — Somewhat paler, more contracted and clumsy than the ultimate stage of the second, but otherwise differing in no essential features.

Pupa.—Having the folded legs well-drawn back from sternum, the hind legs reaching well nigh to anus, with a transverse dorsal row of spines on all but the two or three terminal ventral joints, and about 6 much stouter ones each side of prothorax, near its hind border.

Epicauta cinerea (Forster .

The black, gray-margined form (*marginata* Fabr.) I have had in all stages from the egg to the coarctate larva, reared on the eggs of *Calopteuus differentialis*, and the unicolorous form, from the scarabæidoid stage of the second larva to the imago, on those of *C. spretus*. The egg is 1.3 mm. long, and somewhat stouter than in *vittata*. The triungulin is somewhat darker than that of *vittata*, and not quite so large (length 2.6 mm.) The head has a less formidable aspect, and, with the prothoracic joint, is more nearly of the same diameter as the abdomen. It may also be distinguished by the lateral dark brown of the prothorax being medial rather than at the lower corners, and by joints 3, 9, 10 and 11 being dark—almost black—across their entire dorsal posterior half. The metathoracic joint (3) is always conspicuously dark. The central apical antennal seta is longer, and the maxillary and labial palpi have frequently a minute apical, 2-jointed, fleshy process. The spinous hairs on the body are somewhat less strong. Otherwise it is undistinguishable, agreeing in every minute structural particular, as do all its subsequent phases.

Epicauta pennsylvanica (DeGeer).

The eggs of this species are but 0.9 mm. long. The triungulin averages but 2 mm. in length, and, while having the same form and characteristics as the other species, is easily distinguished by the following particulars, aside from the smaller size: The color is darker and more uniform, joints 1, 4, 5, 10 and 11 contrasting less with the others. The prothoracic joint is more slender, being about as long as wide. The maxillary palpi have the terminal joint less flattened inside and surmounted with a small fleshy 2-jointed apical process: the maxillary piece is scarcely broader than the palpi. The antennæ have the apical tubercles of equal length, the setous one, as also the labial palpi, likewise having a similar 2-jointed fleshy apical process to that on the maxillary palpi. These minute processes

occur on all the specimens I have examined (40), but they are but modified setæ, and may exceptionally be noticed in *vittata* and more often in *marginata*. The subsequent states show no structural differences from the other species.

Macrobasis unicolor (Kirby).

The triungulin of this species is yet unknown to me, but from the coarctate larva to the imago I have noticed no characters of any importance or value which would distinguish it from the previous species.

Henous confertus (Say).

The eggs of this species, which also feeds on Potato, I have had laid in July. They are 1.8 mm. long, ¼ as wide, and differ from those of the other species described, in being of a deeper yellow and more compactly glued together in the lump by means of a reddish, glistening fluid, which separates in globules between the eggs and pulls in fine, web-like threads. The triungulin measures 3.2 mm. in length when first hatched, but otherwise differs but little from that of *vittata*. The dark brown color is more often confined to the lower corners of the prothoracic joint, and never occurs on joints 4 and 5; the head is rather more rounded; the mandibles are slightly more feeble, with only about 8 rather stronger teeth. The spinous hairs are somewhat more numerous and longer, but there are no short conical spines: the abdomen tapers less, being more nearly of a diameter with head and prothorax, and thus giving a heavier, more clumsy look; the dark eyes have a pale centre; the antennal maxillary and labial characters agree with those of *E. pennsylvanica*, and the caudal hairs sometimes exceed the longest lateral ones but very little in length. I have not watched it through the subsequent changes, my notes being from specimens obtained in 1874; but the triungulins act just as in *Epicauta*, and doubtless feed on locust eggs.

ADDITIONAL NOTE ON CANTHARIS.

Since the first part of this paper was run off the press, a communication from M. J. Lichtenstein has reached me.* He has succeeded, by furnishing the larvæ of *C. vesicatoria* with artificial nourishment composed of the filled stomachs of honey-making bees, and especially of *Ceratina*, in tracing the development from the triungulin to the coarctate larva, which last differs from those of the other species considered by me, in freeing itself entirely from the second larva skin. He has thus established the fact that *Cantharis* agrees with the other species of the family in its hypermetamorphosis; but its natural habits remain as much as ever a mystery, which, let me hope, the present communication to the Academy may help to solve.

* *Comptes Rendus de l'Ac. des Sc.*, Paris, Oct. 11, 1877, p. 628.

EXPLANATION OF PLATE V.

All the figures enlarged unless otherwise stated. the hair-lines indicating the natural sizes.

Fig. 1.—Egg-pod of *Caloptenus differentialis* with the mouth torn open, exposing the newly hatched larva of *Epicauta vittata* (1 *a*) eating into an egg, and the passage which it made through the mucous covering—natural size.

Fig. 2.—Dorsal view of the first larva, or triungulin, of *E. vittata*; 2 *a*, one side of the head of same from beneath, greatly enlarged so as to show the mouth-parts; 2 *b*, terminal joint of maxillary palpus showing imbrications and flattened inner surface armed with stout points; 2 *c*, leg, showing more plainly the tarsal spines; 2 *e*, labrum; 2 *d*, one of the abdominal joints from above, showing stout points, stigmata, and arrangement of spinous hairs.

Fig. 3.—Eggs of *E. vittata*, the natural size indicated at side.

Fig. 4.—Dorsal view of the Carabidoid stage of the *Second Larva* of *E. vittata*; 4 *a*, its antenna; 4 *b*, its right maxilla; 4 *c*, its leg: 4 *d*, side view of same, showing its natural position within the locust-egg mass.

Fig. 5.—Lateral view of the Ultimate or full-grown stage of the *Second Larva* of *E. vittata*; 5 *a*. portion of the dorsal skin, showing short setaceous hairs.

Fig. 6.—Third head, or that from the Scarabæidoid stage of the *Second Larva* of *E. vittata*, from beneath, showing the reduction of mouth-parts as compared with the first head (2 *a*); 6 *a*, antenna of same; 6 *b*, maxilla of same; 6 *c*, mandible of same.

Fig. 7.—Fourth head, or that of the full-grown larva of *E. vittata*, from above; 7 *a*, leg of same; 7 *b*, the breast-plate or prosternal corneous piece.

Fig. 8.—Lateral view of the pseudo-pupa or *Coarctate Larva* of *E. vittata*, with the partially shed skin adhering behind; 8 *a*, dorsal view of same; 8 *b*, its head, from the front; 8 *c*, same from side; 8 *d*, tuberculous leg; 8 *e*, raised spiracle: 8 *f*, anal part of same.

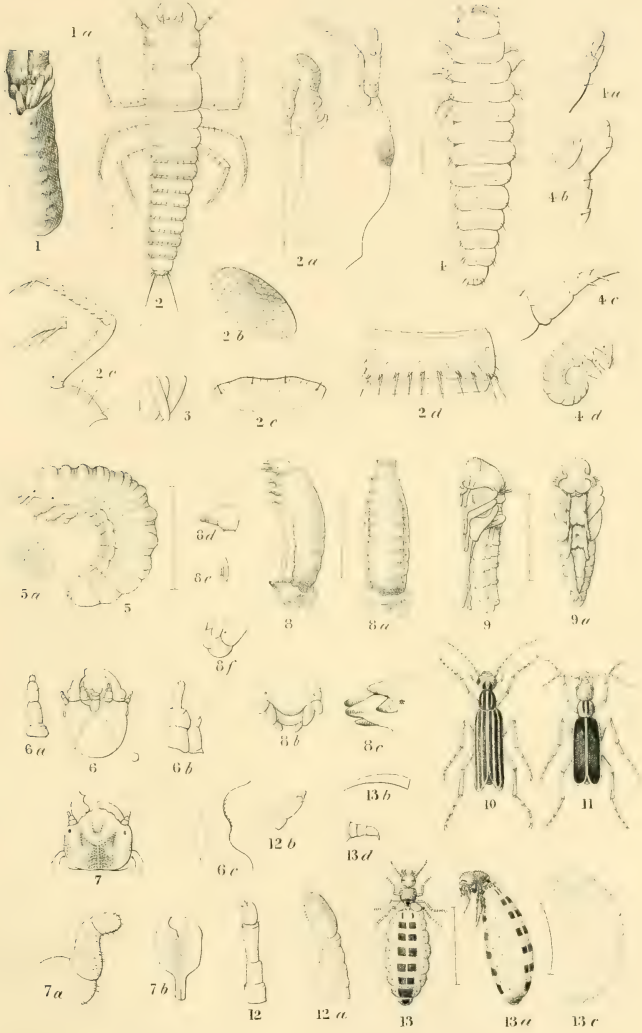
Fig. 9.—Lateral view of the true pupa of *Epicauta cinerea* Forst; 9 *a*, ventral view of same.

Fig. 10.—*Epicauta vittata* (*lemniscata* or trivittate var.)

Fig. 11.—*Epicauta cinerea* Forst. (= *marginata* Fabr.)

Fig. 12.—Antenna of the triungulin of *Epicauta pennsylvanica*; 12 *a*, maxilla of same; 12 *b*, labial palpus of same.

Fig. 13.—♂ *Hornia minutipennis*, dorsal view; 13 *a*. lateral view of same; 13 *b*, simple claw of same; 13 *c*, *Coarctate Larva*; 13 *d*, leg of ultimate stage of *Second Larva*.



C.V. Riley, del

Hypermetamorphoses of Epicauta and Hornia.