ON THE LIFE-HISTORY AND LARVAL ANATOMY OF
MELINDA COGNATA MEIGEN (DIPTERA CALLIPHORINAE)
 PARASITIC IN THE SNAIL *HELICELLA (HELIO-
 MANES) VIRGATA* DA COSTA, WITH AN ACCOUNT OF
 THE OTHER DIPTERA LIVING UPON MOLLUSCS¹.

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(With Plates XXII—XXV and 6 text-figures.)

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INTRODUCTION.

THIS paper consists of two parts: (I) a complete account of the life-history and a description of early stages of *Melinda cognata* Meigen which I found here in Cambridge living as parasites on a common snail, *Helicella virgata* da Costa, and (II) a review of all observations made hitherto on the life-history of different flies feeding upon living or dead molluscs.

Acknowledgments: I am much indebted to Mr C. J. Wainwright for the identification of my specimens of *Melinda cognata* Meig. and those of sarcophagids. I owe also to him, and to Dr J. Villeneuve, valuable information concerning different species of *Onesia* flies. I am grateful to Dr Th. Becker for the identification of some of my specimens of Phorids and the description of a new species of *Phora*. The identification of different snails I owe to the kindness of Mr H. H. Brindley. Finally I have to acknowledge the very friendly assistance rendered by Mr F. Balfour-Browne in revising my manuscript for the press.

I. SYSTEMATIC POSITION OF THE GENUS *MELINDA* ROB.-DESV.
AND ITS RELATION TO THE GENUS *ONESIA* ROB.-DESV.

Before we begin the study of the life-cycle of *Melinda cognata* Meig. it is important to deal with the systematic position of this fly.

The genus *Melinda* was founded by Robineau-Desvoidy in 1830 for a few species of flies which he placed near the genus *Calliphora* in his group of Diptera ovipara. Later on, Schiner (1862) and almost all other entomologists placed the genus *Melinda* as a synonym of the genus *Onesia* which was also created by Robineau-Desvoidy. In 1901, Hendel came back to the old idea of Robineau-Desvoidy in separating from *Onesia* a few species under the generic name of *Melinda*, but most entomologists although agreeing that *Onesia* contained two groups of species, those of the *cognata* type and those of the *sepulchralis* type, nevertheless continued to place all these species in one genus.

As we shall see presently, the separation of the genus *Melinda* from *Onesia* is sustained not only by differential characters of the adult flies but also by a comparative study of their life-history and larval morphology.

As on the other hand, these two genera were confused, the different characters of the species of one genus were often wrongly used in making generalisations regarding species belonging to the other genus.

Therefore, to avoid confusion, we should examine separately and in chronological order all we know of the life-history of species belonging to the genera *Onesia* and *Melinda*.

(a) ONESIA ROB.-DESV. (1830). CHARACTERS OF THE GENUS AND LIFE-HISTORY.

Characters of the Imago. Plump greenish flies; feathering of arista short and confined to basal portion, much as in *Sarcophaga*; cheeks wide; alulae covered with dark hairs as in *Calliphora*; male genitalia large and prominent; two post-sutural intraalar bristles; three strong sternopleural bristles; claws and pulvilli of male elongated.

Life-history.

Geoffrois and Robineau-Desvoidy (1830) were the first to find that these Diptera are viviparous. For *O. sepulchralis* this was also stated by Schiner (1862, p. 576). The latter adds that *Onesia* larvae live upon animal substances, but his statement is merely based on analogy and not upon actual observation.

During my research on *Pollenia rudis* F. (1915 a, pp. 91-105) the larvae of which live as parasites in the earthworm, I often noticed that the worms *Allolobophora foetida* Eisen., *caliginosa* Sav. and *chlorotica* Sav. contained in their vesicula seminalis a few first stage Dipterous larvae other than those of *Pollenia*. These larvae were always dead and surrounded by phagocytes. Being at first unable to identify them, I called them by a letter *A*. Subsequently, I found that the worms which usually contained these larvae (*A*) showed also third stage larvae occupying in the host the same position as those of *Pollenia rudis*.

But, unfortunately, when these larvae left the earthworms they were infested and killed by a fungus thus making it impossible for me to identify them. I called these third stage larvae by the letter *B* supposing them to belong to the same fly as larvae *A*.

Finally, on dissecting some *Onesia* females from the Cambridge Entomological collection, I found that the flies contained in their uterus nearly 250 well-formed larvae which proved to be identical with larvae *A*, thus showing that the first stage larvae of *Onesia* penetrate into the vesicula seminalis of different species of common earthworms.

As to their ultimate development, all I can say at present is that if the third stage larvae *B* belong to the same species of fly as larvae *A*, the life-history of *Onesia* should be similar to that of *P. rudis*, i.e. from the vesicula seminalis of the earthworm, the first stage *Onesia* larva migrates to the host's prostomium, this is perforated by the insect's posterior end so that its spiracles communicate with the air. In this position the larva passes through two moults or three stages, destroying the earthworm more or less completely.

This is all that we know at present of the life-history of the genus *Onesia*.

(b) MELINDA ROB.-DESV. (1830). CHARACTERS OF THE GENUS AND PREVIOUS KNOWLEDGE OF LIFE-HISTORY.

Characters of the genus (Pl. XXII). Flat, blue coloured flies. Feathering of antennae as in *Calliphora*. Alulae free from hairs; male genitalia small, withdrawn almost from sight; three post-sutural intraalar and two strong sternopleural bristles; claws and pulvilli in male not elongated; cheeks narrower than in *Onesia*.

Life-history.

According to Robineau-Desvoidy these flies are oviparous. This statement is solely based upon the observation that the abdomen in the female does not contain larvae as does that of *Onesia*.

In 1909, Pavay-Vajna stated that the larvae of *M. cognata* Meig. cause subcutaneous myiasis in the young of the White Wagtail (*Motacilla alba*). From his note, to which I referred in detail in an earlier paper (1915 a, pp. 95-96), I will only restate the following:

The observations of Pavay-Vajna were made in Hungary (Olahlapad, Komitat Alsó-Fehér) where he found a nest of *M. alba* containing four young birds upon which were pitted wounds. In one of these wounds was a Dipterous larva which soon pupated; the imago emerging 13 days later was identified by Kertesch as *Onesia cognata* Meig. All the young birds died within one to four days after this observation.

In 1917, Father Schmitz, in the course of his research upon *Drilus flavescens*, frequently noticed the appearance of adult flies of *Melinda cognata* Meig. in the breeding vessels containing living snails (*Hygromyia hispida* L., *Patula rotundata* Müller, *Hyalinia cellaria* and others) collected as food for the larvae of the beetle. On May 28th he collected, near Maastricht, a dozen living snails, and, on June 4th, one of these (*Patula rotundata*) died, and from it there emerged a larva which duly pupated. From this pupa on June 25th-26th emerged an imago, which was identified by Dr Villeneuve as *Melinda cognata* Meig.

According to Schmitz, the observation of Pavay-Vajna is based upon an error in the identification of the Insect. This opinion is also expressed in the letters which I have received from Drs Villeneuve and Bequaert. As the identification of Pavay-Vajna's specimen was made by Dr Kertesch, I would hesitate before doubting its correctness, but regarding Schmitz's observation we may consider the occurrence of *M. cognata* on *Motacilla alba* as merely accidental.

II. LIFE-HISTORY OF *MELINDA COGNATA* MEIGEN¹
 PARASITIC IN *HELICELLA* (*HELIOMANES*)
VIRGATA DA COSTA.

Last year I found in and around Cambridge the larvae of *M. cognata* living in a small snail, *H. virgata*. I was able to determine the relation between the parasite and the host, to follow the complete life-cycle of the fly, and to study the anatomy of its larva.

(a) THE HOST.

Helicella (*Heliomanes*) *virgata* da Costa is a small snail varying greatly in size, shape and colour. It is very common in England, Wales and Ireland, and it occurs in France, Corsica, etc. It is gregarious and often appears in thousands covering the pastures and the hedges. In this connection the following statement of E. Steep (1901) is of interest.

The Banded Snail is widely distributed in England, Ireland, and Wales, but in Scotland appears to be found only in Ayrshire. It is most abundant along the south coast, especially in Cornwall, on Dartmoor, and along the South Downs. To get an accurate idea of its profusion in these parts it is advisable to walk out on the pastures after heavy summer rain; then one can excuse the local idea that these snails come not from among the herbage but from the heavens, as though they were hailstones. Fences, gates, stones, thistles, and grass stems are so thickly coated with them that one marvels how it is possible for them to find cover or food at other times. These molluscs have long been regarded as the source of the flavour peculiar to the Down mutton, but I think it is usually considered that they are eaten inadvertently by the sheep in cropping the short grass. I am assured by intelligent Cornish farmers, however, that this is not so: when sheep are turned out to feed on the cliff-pastures they make by preference for those parts near the edge where the "sheepsnaills" (*H. virgata* and *H. acuta*) are most plentiful, and they thrive exceedingly upon them. They do not appear to hibernate. Full-grown specimens measure a little more than half an inch across.

According to Macquin-Tandon (1855) *H. virgata* lays in autumn 30-60 eggs from which the young hatch in 15-20 days. They become adult in the middle of the second year.

The specimens used for this study were collected in or near Cambridge in the following places: hedgerows in Grange Road, Barton Road, Grantchester Road, along the footpath from Grantchester to Barton, Madingley Road and

¹ As previously mentioned, the flies of *Melinda* which I bred from snails were identified by Mr C. J. Wainwright to be the common species *M. cognata* Meig. Since, on the other hand, the type of *M. cognata* Meig. has not been recently examined, Mr Wainwright thinks it is important to specify that this common British species is what Kramer and Villeneuve regard as *cognata* and which Strobl and Schiner called *gentilis* Rob.-Desv., but that it is not the species which the latter describe as *cognata*.

M. cognata of Schiner and Strobl corresponds to *gentilis* Rob.-Desv. as described by Verrall (*Ent. Monthly Magaz.* 1912, p. 192). Until Meigen's type is examined, to place the identity of my specimens beyond doubt, Mr Wainwright advises me to call them *M. cognata* (Meigen?) Kramer = *gentilis* Schiner and Strobl).

along the Hills Road near the "Gogs¹." In all these places, and especially along the footpath mentioned above, a great number of the snails contained *Melinda* larvae. It is interesting to note that in all these places, and especially along the Grantchester Road, this snail was found in the company of *Helicella itala*, *H. cantiana*, *Hygromyia rufescens*, *Helix nemoralis* and *H. hortensis* but in no case were any of these species parasitised by the fly. Further, a white non-banded variety of *H. virgata* found in abundance along the iron fence between the Caius ground and Church Rate Walk, seemed to have escaped the attack of the fly, as I collected several hundreds of specimens on different days and never found *Melinda* larvae. On the other hand I found the larvae in the same variety of snails collected in other places.

(b) MELINDA COGNATA MEIG. AND ITS LIFE-CYCLE.

As previously mentioned, Robineau-Desvoidy placed this fly (*M. cognata*) among the oviparous Diptera. Most probably he relied upon the fact that dissection of the female never revealed the existence of larvae as one would expect to find in a viviparous insect. But the real proof of oviparity or viviparity is to see the eggs or larvae at the time they are laid. I have often found the eggs of *Melinda* in ones or twos or very rarely threes in the mantle cavity of *H. virgata* near the Bojanus organ or kidney of the host (ov. Pl. XXIII, fig. 3). They were usually in different stages of development, one being newly laid while the other contained a well-developed embryo, or there might be an egg and one or two larvae showing that all the eggs had not been laid at the same time. Unfortunately I was never able to observe the actual deposition of an egg, but I imagine that the fly oviposits near the pneumostome, or directly in the mantle cavity, as the pneumostome is often widely open especially when the snail is in motion, but even in the snail contracted within its shell it opens and closes rhythmically. It is probable that the most favourable time for infection is during the copulation of the snails, when the latter are incapable of rapid contraction, but infection certainly takes place at other times also, as I have found *Melinda* larvae in immature snails.

From the egg there emerges a small larva which by means of its strongly chitinated mouth-parts bores its way into the kidney of the host where it lies with its posterior end protruding into the mantle cavity or pulmonary cavity of the snail (L. Pl. XXIII, fig. 3). This position is obviously connected with the fact that the larva is metapneustic and requires to keep its only pair of spiracles exposed to the air.

During this stage the larva feeds upon the fluid of the kidney and destroys the renal epithelium the cells of which contain crystals of ammonium urate. Thus the alimentary canal of the parasite becomes filled with these crystals.

So far, the snail shows no signs of distress, one cannot distinguish a healthy snail from an infected one without removing it from its shell. If this is done,

¹ I have to express here my best thanks to Capt. J. Munro for kind help in collecting the snails.

however, one can see through the transparent tissues the flattened or folded empty egg-shell lying in the posterior end of the mantle cavity, and, in the posterior end of the kidney can be seen the moving mouth-parts of the larva, these appearing as a small black spot. The rest of the larva is difficult to see but sometimes its posterior end is visible when it projects from the kidney into the mantle cavity (*L. Pl. XXIII*, fig. 3). Within the kidney, the larva passes through its first moult, the excuvia, including the mouth-parts of the first stage, remaining by its side.

During the *second stage* it grows rapidly, enlarges the kidney and lies in the mantle cavity with its ventral side toward the shell of the snail. It thus assumes a curved position, its ventral side being convex and following the curve of the shell, but the spiracles always remain in communication with the air, being directed towards the pneumostome of the mantle cavity (*L. Pl. XXIII*, fig. 1). The snail may still retain its activity and may be seen moving about slowly, but more frequently it fixes itself to a plant and lies retracted in its shell.

The larva now moults a second time and passes to its third and final stage. It becomes very active and voracious, entirely destroys the kidney, attacks the liver, and its effect upon the host becomes very distinct. The snail no longer moves about but is always retracted within its shell which is sometimes fixed upon a plant but more frequently lies loose upon the ground.

The larva grows rapidly and soon occupies the whole length of the mantle cavity whilst it projects its posterior end through the pneumostome into the external air (*L. Pl. XXIII*, fig. 6).

In the meanwhile the walls of the mantle cavity have become shrunken and have presumably ceased to function, although the snail is not yet dead as is shown by small contractions of the foot and of the region surrounding the pneumostome.

All the organs of the host are attacked in turn. The liver, which is very fragile, is destroyed, the alimentary canal is perforated, and the snail ultimately dies before the larva is full grown.

One knows with what rapidity a snail decomposes after death. Within two days of its ceasing to show any movements the animal is transformed into a strongly smelling decomposed liquid mass forming the final meal of the parasite which thus ends by being saprophagous.

As previously mentioned, while feeding upon the living snail, the larva lies with its ventral side towards the shell and assumes a curve by which that side is convex, and it is interesting to note that this curve is retained even when the larva is lying free in the putrefying remains of the host.

As the food supply is exhausted, the larva works its way into the upper whorl of the shell which it completely occupies. During the whole of the saprophagous period, the posterior spiracles of the larva remain in communication with the external air.

If one of the shells containing the larva in this stage is broken, and its contents emptied into a dish with some water, a transparent tube, many times

the length of the larva, will be found coiled around it and attached by one end to its anus. This tube, which is the peritrophic membrane, is fairly resistant and keeps the excrement separated from the putrefying snail which is the food of the larva.

The larva, when full grown, leaves the shell, penetrates into the earth, and by the next day it becomes a pupa from which about 14 days later the adult emerges.

I endeavoured to find out the duration of each stage of the larval life but did not succeed because it was impossible to discover by any external signs whether or not the snail was parasitised. Had I found the Church Rate Walk snails at a sufficiently early date I would have dissected out the eggs and different larval stages from parasitised snails and inserted these in the unparasitised ones; but, by the time I discovered this apparently immune colony, the parasite was too far advanced in its development. I can only say that the development from egg to pupa is completed in about 15 days so that the whole life-cycle occupies about a month. I found the parasitised snails during June to September, but, as in June the snails contained some advanced larvae, it is probable that the life-cycle begins in May. The rapidity of the larval development indicates that *Melinda* probably passes through three generations in the year. The species hibernates in the pupal stage since I have found pupae during the whole year.

I mentioned previously that a snail may contain two or three larvae in different stages of development but only one of these larvae succeeds in completing its life-cycle. The others are always killed; the surviving larvae biting the others and possibly sucking them by accident; the brown scar of the bite can be seen on the deflated skins of dead larvae.

The parasitised snail cannot rid itself of the parasite. I never found a *Melinda* larva mechanically expelled from the snail nor phagocytised in the host's body as was often the case with *Pollenia rudis* in the earthworm (cf. Keilin, 1915 a, pp. 50-57).

Attempts to obtain eggs under artificial conditions were unsuccessful. A large number of males and females of *Melinda*, bred out from the snails and enclosed in a muslin cage, were fed with sugar and honey which they readily took. At intervals I dissected females but in no case did I find the ovaries developed or spermatozoa in the spermathecae. In all the females the fat body was largely developed, and this condition persisted from August until December by which time I had exhausted my material. Pl. XXV, Fig. 16, shows the state of the internal genital organs of one of these females.

(c) HYMENOPTERA HYPERPARASITES OF *M. COGNATA*.

As parasites of *Melinda cognata* Meig. I can only mention two Ichneumonids, which were kindly identified by Mr Claude Morley as *Atractodes exilis* Hal. and *Exolytus petiolarius* Thomson. Very little is known of the life-history of these Hymenoptera. In Morley's book on British Ichneumonids there is

only mentioned that the author found *Atractodes exilis* in August 1901 "swarming on *Heracleum* flowers in an ordinary meadow, at Lyndhurst in the New Forest." There is no record of the habits of *Exolytus petiolaris* which are only known to visit the flowers of *Angelica sylvestris*. And, referring to the whole genus *Exolytus*, Morley writes (p. 254) that "very little is at present known of the economy of this genus, though both Brischke's record of *E. laevigatus* from Tenthredinidae and Thomson's of *E. incertus* Först. from Syrphid larvae point to its relation with the Tryphoninae." These two Ichneumonids: *A. exilis* Hal. and *E. petiolaris* Thomson were bred by me under the following conditions:

Several parasitised snails of *H. virgata* were collected bearing the third stage larvae of *M. cognata*; they were kept in the laboratory in a jar covered by muslin. The *Melinda* larvae soon pupated and from the pupae emerged several imagines of *Melinda*, two specimens of *A. exilis* Hal. and two of *E. petiolaris*.

This shows us that the Ichneumonids oviposited in *Melinda* larvae when the latter were still in the snail. The oviposition probably takes place either when the larva protrudes the posterior end of its abdomen from the pneumostome of the snail, or when it lays free in the decomposed mass of its host.

III. DESCRIPTION OF THE EARLY STAGES OF *MELINDA COGNATA* MEIG.

(a) THE EGG of the parasite, extracted from the mantle cavity of its host, is elongated, slightly curved, and 1.1 mm. long (Pl. XXIII, fig. 4 a), it is white, has a very fine granulated surface, the markings being in the form of elongated hexagonal cells (fig. 4 b).

(b) FIRST STAGE LARVA.

As in almost all Cyclorhaphous Diptera, the larva passes through three stages separated by two moults. The first stage larva when full grown is about 2.6 mm. long. The fat cells being poor in reserve material, the larva is transparent and consequently its internal organisation is easily seen through the skin. The larva has a small head or pseudocephalon, three thoracic and eight abdominal segments (Text-fig. 1). The head, as is the case in all Cyclorhaphous larvae, is divided in its anterior portion by a deep median groove into two lateral lobes which bear each a rudimentary bell-shaped antenna and a slightly prominent maxillary palp, the latter composed of a number of sensory papillae.

On the ventral side of the first thoracic segment and near its anterior border are several series of black chitinous hooks with the points directed backwards. The meso- and metathoracic segments bear similar series of hooks but on these two segments they are smaller in size and fewer in number. Each of the first seven abdominal segments bears on its ventral surface two series

of similar hooks: one towards its anterior margin and with the points directed backwards, the other towards its posterior margin and with the points directed forwards. Thus each of the intersegmental grooves of the abdomen are bordered by two series of hooks with their points pointing in opposite directions (Text-fig. 2). This disposition of hooks is similar to that in the primary larva of *Pollenia rudis* (Keilin, 1915 *a*, p. 69) and in both cases it enables the larva to fix itself in the tissues of its host. On the ventral surface of the eighth or last abdominal segment is the anus which is in the form of a cleft surrounded by a perianal protuberance, while above and behind this are the only pair of functional spiracles which the larva possesses. The spiracles communicate with the lateral tracheal trunks through a "felt-chamber" which is a short tube filled with a spongy chitinous structure.

As the anatomy of the larva does not change very much during its development, I shall describe it in connection with the third stage. I shall confine myself here to a description of the mouth-parts as these are the only structures which differ considerably in the different stages.

The *Buccopharyngeal armature* is composed of the following parts (Pl. XXIV, fig. 7):—the basal or pharyngeal sclerite (*b.scl.*), which is strongly chitinated, its posterior lateral emargination (*l.e.*) through which the dilator muscles of the pharynx are visible, being very deep and wide. Anteriorly this sclerite becomes narrow and lengthens out into a chitinous plate which lies vertically in, and protrudes from the mouth, its anterior edge being sharpened like the blade of a knife. This anterior plate forms the labrum (*Lbr.*) of the larva. Ventrad to this anterior plate is another smaller sclerite, connected with it near its base and close to this connection the single salivary duct (*s.d.*) opens into the floor of the pharynx. The sides of this ventral sclerite are strongly chitinated and its anterior portion is thickened to form the labium (*lbm.*). On either side of the mouth is a "lateral hook," a flattened chitinous structure with a strongly dentate ventral edge (*l.h.*). These lateral hooks, hinged upon the sides of the ventral sclerite, are moved by extensor and retractor muscles, the motion of the hooks being in the vertical plane of the larva, their function being to scratch or hold on to the tissues of the host while the labrum cuts its way forward.

In the first stage *Melinda* larva the labrum is ankylosed with the basal plate so that the whole of this structure is moved as one piece when the

Fig. 1. First stage larva of *Melinda cognata* Meig. seen from the side.

Fig. 2. Intersegmental portion of the first stage larva of *Melinda cognata*.

labrum is being used as a cutting instrument. In *Pollenia rudis* on the other hand, the labrum is articulated with the basal plate and thus moves independently (Pl. XXIV, fig. 12).

(c) SECOND STAGE LARVA (Text-fig. 3).

The average length of the second stage larva is 7 mm. During this stage the larva is more opaque than in the first stage but its internal organs are still visible by transmitted light. The three thoracic segments, near the anterior border, show a few series of hooks with backwardly directed points, while each of the first five abdominal segments bears two series of hooks as in the previous stage. The three last segments show only the posterior series of hooks. The larva has now become amphipneustic, and the anterior prothoracic spiracles usually bear four to six short papillae (Pl. XXV, figs. 15, 17 and 25).

Fig. 3. Second stage larva of *Melinda cognata* seen from the side.

In some cases there are four or five of these papillae on the one spiracle and five or six on the other. I described a similar case in the larva of *Muscina assimilis* Fall. (1917, p. 410).

The structure of the postabdominal spiracles is the same as in almost all the Cyclorhaphous larvae (Pl. XXV, figs. 23 and 24). There are two spiracular tubercles and each possesses two oval clefts surrounded by a peritreme (*per.*) of irregular form. Near the outer border of this peritreme is a small white spot which marks the external opening of the perispiracular glands (*o.*) and this opening is surrounded by a series of chitinous hairs expanding in the form of a fan. Each spiracular tubercle, near its internal border, shows a scar (*sc.*) which represents the opening through which the tracheae of the previous larval stage were expelled.

Occasionally an abnormal spiracle is found in which one of the peritremes is double so that the tubercle has the appearance normal to the third stage larva (Pl. XXV, fig. 24, cf. also a similar abnormality in the third stage, p. 441 and Pl. XXV, fig. 21).

The *Buccopharyngeal armature* (Pl. XXIV, fig. 10) has now the appearance which is very usual in Cyclorhaphous larvae. The above mentioned figure shows clearly its structure and the relations of the different parts to one another. The basal sclerite is large and the floor of the pharynx, as in all parasitic Dipterous larvae, is without the longitudinal ridges which are so well developed in saprophagous larvae (cf. Keilin, 1915 *a*, pp. 127–142).

(d) THIRD STAGE LARVA.

The full-grown larva, when ready to pupate, is 12 mm. long and 0.6 mm. in diameter; the boundaries between the segments are not clearly marked and

the skin shows also supplementary folds which mask the real segmentation of the body (Text-fig. 4).

The chitinous hooks, which are small and transparent, vary in shape and there are all the transitions between a real hook-like process on the one hand and wide flattened scale on the other; these hooks or scales are disposed in series of sinuous rows.

The sensory organs of the skin are either in the form of small pits surrounded by chitinous rings, or in the form of hairs; the latter being in six groups, each composed of three hairs, which represent the remains of the thoracic legs, and are connected with the imaginal discs of these legs (cf. Keilin, 1915 *a*, pp. 166–173).

The larva is amphipneustic, the anterior, prothoracic spiracles are composed of five papillae (Pl. XXV, fig. 26) similar to those of the second stage. Each of the postabdominal spiracles (Pl. XXV, fig. 20) bears three oblong clefts surrounded by oval peritremes having the internal border dentate; the peritremes lie so that their axes converge towards the scar (*sc.*). The spiracular tubercle shows also four openings (*o.*) of perispiracular glands, which, as in the previous stage, are surrounded by divergent chitinous hairs. In a few cases these spiracles were abnormal, one peritreme being smaller than the other two (Pl. XXV, fig. 21). A similar abnormality was observed by Nielsen (1909, Pl. II, fig. 18 and Pl. III, fig. 49 *b*) in a third stage larva of *Ptychomyia selecta* Meig.

The *Buccopharyngeal armature* is of the same general structure as in the previous stage (Pl. XXIV, fig. 9) but it is much larger and the basal sclerite (*b.scl.*) shows, near the pharynx, a supplementary emargination, which is narrow and deep, thus marking out a small triangular plate (*t.*). The two lateral hooks (*l.h.*) are narrower and more slender than those of the second stage.

For the details of the structure of this organ I need only refer to Pl. XXIV, Fig. 9 which shows also the reduced antennae (*an.*), maxillary palpe (*m.p.*), and radiating furrows of the cheeks.

The *alimentary canal* (Pl. XXV, fig. 14). The pharynx (*ph.*) is followed by a short oesophagus (*oe.*), which, after passing through the nerve ring, penetrates the proventriculus (*pr.*) forming the oesophageal valve. Four short coeca (*c.*) arise from the anterior portion of the midgut, just behind the proventriculus. The midgut (*m.g.*) is very long and sinuous so that it is very difficult to trace its course. The two pairs of Malpighian tubes arise at the

Fig. 4. Third stage larva of *Melinda cognata* seen laterally.

junction of the mid- and hindgut. The salivary glands (*s.gl.*) are elongated, extending to nearly half of the length of the larva, their posterior ends being embedded in a patch of a fat-body.

(e) PUPARIUM AND PUPA.

The puparium (Pl. XXIII, fig. 5) is of a brown colour, oval and with clearly marked segments. The prothoracic spiracular horns (*h.*) of the pupa emerge from the puparium through a pair of holes on its latero-dorsal side near the intersegmental space which separates the first and the second abdominal segments. These horns (Pl. XXV, fig. 19) bear a great number of small spiracular papillae and each horn communicates with a long "felt-chamber" (*f.c.*) which, near its basal portion, inside the puparium, bears an internal spiracle (*i.sp.*). This latter has the form of a bifurcated tubercle bearing papillae upon each process.

IV. THREE OTHER FLIES LIVING UPON *HELICELLA*
VIRGATA DA COSTA.

(a) *MELINDA* SP. PROBABLY *M. GENTILIS* (R.-D.) Verrall (1912)¹.

In the kidney of several living specimens of *Helicella virgata* there occurred a first stage larva of another Calliphorine of which unfortunately I could not obtain either the other stages or the adult. This larva occupied the same position in the host as the larva of *M. cognata* and very often the two occurred simultaneously in the same host.

The anatomical study of this larva revealed its striking resemblance to that of *M. cognata*; in fact it differs from the latter only in the form and the size of the external cuticular hooks or spines and a few details in the structure of the buccopharyngeal organs. As shown in Pl. XXIV, fig. 8, the medio-dorsal sclerite or labrum (*Lbr.*) is more prominent, pointed, and curved dorsally; the lateral hooks (*l.h.*) are larger and more strongly chitinised. It is very probable that this larva belongs to *Melinda gentilis* which is also a very common species in England. The fact that these larvae occur less commonly in *H. virgata*, and are always killed by the larvae of *M. cognata* indicates that this snail is not their usual host. As on the other hand the different species of snails which I collected with *H. virgata* did not contain this larva, it is possible that the real host of *M. gentilis* is a *Limax* or an *Arion* as the slugs were common in all the places where I collected the *H. virgata*.

(b) *SARCOPHAGA NIGRIVENTRIS* MEIG.

Böttcher, in his paper on the genus *Sarcophaga* (1913, p. 367) quotes Villeneuve as authority for the statement that Prof. A. Giard, in September 1906, bred *S. nigriventris* from a snail, *H. cantioniformis*, collected near Wimeux in the Pas-de-Calais.

¹ *Melinda gentilis* R.-D. described by Verrall (1912) = *cognata* of Schiner and Strobl.

Another record on the habits of this very common species of Sarcophagid is contained in a short note of E. W. Howell (1917), published in the *Proceedings of the Malacological Society of London*. The note is as follows: "Some time since I found a number of dead and moribund *H. itala* on the common by Chipstead Station in Surrey which are apparently being destroyed by some dipterous larvae. Some of the imagines were bred out, and have kindly been identified by Mr K. G. Blair of the British Museum as *Sarcophaga nigriventris* Mead. The causes of the death among the Mollusca are so little understood that this identification seems worth recording."

From several specimens of *H. virgata* killed by the larvae of *Melinda cognata* and also from dead and decomposed specimens of *Theba cantiana* I extracted the full-grown larvae of a Sarcophagid from which the adults of *S. nigriventris* were bred. On the other hand I never obtained this fly from *H. itala* which were collected in great numbers along the Grantchester Road.

(c) *SARCOPHAGA* SP. PROBABLY *S. CRASSIMARGO* PAND.¹

There is not a single record in entomological literature of the life-history of this Sarcophagid.

I found its larvae last year in a few specimens of *H. virgata* collected from a large colony of these snails living on grass along a garden fence on the Barton Road, Cambridge.

The contents of the shells which harboured these larvae were reduced to a liquid putrefying mass, which, on a careful examination, showed also the chitinous remains of the mouth-parts, cuticle with spiracles, etc., of different stages of *Melinda* larvae. In one case, close to a *Sarcophaga* larva, I also found a recently killed larva of *M. cognata* which still contained all its internal organs.

All this shows clearly that the larva of *S. crassimargo* invades the snail which has been previously parasitised and killed by the larvae of *M. cognata* and that it then kills these larvae and lives upon the decomposed remains of their host.

The full-grown larva is 11 mm. long; it is composed of a pseudocephalon, three thoracic and eight abdominal segments, which bear numerous sinuous rows of small transparent and flattened hooks. The ventral side of the segments is covered with numerous hemispherical projections each bearing the sensory organs in the form of a pit surrounded by a ring of thickened chitin. The remains of the thoracic legs of the larva are represented by six groups of sensory organs each composed of three very short hairs. The respiratory system is amphipneustic. The prothoracic spiracles end in 15 papillae (Pl. XXV, fig. 22), the postabdominal, as is always the case in Sarcophagid larvae, lie in

¹ From the four pupae of this fly I obtained only one adult female. Unfortunately the females of *Sarcophaga* do not present very good characters for purposes of identification, though Mr Wainwright who examined this specimen found it to be almost certainly a ♀ of *S. crassimargo* Pand.

a deep posterior groove of the last (eighth) abdominal segment. The external chitinous ring which surrounds each spiracle (Pl. XXV, fig. 18) is not complete but interrupted near the scar (*sc.*). The three spiracular clefts are elongated and with their axes convergent towards this scar; the external openings of the perispiracular glands are exceedingly small.

The *Buccopharyngeal armature* (Pl. XXIV, fig. 11) is of the typical Cyclo-rhaphous form; the specific character here being the bilobed dorsal arm of the pharyngeal sclerite. All the other details of the structure of this organ are shown in the above mentioned figure.

The puparium of this fly can be easily recognised as belonging to a Sarcophagid by an examination of its posterior end which shows the spiracular pit. The prothoracic spiracles of the pupa are reduced to a pair of internal rosette-like organs which bear numerous papillae (Text-fig. 5) and which correspond to the internal spiracles of the *Melinda* pupa. The prothoracic spiracular horns, which in the latter protrude through the cuticle of the puparium, do not exist in this pupa nor in those of all the other Sarcophagids.

Fig. 5. Prothoracic spiracle of the pupa of *S. crassimargo* Pand. *f.c.* felt-chamber; *i.sp.* internal spiracle; *p.* spiracular papillae; *Tr.* tracheal trunks.

V. AN ACCOUNT OF ALL THE DIPTERA FEEDING UPON LIVING AND DEAD MOLLUSCS.

A great number of Diptera have been recorded living upon Molluscs, but our knowledge of the life-history of these insects is still very unequal. Whereas for a few of them we have a complete account of their development, for many others we only know that they were obtained from a particular species of Mollusc.

All these Diptera can be separated into four groups: (1) Parasitic, (2) Carnivorous, (3) Epizoic, and (4) Saprophagous.

(1) PARASITIC FORMS.

The following species have been recorded as parasites of different snails:

Chironomus sp., the larvae of which were recorded by Barnard (1911) as living in the mantle cavity of *Limnea peregra* Müller, collected in the foun-

tain of Trafalgar Square (London). The larvae attack chiefly the young snails, which, when parasitised, usually leave the water. The author was not sure as to the real necessity of the Mollusc for the development of this Chironomid. This case of parasitism needs verification and more attention ought to be paid to the feeding habits of the larva and to its close relation to the host.

Melinda cognata Meigen.: the larvae live as parasites on *Patula rotundata* Müller and *Helicella virgata* da Costa. For the complete life-cycle of this fly see the first part of this paper.

Melinda sp., probably **Melinda gentilis**, is a parasite of *H. virgata* (see p. 442 of this paper).

Melanophora helicivora Goureau. Goureau (1843) obtained six specimens of this fly from seven specimens of *Helix conspurcata*, which he collected in Paris and enclosed in a paper cone. He concluded that the fly lays one egg in each shell, and that the larva which hatches from the egg devours the Mollusc and transforms itself into a pupa inside the shell of the host; the adult fly emerges in autumn. Goureau's observation, as I have already mentioned (1915*a*), is very incomplete and this case of parasitism also needs further verification.

It is somewhat interesting to mention here that the other species of this genus: *Melanophora roralis* L. was obtained by Heylaertes from *Asopia farinalis* (recorded by Van der Wulp 1869, pp. 184–185). Brues (1903), on the other hand, found the pupae of this species in an empty skin of *Porcellio* (terrestrial Isopod).

Some unidentified Dipterous larvae, living as parasites upon Molluscs, were recently recorded by Schmitz (1917). In two cases he found them in an *Arion* collected near Sittard, Holland, and in one case in a *Helix aspersa* L. collected in Luxemburg.

(2) CARNIVOROUS FORMS.

Mydaea sp. allied to **Mydaea bivittata** Macq. In a recent paper by Rodhain and Bequaert (1916, p. 248) we find the following observation on the feeding habit of the larvae of this Anthomyid:

"The genus *Mydaea* exists in central Africa and its larvae are carnivorous; one of us bred at Kivou a great number of a species allied to *M. bivittata* Macq. (identified by Dr Villeneuve) from the larvae devouring a big terrestrial Mollusc (*Burtoa nilotica* Pfeiff.)."

I would note that the larvae of the other species of this genus (*Mydaea ancilla* Meig., *urbana* Meig. and very likely *tincta* Zett. and *pertusa* Meig.) are either carnivorous, living upon the larvae of other Insects, or (*Mydaea pici* Macq., *anomala* Yaenn., *torquans* Nielsen and *spermophila* Townsend) producing subcutaneous myiasis in different birds.

(3) EPIZOIC FORMS.

Wandolleckia cooki Brues, a wingless Phorid fly discovered by Cook on a large terrestrial Mollusc from Liberia. According to Wandolleck (1898) these flies seem to feed upon the mucus of their host.

Wandolleckia biformis Schmitz, collected by Bequaert on a large Mollusc: *Achatina*, found in virgin forest, Belgian Congo.

According to Schmitz (1917), who described this fly, its development is similar to that of *Termitoxenia* as described by Wasmann (1900–1913), i.e. it has lost its larval and pupal stages and become *Ametabolic*, this loss being compensated for by a certain degree of development during the imaginal stage. As in *Termitoxenia*, Schmitz found also in this species two kinds of individuals: (1) stenogaster females with soft chitin and retracted abdomen and (2) physogaster, normally chitinised females, with well extended abdomen. The males are unknown, and Schmitz supposes this insect to be a protandric hermaphrodite.

In my previous paper (1915b) I criticised the statement of Wasmann and insisted upon the fact that neither ametaboly nor hermaphroditism of *Termitoxenia* and *Termitomyia* is yet proved. To what is mentioned in my paper I can now add that the existence of steno- and physogaster forms does not demonstrate the ametaboly of an insect; in fact these forms are known in *Puliciphora pusillima* de Meijere (1912, Pl. IV, figs. 16 a and 16 b) while in another species of the same genus, *P. beckeri* de Meijere, both larval and pupal stages have been described and figured by de Meijere.

As to the protandric hermaphroditism of these insects, the only way to prove its existence is to find in the stenogaster forms all the stages of spermatogenesis, i.e. the spermatogonia and spermatids.

(4) SAPROPHAGOUS LARVAE AND DOUBTFUL PARASITES.

In this group, besides Phorids and several Acalypterates, we shall place Sarcophagids, though for a few of these flies the records are still contradictory and there is even a tendency to consider them as true parasites.

As on the other hand the complete life-history of these Sarcophagids is still unknown it is better to consider them as doubtful parasites and to examine them with the saprophagous forms.

SARCOPHAGIDAE.

Sarcophaga carnaria L. According to Portchinsky (1887, p. 17) a great number of these flies, which he identified as *S. atropos* Meig. (= *S. carnaria* L.), emerged from a lot of *Helix stavoropolitana* collected by König in the Caucasus. König mentioned that the larvae had apparently no effect upon the life of the snails, which lived in captivity a long time after the appearance of the flies.

This observation does not seem to be complete, and very likely the Sarcophagids hatched from pupae enclosed in some dead snails which he probably overlooked since he was dealing with a great number of these animals.

Mik (1890, p. 153) stated that this *Sarcophaga* was obtained by Brischke from another Mollusc: *Succinea* sp. We know also that the larvae of this common and well known species have often been recorded from wounds and from the cavities of the mouth, nose, ears, etc., of different mammals.

***Sarcophaga* sp.** probably *S. crassimargo* Pand. The larvae of this species live upon dead *Helicella virgata* da Costa previously killed by *Melinda cognata* Meig. (see p. 443 of this paper).

Sarcophaga haemorrhhoa Meigen. According to Mik (1890, p. 153) this species was bred by Prof. Bertkau of Bonn, from a *Helix hortensis* found attached to a leaf and which he supposed to be still alive. Schmitz (1917, pp. 25-27) obtained this fly from a young *Helix (nemoralis* or *hortensis*) collected in a wood near Maastricht.

Sarcophaga heliciis Townsend. The first record regarding the life-history of this Sarcophagid is found in an interesting note by Townsend (1892, pp. 220-221) the main part of which I reproduce here:

"I have recently received from Mr H. A. Surface, of the Ohio Experiment Station, a small Sarcophagid which he bred from *Helix thyroides* Say, while engaged on his catalogue of shells of Franklin County, published in Bulletin 2, Vol. 1, technical series, of that station.

Mr Surface accompanies the specimen with the following note: 'The snail was placed in a tight bottle August 25, in Warren County, Ohio, and during the first part of September the pupae were seen. From September 27 to 30 five or six mature flies came forth.' The fly proves to be a small species of *Sarcophaga*. After considerable time spent in looking over descriptions of North American species, I felt justified in considering it new."

According to Aldrich (1916, pp. 158-161) this species is one of the commonest North American Sarcophagids, and was bred from different Insects. Numerous records of the life-history of this species were mentioned by Aldrich in his note on "The economic relations of the Sarcophagidae" (1915) and in the above quoted monograph on the "*Sarcophaga* and allies."

I will quote here the following passage from the latter monograph (p. 160): "It is very likely that the species breeds largely in dead insects, and some of the records were made without allowing for this possibility. However, the species is a true parasite in grasshoppers and in *Eleodes*, and probably quite often in Lepidoptera and other insects. With this element of uncertainty to be kept in mind, the following are the cases of rearing recorded for the material I have examined." He then gives a full report on these cases, from which it is only necessary to mention that this fly was recorded from adult *Corydalus cornuta*, *Cicada tibicen*, *Calosoma* sp., *Leucania unipuncta*, adult *Lachnosterna*

arcuata, adult beetle *Dinapate wrightii*, from grasshoppers, larvae of Army Worm, from *Eleodes opaca* and finally from a Myriapod: *Sparabolus* sp.

Sarcophaga nigriventris Meigen, obtained by Giard (see Böttcher, 1913, p. 367) from *Helix cantioniformis* by Bowell (1917) from *Helicella itala*, and by me from *Helicella virgata* da Costa and *H. cantiana* Montagu (see pp. 442–443 of this paper).

Sarcophaga noverca Rond. bred by Schmitz (1917, p. 30) from a *Helix* found in Maastricht.

Sarcophaga privigna Rond. According to Mead (1897, p. 251), J. Künckel d'Herculais obtained this Sarcophagid from a *Helix lactea* from Algeria.

Sarcophaga setipennis Rond. bred by A. Giard (see Böttcher, 1913, p. 367) from *Helix acuta*, collected near Wimereux, Pas-de-Calais and by Schmitz (1917, p. 30) from an empty shell of a snail collected near Zaragoza, Spain. The adult fly was also recorded by this author from near Sittard, Holland.

Sarcophaga teretirostris Pand. obtained by me from a dead specimen of *Helicella cantiana* Montagu.

Sarcophaga sp. I found a few larvae of an unidentified Sarcophagid in dead *Helix aspersa* collected near Paris and in *Helicella cantiana* collected in Cambridge.

Helicobosca muscaria Meigen. The larvae of this fly were discovered by Perris (1850, pp. 119–122) in the snails *Helix pisana* Müll. collected in France near Mont-Marsan (Landres). He never found more than one larva in each snail. Before it pupates, the larva usually leaves the shell and burrows into the earth, but in some cases the pupae are formed in the snails. Perris supposed that the larvae feed only upon the dead Molluscs. In his paper he gives a description and figures of this larva. More recently, Schmitz (1910, pp. 107–109, 1917, p. 27) gave a complete account of the life-history of this fly. He found that the female deposits a big larva, about 5 mm. long, in a dead snail, about every 14 days; four or five weeks later this larva pupates and in this stage the insect hibernates, the adult emerging in the following spring. This low productive capacity of the fly and the long duration of the life-cycle explain according to Schmitz the rarity of this insect.

The internal genital organs and their function were described by Cholodkovsky (1908) and the mouth-parts of the first-stage larva by Nielsen (1917).

ANTHOMYIDAE.

Homalomyia canicularis L. I have bred this fly many times from different dead snails: *Helix pomatia*, *aspersa*, *nemoralis* and *hortensis* (see Keilin, 1911, p. 30). On the other hand the larvae are very common in all kinds of decomposed organic matter; they prefer however matter containing much ammonia,

and continue to live therein when all other dipterous larvae either depart or are killed in it.

PHORIDAE.

Aphiochaeta rufipes Meigen. The larvae of this fly were found by me in very great numbers, and in different places, living in dead snails: *H. pomatia*, *aspersa*, *nemoralis* and *hortensis*. My previous paper (1911, pp. 61-75) gives an account of its complete life-history and a description of the larval and pupal stages. The larvae of this species have also been recorded from different decomposed organic substances.

Aphiochaeta ruficornis Meigen. I have obtained the larvae of this fly only by killing snails and allowing them to putrefy. The material was obtained in Paris in the garden of the "École Normale Supérieure." For a complete description of the different stages of this insect see my previous paper (1911, pp. 76-78).

Phora bergenstammi Mik. According to Mik (1864, p. 793) this fly was obtained by von Bergenstamm from pupae found in a shell of *Helix pomatia*. In 1908 and 1910 Schmitz recorded the pupae of this insect from different snails. In 1911 I gave a complete description of the life-history and larval morphology of this fly (pp. 31-56) which I bred from different dead snails: *H. pomatia*, *aspersa*, *nemoralis*, *hortensis* and *arbustorum*.

Phora bohemani Becker. Schmitz (1908, 1910, 1917) found the pupae of this fly in different dead snails.

Phora immaculata Strobl, bred by Schmitz (1917, p. 36) from dead snails; there are two generations per annum. The pupa resembles that of *Ph. bergenstammi* Mik.

Phora maculata Meigen. The pupae of this species were found by Dufour (1840) in a shell of *H. aspersa*. Schmitz (1908, 1910, 1917) recorded them from the shells of different snails. To this species belongs also the puparium which I described as *Phora* No. 1 (1911, pp. 57-60). In 1912 my late friend J. Bonnet sent me a great number of dead snails: *H. aspersa* and *nemoralis*, collected by him near Toulouse, France, which contained the larvae and pupae of *Ph. maculata* Meig. (Text-fig. 6.)

Phora pressata Becker. In a few *Helix nemoralis* collected at Chaville, near Paris, I found the pupae which by breeding gave a *Phora* described by M. Becker as *Phora pressata* n.sp. In 1912 M. Becker proposed that I should insert his description of this species in the second part of a paper on the life-history of different Phorids. Circumstances prevented me from finishing this investigation and I therefore give now the description as it was sent to me in 1912.

Phora pressata n.sp. ♂ ♀.—

Rufa, thoracis dorso vix nitente, pilis nigris, setis dorsocentralibus duabus;

scutelli margine setis duabus; halteribus flavis.—Frons lata nigra opaca; antennis mediocribus fulvis, arista vix pubescente, palpis flavis.—Abdomen nigrum opacum, secundo et sexto segmentis longioribus, anguste niveo-marginalis.—Pedes toti flavi, femoribus posticis dilatatis; tibiis anticis antice unispinosus; tibiis mediis antice et apice unispinosus; tibiis posticis in medio et apice bispinosus.—Alae fere hyalinae, margine antico setulis brevibus.—Longit. corp. 2 mm. Patria: Gallia.

Affinis *Phorae unicalcaratae* Beck et *erythronotae* Strobl.

Phora unispinosa Zett. I found the larvae and pupae of this insect in dead *H. aspersa* picked up in the garden of the "École Normale Supérieure" of Paris. Their life-history is similar to that of *Phora bergenstammi* Mik.

Fig. 6. A shell of *Helix aspersa* with the upper whorl broken, showing the pupae of *Phora maculata* Meigen fixed to the inner side of the shell.

Phora sp. No. 2. Under this name I described the empty pupae (1911, p. 60) of a Phorid found in one specimen of *H. nemoralis* collected in Bernese Oberland, Switzerland.

Phora sp. the pupae of which were recorded by Schmitz (1917, p. 39) from a shell of a species of Pupid mollusc collected near Lisbon.

Hypocera molluscivora Schmitz, **Dorniphora bequaerti** Schmitz and **Pulci-phora spinicollis** Schmitz, according to Schmitz (1917), were bred by Bequaert with **Aphiochaeta xanthina** Speiser from different Molluscs (probably bivalves) from Africa.

EPHYDRIDAE.

Discomyza incurva Fallen. The larvae of this fly were found by von Bergenstamm (1864) in a dead *H. pomatia*. The pupae are fixed inside the shell in the same way as those of *Phora bergenstammi* Mik. I found near Paris one shell of *H. pomatia* containing a few of these pupae.

SCIOMYZIDAE.

Ditaenia cinerella Fallen, obtained by Schmitz (1917) from a shell of a *Helix* collected near Zaragoza, Spain.

Salticella fasciata Meigen. Perris (1850, pp. 122-123) found the larvae in a dead *Helix pisana*. According to Schmitz (1917, p. 29) it is not yet proved whether they are parasites or saprophagous larvae.

DRYOMYZIDAE.

Dryomyza sp. Schmitz recorded this fly as a not very common inhabitant of dead snails.

SEPSIDAE.

Nemopoda cylindrica Fabricius, bred by me from the larvae found in different dead snails. The eggs are of a peculiar shape having a very long filiform peduncle. These larvae occur also in the excrement of different domestic animals.

BORBORIDAE.

Borborus, **Sphaerocera** and **Limosina** have been recorded by Schmitz (1917, p. 30) from dead snails, but they occur also in all kinds of decomposed organic substances and especially in manure.

PSYCHODIDAE.

Philosepedon phalaenoides L. I have often found the larvae and pupae of this species in different species of decomposed snails (see Keilin, 1911, p. 30).

Philosepedon humeralis Meigen was recorded in dead snails by Westwood, Verrall, and recently by Schmitz (1917) who bred this insect from snails collected in Lisbon, Zaragoza and Maastricht.

APPENDIX.

OBSERVATIONS OF M. E. SÉGUY ON *MUSCA DOMESTICA* LARVAE
DEVOURING LIVING SNAILS.

On 24. iii. 1919 I received from M. E. Séguy of Rambouillet, France, a letter in which he communicated several of his unpublished observations bearing upon the relation between the house-fly and snails. The following is a summary of his letter:

He collected several snails, having the shell closed by the epiphragm, and examined them, breaking the latter, in the hope of finding the Phorid larvae. The snails secreted another epiphragm, but ten days later they were destroyed by the larvae of *Musca domestica*.

Living snails, closed with epiphragms, were put in a jar containing the larvae of *M. domestica*. In eight days the snails were completely eaten up by the larvae. The latter burrowed their way through the epiphragm and completely penetrated into the foot of the Mollusc. The penetration occupied about eight hours, and the abundant secretion of mucus by the snail did not seem to disturb the larva. The attacked snails are very often covered with a mite: *Eyrenetes limaceum* Schrank. The larvae, after they have destroyed one snail, pass easily into another living or dead specimen.

Living snails were placed under a bell-jar containing several pairs of *M. domestica* and 12 days later they were all devoured by the maggots. In the middle of January, 50 snails were collected from the wall close to the military hospital, they were separated in tightly closed jars which were placed at 25° C., 9 of the 50 Molluscs yielded *M. domestica* larvae.

The larvae, pupae and adults of this fly, bred from the snail, seem to be smaller than those which live or are bred from decomposed organic substances.

Séguy also recorded the presence in the snails of the larvae of *Calliphora erythrocephala* and *Phora giraudii* Egg.

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EXPLANATION OF PLATES XXII—XXV.

PLATE XXII.

Male (1) and Female (2) of *Melinda cognata* Meigen. $\times 8$.

PLATE XXIII.

(The surface structure of the snail's skin is schematized in Figs. 1 and 3.)

- Fig. 1. *Helicella (Helio manes) virgata* da Costa, with the anterior part of its body extracted from the shell and with opened mantle cavity (*m.c.*) showing a big second stage larva (*L.*) of *Melinda cognata* Meigen. The larva has been cleared from the distended integument of the kidney which partly covered its body. The dissecting needle (*a*) points the position of the pneumostome of the host towards which are directed the postabdominal spiracles of the larva.
- Fig. 2. An empty shell of a young specimen of *H. virgata* with two larvae of *Melinda cognata*; *sp.*, spiracles. One of these larvae developed in this shell, the second migrated thither from another shell as the insects frequently do before pupation. $\times 8$.
- Fig. 3. A young *H. virgata* extracted from its shell and showing by transparency in its mantle cavity (*m.c.*) an egg (*ov.*) of *M. cognata*, and, in the kidney (*k.*) a first stage larva (*L.*) of this fly. The posterior end of the larva, bearing the spiracles, protrudes into the mantle cavity of the host; *liv.*, liver. The same specimen contains also the crumpled chorion of an empty egg belonging to the first stage larva.
- Fig. 4. Egg of *Melinda cognata* (*a*) and the structure of its surface (*b*). $a \times 42$, $b \times 240$.
- Fig. 5. Puparium of *M. cognata* from dorsal side, showing the respiratory horns (*h.*). $\times 8$.
- Fig. 6. *H. virgata*, retracted in its shell and showing the posterior end with spiracles of the third stage larva of *M. cognata*, protruding from the pneumostome of the host; *f.*, foot of the snail. $\times 6$.

PLATE XXIV.

All the figures are of the buccopharyngeal armatures of different larvae viewed laterally.

Letters common to these figures: *an.*, antennae; *b.scl.*, basal or pharyngeal sclerite; *int.*, intermediate sclerite; *lbm.*, labium; *Lbr.*, labrum; *l.h.*, lateral hooks; *l.e.*, lateral emargination; *m.p.*, maxillary palps; *ph.*, pharynx; *s.d.*, salivary duct; *s.e.*, supplementary emargination; *t.*, triangular plate.

- Fig. 7. Head and buccopharyngeal armature of the first stage larva of *M. cognata*. $\times 240$.
- Fig. 8. Buccopharyngeal armature of the first stage larva of *Melinda* sp. probably *Melinda gentilis*. $\times 240$.
- Fig. 9. The same organ of the third stage larva of *M. cognata*. $\times 84$.
- Fig. 10. The same organ of the second stage larva of *M. cognata*. $\times 240$.
- Fig. 11. Buccopharyngeal armature of the third stage larva of *Sarcophaga* sp. probably *S. crassimargo*. $\times 42$.
- Fig. 12. The same organ of the first stage larva of *Pollenia rudis* Fab. parasite of earthworm (*Alloobophora chlorotica* Sav.).
- Fig. 13. The same organ of the first stage larva of *Onesia* sp. probably *Onesia vespillo*.

PLATE XXV.

Letters common to all the figures of this plate: *a.g.*, accessory glands; *c.*, anterior intestinal coeca; *d.n.*, dorsal central nervous system; *f.c.*, felt chamber of spiracles; *i.d.*, imaginal discs of the head; *i.sp.*, internal spiracles of the pupa; *m.g.*, midgut; *o.*, external opening of perispiracular glands; *od.*, oviduct; *oe.*, oesophagus; *ov.*, ovary; *p.*, spiracular papillae; *per.*, peritremes of spiracles; *ph.*, pharynx; *pr.*, proventriculus; *rec.*, rectum; *r.h.*, respiratory horn of the pupa;

1

2

Melinda cognata Meigen, ♂ (1), ♀ (2)

r.s., receptacula seminis; *s.c.*, external spiracular scar; *s.d.*, salivary duct; *s.gl.*, salivary gland; *Tr.*, tracheal trunks; *ut.*, uterus; *v.n.*, ventral nervous system.

All the figures except figs. 18 and 22 concern *Melinda cognata*.

- Fig. 14. Dissection of the anterior portion of the third-stage larva of *M. cognata* Meig.
Fig. 15. Anterior prothoracic spiracle of the second-stage larva, with four papillae. $\times 240$.
Fig. 16. Internal genital organs of a female emerged from the pupa August 15th, kept in laboratory on sugar and honey and dissected November 5th. $\times 16$.
Fig. 17. Prothoracic spiracle of the second-stage larva, with six papillae. $\times 240$.
Fig. 18. Postabdominal spiracles of the third-stage larva of *Sarcophaga* sp. probably *S. crassimargo*. $\times 84$.
Fig. 19. Prothoracic horns with internal spiracle of the pupa of *M. cognata*. $\times 134$.
Fig. 20. Postabdominal spiracle of the third-stage larva of *M. cognata*. $\times 240$.
Fig. 21. A similar spiracle but of abnormal structure, with one peritreme reduced. $\times 240$.
Fig. 22. Prothoracic spiracle of the third-stage larva of *Sarcophaga* sp. probably *S. crassimargo*. $\times 84$.
Fig. 23. Postabdominal spiracle of the second-stage larva of *M. cognata*. $\times 240$.
Fig. 24. A similar postabdominal spiracle but of abnormal structure. $\times 240$.
Fig. 25. Prothoracic spiracle of the second-stage larva of *M. cognata*, with five papillae. $\times 240$.
Fig. 26. Prothoracic spiracle of the third-stage larva of *M. cognata*. $\times 240$.