

ORIGINAL ARTICLES

LIFE-HISTORIES OF SOME INDIAN SYRPHIDAE

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(With Plates LX-LXVII.)

INTRODUCTION

The Syrphidae of India, as far as the adults are concerned, have been dealt with by Brunetti [1923]. Since then no attempt has been made to revise his work on the family. Taking Brunetti's work as a basis for further investigations, such a revision is badly needed, for it will bring forth some very useful information and add many new genera and species to the list of those already described in the Fauna Volume. There is a great diversity of forms within this family and there is no family of insects which resembles bees and wasps so much as the Syrphidae. Like the adults the larvae of Syrphidae present different forms associated with different feeding habits. Some are of the ordinary maggot type, others possess a long tail which is three to four times the length of the body and on this account have been called rat-tailed larvae, and still others (*microdon*) possess such a peculiar combination of characters as to have baffled the entomological workers so much as to have made them give to the larvae the rank of distinct species in the Phylum Mollusca.

The economic status of the family is on the whole beneficial. There are some species the larvae of which have been known to cause some damage to the leaves and flowers of maize [Riley and Howard, 1888] in certain localities in America and still others, e.g., *Eumerus strigatus* whose larvae destroy to a certain extent the bulbs of onion. Verrall [1901] mentions that *Eumerus strigatus* Fallen has been bred from the bulbs of common onion (*Allium cepa*) of which they sometimes destroy the whole crop. The larvae occurred in July and pupated in the bulbs or in the neighbouring earth; sometimes bred from soft and rotten bulbs. These stray instances of damage done by the larvae of some species of Syrphidae are nothing as compared to the immense good done by others the larvae of which prey upon the nymphs of Aphidae, Coccidae, Psyllidae and Aleyrodidae. The ravages of plant lice, scale insects and the white fly to the cultivated crops are too well known, both to the cultivator and the scientific worker, and therefore need not be mentioned here.

It seems that the good done by the larvae of the aphidophagous species of Syrphidae in reducing to a considerable extent the attack of plant lice has not been properly appreciated, for, had it been so, our knowledge of the immature stages of the species of these flies would not have been so incomplete. Excepting a plate illustrating the various stages in the life-history of *Ischiodon scutellaris* (Fabr.) in the Indian Insect Life [Howlett, 1910] and some notes on *Paragus serratus* (Fabr.) published in *Pusa Bull.* No. 59 [Fletcher, 1916] there is no published record of the immature stages of any other species of Syrphidae feeding on Aphids.

The present paper is the result of observations made on the various stages in the life-cycles of some aphidophagous species both in the field and the laboratory during the years 1931-32, and has been written with the intention of helping the scientific worker with some information which may be of some use to him in distinguishing in the field the larvae of the various species dealt with in this paper.

The life-histories of altogether eight species have been included in this paper, of which seven are those of the aphidophagous species and the eighth deals with the life-history of *Helophilus bengalensis* (Wied.). The life-history of each species is accompanied by a plate. Some of the drawings in the plates have been made by the senior author and hence are not artistic though in the matter of details they will not be found lacking.

The identification of a species of insect by its larval characters is important and desirable, but it will be found that very little attention has been paid towards this side of entomology. An attempt would have been made to draw out a table for the identification of the aphidophagous species of Syrphidae by their larval characters, had the material been enough. As such, it is hoped that the characters of the larvae of various species given here will be made use of by any future worker on this problem.

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THE RELATION BETWEEN THE LARVAE OF APHIDOPHAGOUS SPECIES OF SYRPHIDAE, THEIR HOSTS AND THE PLANTS ON WHICH THEY ARE FOUND

There are many plants both wild and cultivated which are infested by one or more species of aphids, and some are heavily attacked. Besides this there are insects belonging to other families such as Coccidae, Aleyrodidae, Psyllidae, Membracidae and Jassidae, the nymphal stages of which do appreciable damage by sucking the juices of the plants upon which they are found. Very often larvae of a single

species of Syrphidae or belonging to two or three distinct species will be found among the colonies of aphids on a plant. It is rare to come across a colony of aphids on a plant which does not possess in the midst of its individuals a Syrphid larva. The Syrphid larvae prey upon the aphids very voraciously, so much so, that sometimes the plant is free from their attacks. The voraciousness of the Syrphid larva can not be questioned. A simple observation with a pocket lens in the field while the larvae are feeding, or in the laboratory when they are brought for examination will prove this. It was observed in a four to five days old larva of *Baccha pulchrifrons* Aust., which was found feeding on the nymphs of the Psyllid, *Ctenophalara elongata* Crawf., that it sucked a nymph of small size in less than a minute after which it attacked another bigger in size and sucked it in one minute and thirty seconds. The larva was then placed in a Petrie-dish with a leaf of *Bombax malabaricum* infested with the nymphs (both grown up and small) of *Ctenophalara elongata* Crawf. Only one hundred nymphs were allowed to remain on the leaf and the rest removed. The larva was examined after an hour and was found to have killed sixty nymphs. Similar observations were made on larvae of *Paragus serratus* (Fabr.), *Sphacrophoria javana* (Wied.), and *Syrphus balteatus* (De Geer) and the results obtained were much the same as derived from the larva of *Baccha pulchrifrons* Aust.

The larvae of the aphidophagous species of Syrphidae take in more food than is required for enabling them to pupate. This surplus amount of food is stored by them in the form of fat. The amount of fat stored by the larva is in proportion to the quantity of food available to the larva in the field. Thus the larvae possess sufficient powers to resist starvation. Two adult larvae of *Baccha pulchrifrons* Aust. bred under laboratory conditions with ample food were found to resist starvation for a number of days, one dying nine days, and the other ten days, after they were subjected to these conditions.

It is quite natural to presume that a close relationship exists between the life-cycle of a particular species of Syrphidae and that of the aphid upon which it preys. This statement was verified during field observations, when many times a single newly hatched Syrphid larva was found on the lower side of the leaf of the plant in association with very few aphids thus proving that the larvae of the aphidophagous species or Syrphidae make their appearance just at the time when the aphids begin to form colonies. They complete their life-cycle while the aphids are on the plant and disappear with the disappearance of the aphids. Nature has therefore introduced enemies to check the prodigious production of the aphids and has saved the plants from destruction.

The larvae of the aphidophagous species of Syrphidae are very voracious. A Syrphid larva devours within a period of one to two weeks of its existence a good

lot of aphids thus saving the plant from its worst enemy during the most critical period of its growth. Although the benefit derived by the plant may not in some cases be appreciable on account of the attack of the aphids being serious and the plant may show signs of withering, yet it may be borne in mind that the harm done by the aphids would have been incalculable if they would have been allowed to breed unchecked. If, as Reamour calculated and others have substantiated, one aphid may be the progenator of over 5,000,000,000 individuals during her existence of a month or six weeks, one can imagine how much benefit the plant derives from these natural enemies of the aphids.

The eggs of the aphidophagous species of Syrphidae are laid singly on the surface of the leaves. The eggs are chalk white and can easily be recognized on the green surface of the leaf on which they are laid. They are seen laid during the day time when the flies are seen actively hovering over the plants, searching for suitable places for laying eggs. Invariably a limited number of eggs are seen on a leaf. Usually one or two eggs or at the most five eggs have been observed on a leaf infested with aphids. An egg will be found very near a colony of aphids, so that on hatching it may not have to search for food which will be lying very close to it. It will be found that a distinct relation exists between the number of aphids and the number of Syrphid larvae that are to prey upon them on a plant. The interest of the plant is also concerned, for, if the aphids are in a relatively greater proportion to the Syrphid larvae, there is a danger of the plant being seriously damaged, and if they are in a lesser proportion, there is a danger of Syrphid larvae dying of starvation.

A peculiar case of predatism was recorded while studying the life-history of *Baccha pulchrifrons* Aust. The egg of this species are laid in association with the nymphs of the Psyllid, *Ctenophalara elongata* Crawf., on the leaves of *Bombax malabaricum*. On the same leaves the stalked eggs of a species of *Chrysopa* (which unfortunately could not be determined) are also laid. The eggs of the *Chrysopa* are light greenish-yellow when they are freshly laid, and turn brown at the time of hatching. The larvae hatching from these eggs are reddish purple at the time of maturity. They are provided with long legs, very long spines on the abdominal segments and powerful inwardly curved hollow mandibles. The *Chrysopa* larva is a very voracious feeder on Psyllid nymphs. Not only that, it was also found to prey upon the eggs and larvae of *Baccha pulchrifrons* Aust. It breaks open the egg shell by the sharp ends of its mandibles after which it sucks the contents of the egg. A single larva of *Chrysopa* was confined in a cage with four larvae of *Baccha pulchrifrons* Aust. at 11 a.m. on 10th December 1931. Next day one larva of the latter was found completely sucked and another partially so by the former which was then in the act of forming a cocoon. In order to find out whether the larvae of *Baccha pulchrifrons* Aust. also prey upon the eggs of *Chrysopa*, two seven-days-old larvae of

the Syrphid fly were placed with 17 eggs of the *Chrysopa* and some Psyllid nymphs in a cage on 11th December 1931. The Syrphid larvae were closely watched while feeding, and during these observations the larvae were found to bend the stalks so as to bring down the eggs on the surface of the leaf and then suck them up. Therefore, there exists a keen struggle for existence between the larvae of *Chrysopa* and those of *Baccha pulchrifrons* Aust., the former preying upon the eggs as well as the larvae of the latter which only preys upon the eggs of the former. The loss sustained by the Psyllid colony through the attacks of the larvae of the Syrphid and the *Chrysopa* species is to a great extent minimized by their mutual warfare. The plant is also saved in a way from the attack of the Psyllid, which would have been heavy, had not there been two different kinds of larvae preying upon the nymphs of the Psyllid.

ENEMIES

The parasitic insects belonging to the family *Ichneumonidae* seem to be the natural enemies of the larvae of the aphidophagous species. Specimens of *Bassus multicolor* Grav., were reared from the larvae and pupae of *Ischiodon scutellaris* (Fabr.). The parasite probably drops its eggs into the body of the larva of *Ischiodon scutellaris* (Fabr.) through the skin. The larva of the parasite grows in the body of the Syrphid larva without hindering its pupation. The parasite emerges through a slit in the anterior broad rounded portion of the pupa. The emergence of the parasite takes place ten to fourteen days after the pupation of the larva. Only one parasite was seen to emerge from one pupa. The description of the adult parasite will be found in the Fauna of British India, Hymenoptera, Vol. III., pp. 279-280.

TABLE I

The habitats and the time of occurrence of the larvae of the aphidophagous species of Syrphidae, the records of which are available in Pusa collection

Name of the species	Found feeding on	Time of occurrence	Locality
<i>Baccha sapphirina</i> (Wied.)	Indigo Psylla	30th October 1912	Pusa
Do. ditto	Orange Aphis	16th June 1913	Do.
		18th February 1916	Do.
		20th February 1916	
Do. <i>pulchrifrons</i> (Aust.)	<i>Ctenophalara</i> <i>elongata</i> Crawf. on <i>Bombax</i> <i>malabaricum</i>	4th January 1927	
		15th November 1931	
		27th November 1931	
		5th December 1931	

Name of the species	Found feeding on	Time of occurrence	Locality
<i>Paragus serratus</i> (Fabr.)	Probably bred on root aphid	19th September 1913	Coimbatore
Do. ditto	Aphis on red gram shoots	23rd November 1906	Samalkot
Do. ditto	Green aphid on <i>Phyllanthus emblica</i>	27th July 1914	Pusa
Do. ditto	Aphis on <i>Solanum</i> sp.	20th June 1915	Do.
Do. ditto	Aphis on water-melon	30th May 1907	Hagari
Do. ditto	Aphis on <i>Dolichos Lablab</i>	9th May 1931	Pusa
<i>Ischiodon scutellaris</i> (Fabr.)	Aphis on <i>Solanum</i> sp.	19th November 1915	Do.
Do. ditto	Aphis on <i>Chrysanthemum</i> .	28th January 1915	Do.
		30th January 1915	
		1st November 1915	
Do. ditto	Aphis on water-melon	2nd May 1907	Hagari
		29th May 1907	
Do. ditto	Aphis on Ak (<i>Calotropus</i>)	2nd June 1906	Pusa
Do. ditto	Aphis on cotton	3rd July 1906	Do.
		2nd August 1906	
		15th February 1908	
		2nd March 1908	
Do. ditto	Aphis on cabbage	1st September 1904	Do.
		27th April 1905	
Do. ditto		25th March 1908	Do.
Do. ditto	Wheat aphid	7th March 1908	Do.
Do. ditto	Aphis on sisso	17th May 1931	Do.
Do. ditto	Aphis on mustard	23rd February 1932	Do.
		1st March 1932	
		16th March 1932	

Name of the species	Found feeding on	Time of occurrence	Locality
<i>Sphaerophoria javana</i> (Wied.)	<i>Ctenophalara elongata</i> , Crawf. on <i>Bombax</i> <i>malabaricum</i>	7th November 1931 23rd November 1931	Pusa
Do. ditto . . .	Aphis on cotton . . .	30th November 1931 23rd December 1931	
<i>Syrphus serarius</i> (Wied.) . . .	Mustard aphis . . .	4th March 1932 8th March 1932	Do.
Do. <i>balteatus</i> (De Geer) . . .	Aphis on sunflower . . .	25th February 1907	Do.
Do. ditto . . .	Aphis on cotton . . .	20th December 1931	Do.
Do. <i>confrater</i> (Wied.) . . .	Cabbage aphis . . .	16th March 1908	Do.
Do. ditto . . .	Aphis on chrysanthemum	1st February 1915	Do.
Do. ditto . . .	Wheat and cotton aphis . . .	14th March 1908	Do.
Do. ditto . . .	<i>Eriosoma lanigera</i> (Woolly aphis).	21st September 1923	Srinagar (Kash- mir)
Do. ditto . . .	Pomegranate aphis . . .	25th September 1923	Do.
Do. <i>isaaci</i> sp. nov. . . .	Aphis on mustard . . .	7th February 1932 11th February 1932	Pusa

LIFE-HISTORY OF *Baccha pulchrifrons* AUSTEN*Allobaccha apicalis*

Introduction

The genus *Baccha* can easily be distinguished by the following characters:—

Head more than hemispherical, face hollowed below frontal prominence, produced again to a central knob, not produced at upper mouth edge; species dark with pale markings on the head, thorax and abdomen, the latter conspicuously constricted at the base.

Baccha pulchrifrons Aust. has been recorded from Bhowali, Darjeeling district; Pusa, Bihar; Mormugoa, Goa; Hot Wells, Trincomalee; Ceylon; Cherrapunji, Assam and jungle at the base of Dawna Hills.

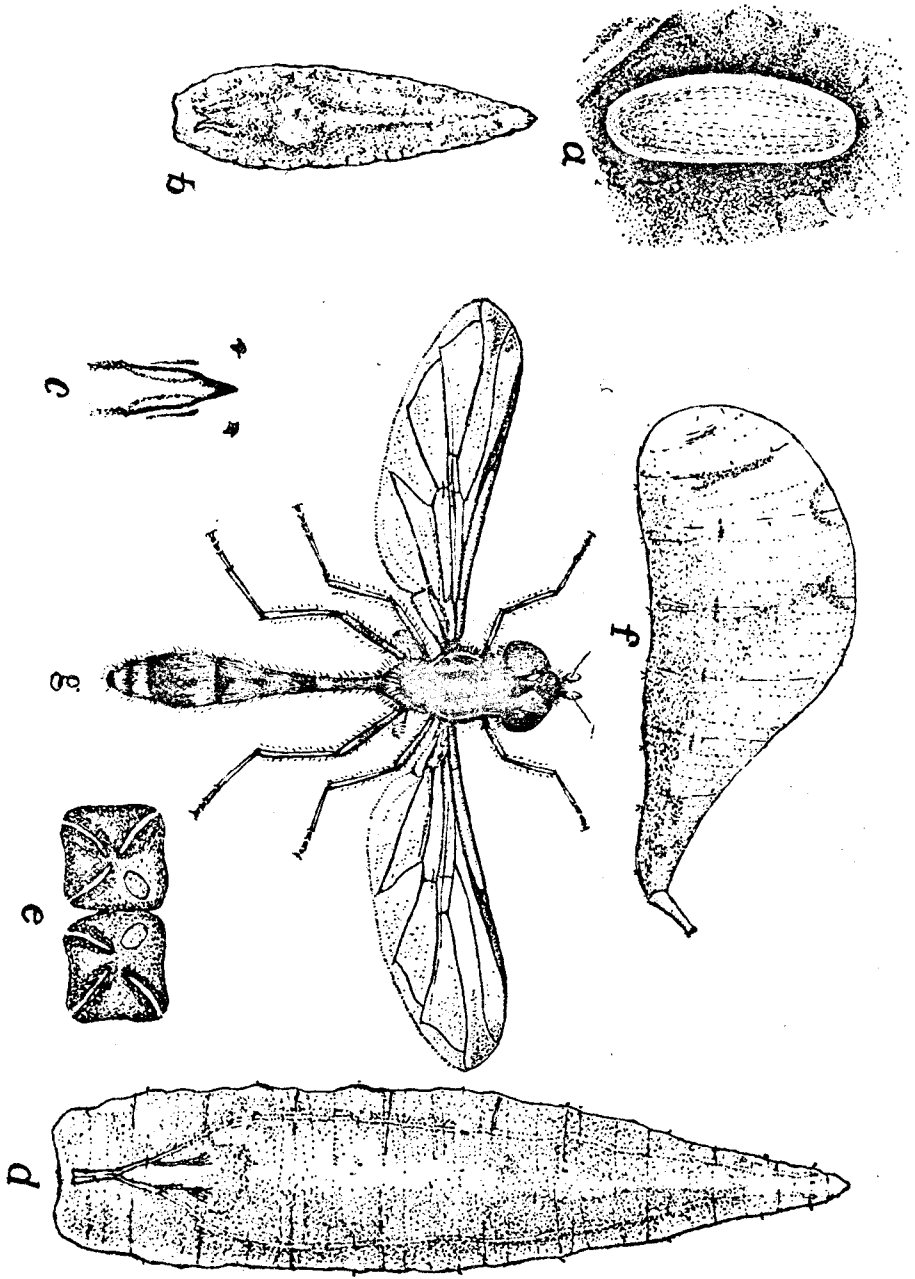
Some observations

In Pusa the fly has been collected during the months of January, February, August, November and December. About the middle of November 1931, the flies were seen hovering about the young plants of *Bombax malabaricum*, probably in search of suitable places for egg laying. It is about this time that the nymphs of the Psyllid, *Ctenophalara elongata* Crawf. make their first appearance on the leaves. The leaves of *Bombax malabaricum* infested with Psyllid nymphs were thus collected from the trees and brought to the laboratory for detecting the eggs. After a careful search the eggs were found. The nymphs of the Psyllid were found both on the upper and the lower surface of the leaves, more particularly on the lower surface as it is soft being less exposed to sun than the upper surface. If the infestation is less, the nymphs are seen collected close to the primary vein of the leaf and in case it is heavy they are seen on the secondary veins also or spreading on the entire surface of the leaf. The eggs of *Baccha pulchrifrons* Aust., as of all aphidophagous species of Syrphidae are deposited singly. An egg is laid by the fly just near a small colony of Psyllid nymphs, so that the larva on hatching may find food at once to begin its existence. The number of eggs laid by the fly is proportionate to the nature of infestation. Usually one to two eggs or at the most four eggs were noticed on a leaf.

Field collections of leaves infested with nymphs of *Ctenophalara elongata* Crawf., were made on a large scale for the eggs and larvae of *Baccha pulchrifrons* Aust. About 200 such leaves were examined every day and eggs and larvae were sorted out and kept separately in Petrie-dishes with food for rearing. Daily observations in the colour changes of the larvae and the pupae of this species were made and the life-history was thus worked out.

The egg (Plate LX, fig. a)—The freshly laid egg is milk-white with a light yellow tinge about its middle. It is .90 mm. long and .30 mm. broad. It is elongated oval in outline, rounded at both the ends, rather slightly narrower at the anterior end which bears the micropyle on a small conical projection. The chorion of the egg is sculptured with small rod-like calcareous structures arranged in longitudinal rows parallel to the long axis of the body of the egg. Each such structure sends out very small branches on both the sides of its body. These small branches from the structures do not form a net-work.

The approximate incubation period can be judged from Table II given below which gives the date of collection and the date of hatching of the eggs.



Baccha pulcherrima Austen.

(For explanation please see p. 570.)

TABLE II

Giving the date of collection, the number of eggs collected and the date of hatching of eggs of Baccha pulchrifrons Aust.

Date of collection of eggs	Number of eggs collected	Number of eggs hatched and the date of hatching
7th November 1931 (morning) .	3	Two eggs hatched at 10 a. m. on 8th November 1931 One hatched at 8 a. m. on 9th November 1931
13th November 1931 ,, .	1	Hatched at 9 a. m. on 14th November 1931
14th November 1931 ,, .	8	Three hatched at 1 p. m. on 15th November 1931
16th November 1931 ,, .	8	Six hatched at 10 a. m. on 18th November 1931
20th November 1931 ,, .	14	Thirteen hatched at 11 a. m. on 22nd November 1931
21st November 1931 ,, .	8	Three hatched at 8 a. m. on 23rd November 1931
23rd November 1931 ,, .	8	Four hatched at 11-30 a. m. on 24th November 1931
27th November 1931 ,, .	14	Four hatched at 10 a. m. on 29th November 1931
28th November 1931 ,, .	13	Four hatched at 9 a. m. on 30th November 1931

The young larva (Plate LX, fig. b)—The newly hatched larva is 1.92 mm. long and .53 mm. broad. The body is sub-cylindrical being flat ventrally and convex dorsally. It is broad posteriorly and is seen to narrow gradually towards the anterior end. In colour, it is greyish white, and beneath the skin, yellowish about the middle and light orange towards the hind end of the body. The segments of the body are marked with transverse wrinkles in the skin at regular intervals. The oral aperture is situated ventrally at the anterior end of the head within which is the oesophageal framework containing the jaws and the mouthhooklets worked backwards, forwards and transversely by a complex set of muscles controlling the working of the oesophageal framework. The two tracheal tubes, one on each side, run a wavy course within the body. They open anteriorly at the sides of the prothoracic segment by the anterior spiracles placed at the end of the small chitinous anterior larval respiratory cornua and posteriorly by spiracles on the last

segment mid-dorsally at the ends of the posterior larval respiratory tubes which in the young larva are separate. The median dorsal blood vessel is almost colourless and can be made out by the pulsation of its various chambers. If followed from the posterior to the anterior end, it is seen to disappear at the prothoracic segment. On the sides of the dorsal blood vessel at about the anterior third of the body of the larva are two triangular patches of fat, their apices being directed forwards. Another rectangular fat area is situated just behind the middle of the body and extends upto the penultimate segment of the body of the larva. The posterior side of this area is produced downwards at the angles. Pairs of small patches of fat, one such pair in each segment excepting the last, are found dorsolaterally in the body segments of the larva.

The young larva feeds very voraciously on the young Psyllid nymphs. During the time when it is feeding, it will be seen piercing at various places the soft abdomen of its victim by the pointed anterior portion of its jaws. As soon as the punctures are made, the jaws begin to work again vigorously backward and forward and by their action, aided by the mouth hooklets, the victim is sucked up completely, the remains of its body being left on the leaf as a small crumpled piece of chitin. It goes on feeding upon its prey in this manner for some time after which it rests on the surface of the leaf during which the pulsation of the various chambers of the heart can very well be seen. It soon becomes active after the repose taken and begins attacking other nymphs on the leaf.

In Pusa the larvae of *Baccha pulchrifrons* have only been found feeding on *Psylla* on *Bombax malabaricum*, there being no alternative hosts. The larvae were tried under laboratory conditions on cotton aphis. Two larvae of *Baccha pulchrifrons*, about six to seven days old, were kept in a cage with all sizes of nymphs of cotton aphis on a leaf of cotton. Fresh food was given to the larvae every day. Although the food was so near at hand, the larvae did not even go near it and were ultimately starved to death, one dying 10 days, and the other 11 days, after they were kept on this food.

Full-grown larva (Plate LX, fig. d).—The full-grown larva of *Baccha pulchrifrons* is 3.5 mm. long and 2.0 mm. broad. It is of a light grey colour with a prominent rectangular white fat area on the dorsal side just behind the middle of the body. The head of the larva is apparently composed of two segments. Protruding from the tip of the first segment at the time of feeding of the larva, can be seen the jaws and the anterior mouth hooklets. The antennae are seen to arise ventrally from the first segment of the head. Each antenna is bifurcated at its distal end, the inner piece being composed of two joints. The first segment of the head is covered over with small sensory spines. In each segment of the body excepting the prothoracic and the last there are three false lines due to wrinkles in

the skin. On account of these wrinkles it is rather difficult to ascertain the number of segments in the body of the larva. The arrangement of spines at regular distances in the region of the body of the larvae of most of the aphidophagous species of Syrphidae solves the difficulty by giving an indication of the position of inter-segmental lines. These spines have been named as segmental spines, but we should prefer to call them inter-segmental spines as they are situated in the inter-segmental regions of the body of the larva. There are 10 rows of spines in the larva of *Baccha pulchrifrons* as in other larvae of the aphidophagous species of Syrphidae. The first row of spines is between the head and the prothoracic segments and the last row between the penultimate and the last segment. In each row there are 12 spines, viz., a pair of median, a pair of dorsal, a pair of dorso-lateral, a pair of ventro-lateral and 2 pairs of ventral spines. Besides this, there is a small bristly pubescence all over the body of the larvae of most of the aphidophagous species.

These inter-segmental spines are more prominent in the young larva. In the adult larva they can only be made out with the help of a microscope. Each spine has the basal portion and the tip white, the middle portion being black.

The mouth parts of the larva (Plate LX, fig. c) consist, as in the larvae of other aphidophagous species, of a pair of inverted V-shaped jaws and 2 pairs of mouth hooklets (2-4 pairs in other species). All these parts are heavily chitinized and are of a black colour. The two pairs of mouth hooklets are an outer and a lateral pair. The hooklets of the outer pair are bidentate, those of the lateral pair are rod-like and slender.

The two tracheal tubes are clearly seen through the translucent skin of the larva. Anteriorly they open by spiracles placed at the tips of the two anterior larval respiratory cornua, one on each side of the prothoracic segment and posteriorly each tube is continued separately into the chitinous respiratory tube situated on the mid-dorsal portion of the last segment. The chitinous respiratory tubes which are separate in the younger stages of the larva become closely applied by their inner sides and form a single posterior respiratory appendage which is seen prominently sticking out from the last body segment. In the adult larva the posterior respiratory appendage is about 1 mm. long. Each tracheal tube gives a branch on its inner side before it passes into the respiratory appendage. This branch is divided at its end into fine branches supplying the ninth segment. At the end of the respiratory tube on each side are seen three digitate spiracles at the three angles and at the fourth inner angle a dorsal circular plate as shown in Plate LX, fig. e.

The two anterior triangular fat areas of the young larva cannot be seen in the adult larva. The two small dorso-lateral patches of fat in each segment are clearly

seen in the full-grown larva. The posterior rectangular fat area is very prominent and extends over the ninth, eighth and seventh segments before which it is seen narrowed abruptly up to the fourth segment.

The dorsal blood vessel is of a light yellow colour in some specimens and in others it is almost colourless and can be made out by the pulsation of its various chambers. It can be followed from the ninth to the fourth segment.

Table III below gives the date of hatching and the pupation of the larvae. From it the larval period can easily be found out.

TABLE III
Showing the larval period in *Baccha pulchrifrons* Aust.

Larva No.	Date of hatching of the larva	Date of pupation of the larva	Larval period
1	1931 9th November	1931 20th November	days 11
2	15th "	27th "	12
3	22nd "	7th December	16
4	22nd "	9th "	18
5	23rd "	7th "	15
6	24th "	10th "	17
7	29th "	11th "	13
8	30th "	11th "	12

The shortest larval period under laboratory conditions is 11 days and the longest 18 days. The lengthened larval period of *Baccha pulchrifrons* in some cases may partly be due to the varying conditions in temperature and humidity under which these larvae were reared and mostly to the insufficient food supply.

Pupa (Plate LX, fig. f)—Length 5.6 mm., breadth 2.15 mm., moulting has never been observed in the larvae of Syrphidae. The tough pupal skin is made by the induration of the larval skin of the adult larva.

The pupa of *Baccha pulchrifrons* is of a light straw colour, and like the pupae of all the aphidophagous species of Syrphidae is broad and rounded anteriorly, and tapering gradually towards the posterior end. The ventral surface is flat, the dorsal prominently convex. In a newly formed pupa many of the larval details e. g., the posterior fat area, the paired dorso-lateral patches of fat, the spines and the wrinkles in the body segments, can well be seen. The spines in the pupa are very small.

The segmentation is indistinct. Dorsally about the middle of the body of the pupa are two small dark diamond shaped areas. There are also five pairs of narrow black markings in the dorso-lateral portion of the pupa. A pair of narrow black transverse stripes is seen in the broad rounded anterior part of the pupa. The ventral side of the pupa is of a straw colour.

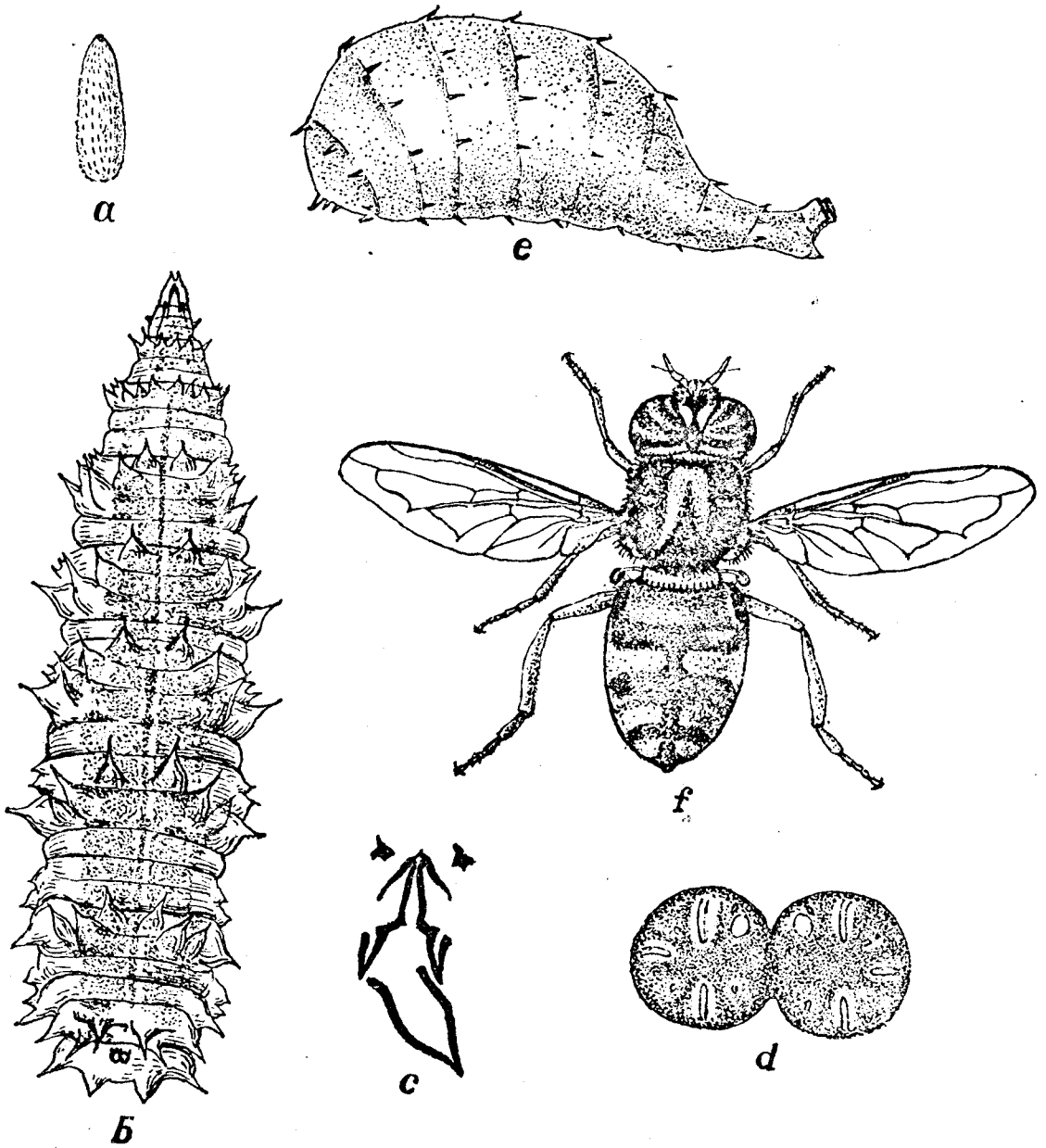
In some pupae obtained from larvae reared in the laboratory, besides the characters mentioned above, the colour is more black dorsally due to the presence of small black dots, and a black longitudinal stripe on each side arising from which are seen four smaller backwardly directed stripes. The ventral side of such a pupa was of a light straw colour with small black dots on the sides. It was observed while rearing the larvae in the laboratory that in some cases when the larva was supplied with more food, it developed more black colour and also the dorso-lateral black stripes and the black dots. It may be mentioned here that the difference in the colouration of the pupa has no bearing on the sex of the imago. Both males and females were seen to emerge from the black type of pupa.

The pupal period is generally 11 days but flies were seen in some cases to emerge 8 or 9 days after the pupation of the larva. The pupa at the stage when the fly is about to emerge shows a red colour in the broad anterior portion—the colour of the eyes of the developing imago within the pupa case, the rest of the pupal skin appears darker, more specially the middle portion.

Imago (Plate LX, fig. g)—A large number of flies, both males and females, were reared in the laboratory from eggs which were collected in the field. Brunetti, in the Fauna of British India, Vol. III, pp. 123-124, while recording descriptions of male and female of *Baccha pulchrifrons* adds "Austen notes a male and female which may be a variety of this species". There are also in the Pusa collection two females of *Baccha pulchrifrons* Aust., determined by Brunetti. The males and females obtained from the eggs were compared with the determined specimens in our collection and the description given in the Fauna Volume. From the comparisons thus made, it is evident that Austen's descriptions of the male and female of *Baccha pulchrifrons* are of one and the same species.

LIFE-HISTORY OF *Paragus serratus* (FABRICIUS)

Paragus serratus (Fabr.) is a widely distributed species in the east. It is also quite common in Africa. It is a small fly, 5 mm. in length with a yellow face, shining blue black punctulate thorax, with a pair of grey diverging stripes on the dorsum and with light brown to black abdomen. It can be recognised at once by its serrated scutellum. The fly is quite common in Pusa and has been collected in every month of the year. As seen from the Table given on p. 548, this species predares on root aphis, red gram shoot aphis, aphis on *Phyllanthus emblica*, aphis



Paragus serratus Fabricius.

(For explanation please see p. 570).

on *Solanum* sp., aphid on water-melon, aphid on *Dolichos*, *Aphis sacchari*, aphid on cotton, aphid on mustard and others. It is not uncommon to see, on any one of the above-mentioned plants attacked by aphids, small greenish yellow larvae, each with a broad black stripe on the dorsal surface. Field collections of the eggs and larvae of this species were made from the leaves of *Dolichos Lablab* on which a heavy attack of aphids was noticed in May, 1931 and the life-history was worked out.

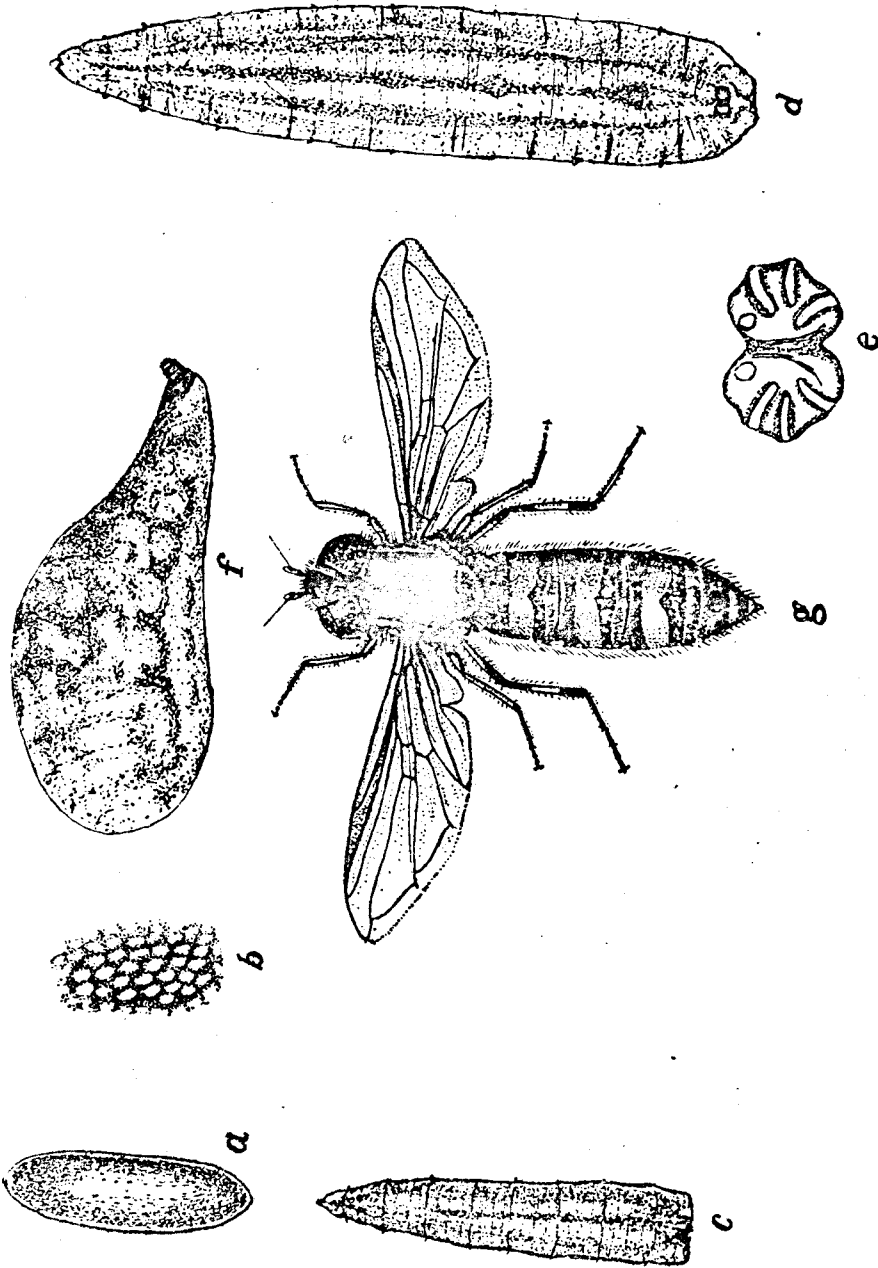
Egg (Plate LXI fig. a)—The egg when freshly laid is chalk-white and is 0.8 mm. long and 0.27 mm. broad. It is rounded at both ends, the anterior end being slightly narrower than the posterior end. The surface is ornamented with small elongated white areas arranged in longitudinal rows, each such area giving small branches on the sides.

Full-grown larva (Plate LXI, fig. b)—The adult larva is 9.3 mm. long and 2.5 mm. broad. The body of the larva is pale greenish yellow ventrally, black dorsally, excepting the sides (which are also greenish yellow), with splashings of orange colour throughout. The body is almost equally broad for about two-thirds of its entire length from the posterior end and is then seen to gradually narrow towards the anterior extremity. The inter-segmental spines are very prominent in this species. The bases of the spines are broad and swollen and are pale green excepting those of the median and the dorsal spines which are orange. The skin of the larva is tough and therefore the tracheal tubes cannot be seen through it. The anterior larval respiratory cornua are very small and ochraceous. The posterior spiracular tubes forming the posterior respiratory appendage are seen slightly raised above the surface of the last segment in the body which is entirely greenish yellow. They are of a light brown colour. At the end of the respiratory appendage on each side are three digitate spiracles, four small inter-spiracular spurs and a circular dorsal plate as shown in Plate LXIII, fig. d.

The mouth parts of the larva consist of inverted V-shaped jaws and three pairs of mouth hooklets. The outer pair of mouth hooklets are small and tooth-like, the other two pairs, one at the anterior and the other at the posterior end of the jaws, are elongated and rod-like.

The larval period in this species was found to be about a week in May, 1931.

Pupa (Plate LXI, fig. c)—The pupa is 6.1 mm. long and 2.3 mm. broad. It is of a pale ochraceous colour. The ventral surface is flat and the dorsal, just as in other species, humped. The body of the pupa is broad and rounded anteriorly, narrowing gradually towards the posterior end on which is found the posterior respiratory appendage. The skin is wrinkled as in the larva. The inter-segmental spines are very prominent. The pupal period is about one week. Towards the end of this period, the pupa becomes dark, specially more in the anterior half of its body. This is due to the colour of the fly within the pupa.



Sphaeroporijavana Wiedemann.

(For explanation please see p. 570).

LIFE-HISTORY OF *Sphaerophoria javana* (WIEDEMANN)*Introduction*

While making observations in the field and working in the laboratory on the various stages in the life-cycle of *Baccha pulchrifrons* Aust., it was found that there were also larvae of another species of Syrphid fly preying upon nymphs of *Ctenophalara elongata*. These larvae were green in colour in the adult condition, with a pair of fairly broad median dorsal fat stripes. The flies bred from these larvae were identified as *Sphaerophoria javana*. It may be stated that the fly has never so far been recorded from Bihar. Collections of this species have been made from Coorg, South India, 15-20. X. 1915 (Fletcher); above Tura, Assam (Kemp). It has also been recorded from Ceylon, Sumatra and New Guinea. Fletcher reared a fly from larva which he found feeding on Psyllids on a tree in Shillong in the beginning of November, 1918. It was in the months of November and December, 1931, that the eggs and larvae of this species were collected at Pusa and flies reared. Later in the month of January, 1932, the larvae of this species were found feeding on aphids on cotton plants and a male was reared.

Egg (Plate LXII, fig. a)—Length .89 mm., breadth .29 mm. Freshly laid eggs are white, comparatively narrower than those of *Baccha pulchrifrons* which are also found on the same leaf of *Bombax malabaricum* in association with the nymphs of the Psyllid *Ctenophalara elongata*. The chorion of the egg is marked with elongated oval areas all over the surface without any processes on the sides. The egg assumes a darker hue with a purplish tinge at the time of hatching. The incubation period is about 48 hours.

Young larva (Plate LXII, fig. c)—The newly hatched larva is 2.33 mm. long and .48 mm. broad. It is pale yellow in colour with a slight greenish tinge, equally broad in the posterior half and gradually tapering towards the anterior end. At a little later stage the larva becomes more yellow, the middle portion being bottle-green, and a reddish tinge appears in the fourth and fifth segments of its body. A pair of median fat lines, much more prominent in the full-grown larva but not so in the young stage, can be seen enclosing between them the median dorsal blood vessel which is reddish in colour. The anterior larval respiratory cornua are distinctly seen as two small light ochraceous processes, one on each side between the head and the prothoracic segment. The posterior larval respiratory tubes, ochraceous in colour, are quite separate and are situated on the last segment. The inter-segmental spines are small and of pale ochraceous colour.

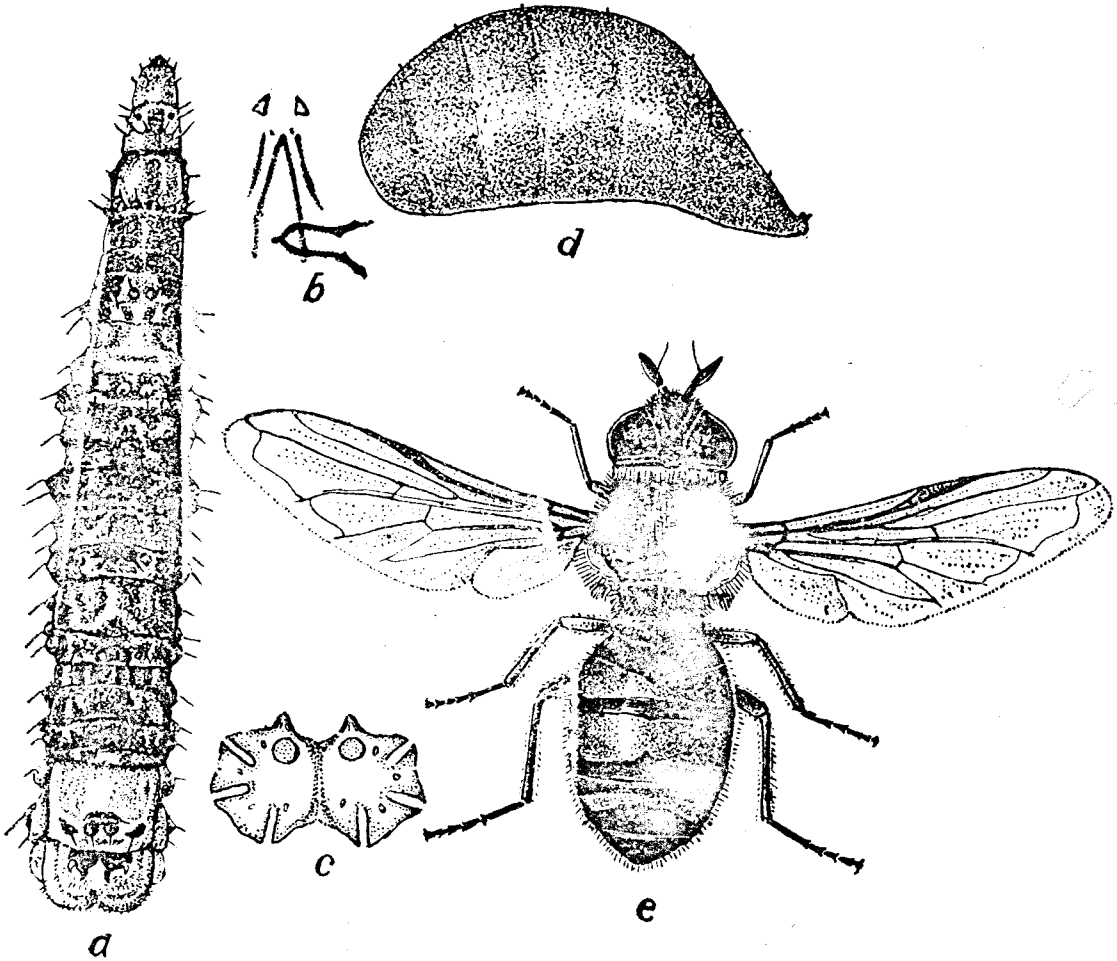
Full-grown larva (Plate LXII, fig. d)—Length 10 mm., breadth 2.0 mm. The full-grown larva is pea-green in colour. Mid-dorsally there are two fairly broad fat stripes extending from the ninth to the fourth segment. The stripes appear green

due to the general body colour of the larva being green. The body of the larva is uniformly broad posteriorly and is seen to narrow very gradually towards the anterior end. The head of the larva is small, conical, being composed of two segments. It encloses within it the oesophageal frame-work containing the jaws and the mouthhooklets. Each arm of the inverted V-shaped upper jaw possesses three teeth which, when the jaws are in action, serve the purpose of puncturing the body of the victim at various places. Both upper and lower jaws are heavily chitinized. The outer mouthhooklet of each side is bidentate and is of a black colour. There is only a single pair of lateral mouthhooklets. They are situated one on each side of the jaws and are much less chitinized than the other mouth parts. They are long and slender, broad anteriorly, gradually narrowed towards the posterior end.

After the head, ten clear segments can be counted. The inter-segmental spines are small, ochraceous and can only be seen in the adult larva by the help of a microscope. The skin of the larva is thrown into folds or wrinkles and three such wrinkles can be counted in most of the segments. The entire course of the tracheal tubes can be seen beneath the green translucent skin of the body of the larva. Mesially on the dorsal surface of the last segment can be seen the posterior respiratory appendage, composed originally of two chitinous posterior respiratory tubes, separate in the young larva, and closely applied by their inner sides when it is about full-grown. The respiratory appendage is of brown colour and, unlike the same appendage of the larva of *Baccha pulchrifrons*, is slightly raised above the surface of the body. In the end view of the posterior respiratory appendage (Plate LXII, fig. e) can be seen, on each side, three digitate spiracles and a dorsal plate. The anterior spiracles, two in number, are placed on sides at the anterior portion of the prothoracic segment at the tips of the larval respiratory cornua which are of a pale ochraceous colour. The dorsal blood vessel in the larva is of a reddish orange to purple colour. In the posterior segments of the larva it is darker. The various chambers of the vessel can be seen undergoing rhythmic contraction and expansion at the time when the larva is quiescent after a feed.

The larval period, as calculated from the data compiled, while rearing of the flies was carried in the laboratory, varies from 10-15 days.

Pupa (Plate LXII, fig. f)—Length 5.1 mm., breadth 2.1 mm. The pupa is green in colour. Like the pupae of other aphidophagous species of Syrphidae it possesses a flat ventral surface and is inflated dorsally. It is fusiform in outline, being broad and rounded anteriorly and gradually tapering towards the posterior end which bears the posterior respiratory appendage. In a newly formed pupa, the two fat stripes, the inter-segmental spines and the wrinkles on the skin of the body segments can be seen as in the larva. The posterior respiratory appendage is



Syrphus serarius Wiedemann.

(For explanation please see p. 570.)

shining brown in the beginning but later on becomes darker. The ventral surface is lighter in colour than the dorsal surface.

While breeding flies of *Sphaerophoria javana* two different types of colouration were noticed in the pupae. In one type the colour of the pupa is as described above and from it male fly was seen to emerge. In the second type the pupa is equally green on the dorsal as well as the ventral surface. Dorsally black patches can be seen over the green surface presenting the appearance of five pairs of laterally placed oblique stripes. The ventral side in this type of the pupa develops small black dots on the sides. From this type of pupa female fly was seen to emerge. Towards the end of the pupal period which is of eight to ten days' duration, the colour of the eyes, thorax and abdomen of the imago can be seen through the pupal skin, the anterior third of which appears reddish-brown, the middle portion black and the hind portion black with greenish yellow stripes.

Imago (Plate LXII, fig. *g*)—A sufficient number of flies, both males and females, were reared in the laboratory from the eggs, and larvae collected in the field. In fresh specimens thus obtained, the colour of the face, thorax and abdomen was lemon-yellow instead of orange-yellow as found in the description of the species given in the Fauna of British India, Diptera, Vol. III, pp. 100—101. In all other respects the specimens exactly tallied with the named ones in the Pusa collection and answered perfectly to the description of the male and female given in the Fauna Volume.

Life-cycle

The life-cycle of *Sphaerophoria javana* takes about three weeks to complete. The egg hatches in about forty-eight hours after it is laid. The larva, under proper laboratory conditions, pupates 10 to 12 days after the hatching takes place and the adult fly emerges 8 to 10 days after pupation of the larva.

LIFE-HISTORY OF *Syrphus serarius* WIEDEMANN

Syrphus serarius Wied., is a hill species and has been recorded from various hill stations, such as, Masuri, Kumaon, Almora, Murree, Darjeeling, Shillong and other places besides Pusa, Coorg (S. India) and Ceylon. It has been reported from Java, and Coquillett records it from Japan.

The larvae of this species were found feeding on aphids on mustard in Pusa in February and March 1932. The eggs could not be obtained and hence the description of only the larva and pupa is given below.

Full-grown larva (Plate LXIII, fig. *a*)—The adult larva is 9.1 mm. long and 1.5 mm. broad. In the earlier stages the larva is black both ventrally and on the

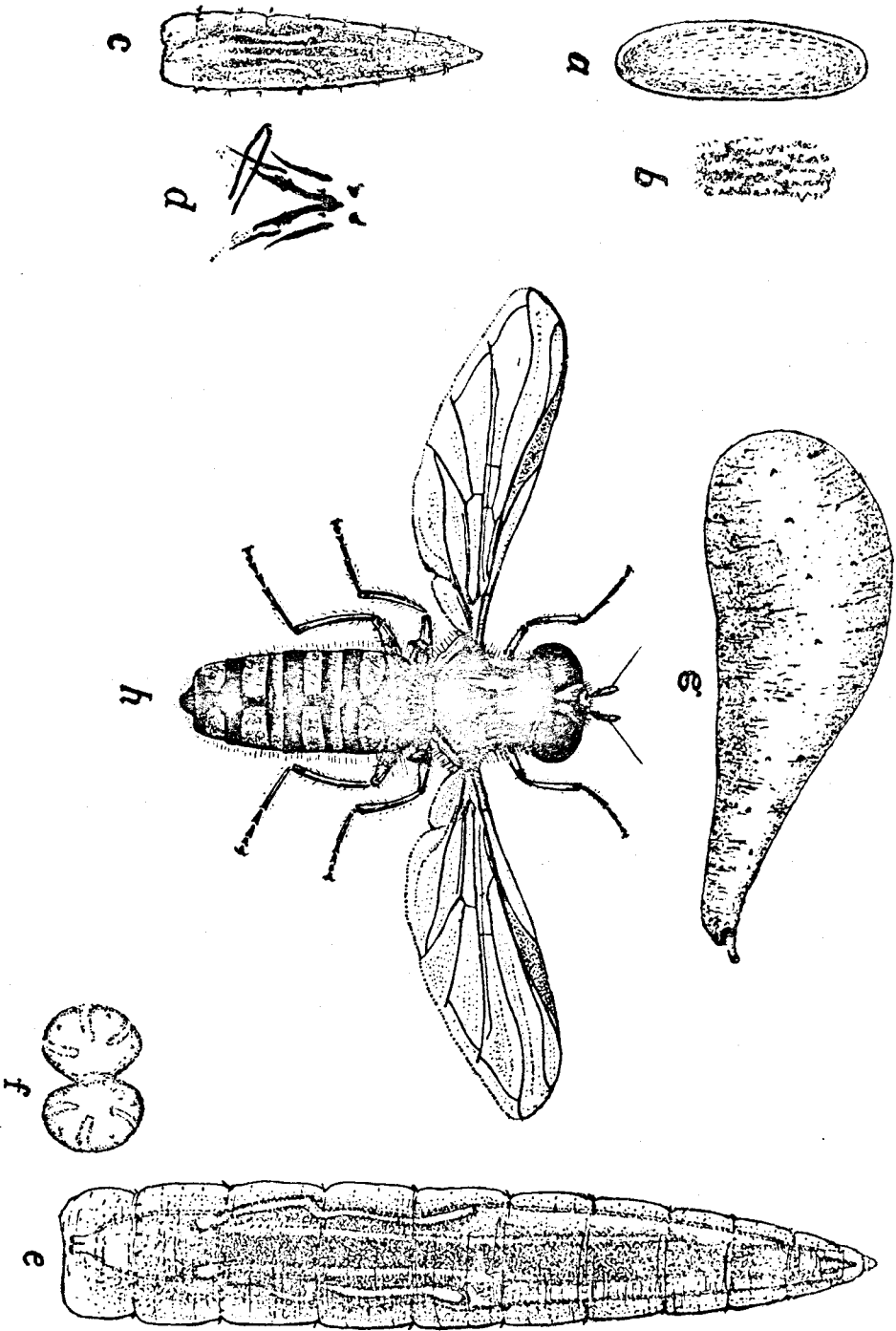
dorsal surface excepting the 4th, 11th and the 12th segments which are white above due to the development of fat. The larva, like those of other species of aphidophagous Syrphidae, is broad posteriorly and is gradually seen to narrow towards the anterior end. The skin is tough. The body is covered all over with small black bristly hairs which can even be seen on the 4th, 11th and the 12th segments which are white. The tracheae can not be seen through the tough skin due to its black colour. The anterior larval respiratory cornua are pale in colour and can be seen on the anterior side of the prothoracic segment, one on each side. The posterior larval respiratory tubes are seen joined by their bases. They are shining black and are slightly raised above the surface of the segment on which they are situated. At the end of each tube will be found three digitate spiracles, four inter-spiracular spurs and a prominent shining dorsal spine. The wrinkles on the segments are as in other larvae of the aphidophagous species. The inter-segmental spines are black and very prominent. The median spines are situated a little in front of the dorsal and dorso-lateral spines. There are also two rows of small spines in the two head segments. The bases of the median spines are sometimes white in some of the segments in the body.

The fat in the larva increases as it approaches maturity. The colour of the larva, when it is about to pupate, is as follows: Ventral side of the larva black; dorsal surface black, excepting a patch of white on each side of the head and the first segment; sixth and the anterior portion of the seventh segment white; eighth, ninth and tenth segments partially white due to irregularly distributed white fat patches; eleventh segment entirely white and twelfth segment white excepting the posterior respiratory tubes which are shining black.

The mouth parts of the larva are a pair of inverted V-shaped jaws and three pairs of mouth hooklets. The outer pair of hooklets are tooth-like, each possessing a broad base and pointed apex. Out of the two pairs of lateral mouth hooklets on the sides of the jaws, there is a pair of rod-shaped mouth hooklets. The second pair of mouth hooklets are very small chitinous structures on the sides of the jaws at their anterior end.

The adult larva has a peculiar habit of bending its body at times while it is feeding. Sometimes in this position it is easily mistaken for a caterpillar.

Pupa (Plate LXIII, fig. *d*)—The larva pupates either on the leaf or on the fruit of mustard. The newly formed pupa is fusiform, broad and rounded anteriorly and narrowing towards the posterior end on which is situated the posterior respiratory appendage. It is 6.4 mm. in length, 2.8 mm. in height and 3.1 mm. in breadth. The inter-segmental spines are not so conspicuous as in the larva. The wrinkles on the segments are as in the larva. The pupa is black ventrally, and on the dorsal surface besides the black colour white patches of larval fat can be seen just as in the



Syrphus balteatus De Geer.

(For explanation please see p. 570.)

larva. After two or three days the colour of the pupa becomes light ochraceous, the anterior portion being dark, and also there is a broad diamond-shaped area of a dark colour about the middle of the dorsal surface. The pupal period is about eight days.

LIFE-HISTORY OF *Syrphus balteatus* (DE GEER)

Introduction

The fly *Syrphus balteatus* (De Geer) is one of the commonest species of the genus *Syrphus* and has been reported from all over India. In Pusa the fly is fairly common and is available during most of the months in the year. From January to March the flies of this species are seen in a sufficient number in the fields and can be collected at any time in the day. They are seen hovering over flowers in search of food which they find in honey stored in the nectaries of the flowers. The gravid female besides looking for the honey will be seen here on this leaf, there on another and ultimately will be out of sight and if these leaves are examined with a field lens carefully, one may find on any one of them on its underside a newly laid egg in a small colony of green aphids.

The adult flies of this species can be recognised at a glance in the field by the orange coloured face, shining aeneous thorax and orange coloured abdomen with black segmentation, and, in most of the specimens, with an additional narrow black stripe in each one of the third and the fourth segment.

Field collections of the eggs and the larvae of this species were made on a large scale in a cotton field in January and February, 1932. The larvae were found both on the underside of the leaves preying upon nymphs of the cotton aphid and on the thalami of flowers which had just opened, where they were found mainly feeding on young nymphs of Coccids which attack the shoots of cotton plant. It is in the latter position that maggots of the Drosophilid, *Getonides perspicax* Knab, are also found but it is not difficult to distinguish the larvae of one from the other. The young, and in some cases the adult, larva of *Syrphus balteatus* (De Geer), is black on the posterior two thirds of its body, the anterior third being light yellowish grey. In the posterior portion of the body of the larva will be found a red coloured loop underneath the skin.

All the stages in the life-cycle of this common Syrphid fly were carefully studied in the laboratory and the life-history was thus worked out.

Egg (Plate LXIV, fig. a)—The eggs are 1.1 mm. in length and .35 mm. in breadth. They are singly laid on the under-surface of the cotton leaf. Freshly laid eggs are milk-white, elongated oval in outline and rounded at both the ends. The chorion of the egg, when examined under the microscope, is seen ornamented

with elongated chalky areas arranged in longitudinal rows parallel to the long axis of the egg. On both the sides of each such area are seen small dentate processes. The egg, when about to hatch, becomes dirty white. The incubation period is about 48 hours.

Young larva (Plate LXIV, fig. c)—The young larva is 1.4 mm. long and .35 mm. broad. The newly hatched larva is of black colour dorsally. It is broad posteriorly and gradually narrows towards the head segments. The flat ventral surface of the larva is pale grey, so also are the sides, the head, the prothoracic segment and the last body segment bearing the chitinous posterior respiratory tubes. A pair of thin white fat streaks can be seen extending from the posterior to the anterior end on the median dorsal surface of the body of the larva. The dorsal blood vessel is not clear owing to the black colour of the larva. A pair of red tubular markings on the posterior surface of the larva gives a characteristic appearance to it by which it can be easily recognised in the field. The rows of small inter-segmental spines can be seen with a hand lens, the first between the head and the prothorax and the last between the 11th and the 12th segments. The tracheal tubes can be seen within the skin throughout their entire course in the body of the larva. The pale anterior larval respiratory cornua are very small but can distinctly be seen. The posterior chitinous spiracular tubes on the last body segment are separate.

Full-grown larva (Plate LXIV, fig. e)—The adult larva is 9.1 mm. long and 1.6 mm. broad. There are in all twelve segments in the body of the larva. On the last segments is seen the ochraceous posterior respiratory appendage which is about 4 mm. above the surface of the segment. At its end (Plate LXII, fig. f) on each side are three digitate spiracles, a circular plate and four interspiracular spines. The colour of the body is pale ventrally, black on the dorsal surface from the ninth to the fourth segment. The anterior four segments are pale grey. The red tubular marking on each side of the body extending from the sixth to the eighth segment stands out in contrast to the black colour of the segments over which it extends. The tubular area of each side encloses fat within and around it on the sides. The dorsal blood vessel cannot be made out due to the black colour of the larva. The inter-segmental spines are microscopic.

The mouth parts (Plate LXIV, fig. d)—The mouth parts consist of a pair of inverted V-shaped jaws and four pairs of mouthhooklets. Near the distal end of each limb of the upper jaw can be seen three small teeth. The outer mouth hooklets are conical with sharp apices. The other three pairs are lateral, a pair of very small comma-shaped mouth hooklets and two pairs of rod-like mouth hooklets.

The black colour dorsally on the body of the larva is not constant and has been found to vary to a great extent in the larvae both obtained from the field and

reared in the laboratory. Some larvae of this species collected in the field on cotton aphid in December, 1931 and January, 1932 and others on cabbage aphid about the first week of March, 1932, were white, each with a red tubular marking on its sides. Larvae reared in the laboratory from eggs of this species collected in the field also developed black colour to a varying extent. The black colour disappears in the larva as it is about to pupate. At this stage the larva presents a white appearance, the colourless dorsal blood vessel is seen surrounded by fat on its sides, there being more fat within the tubular marking and around it on the sides. The Table given below shows the larval period in *Syrphus balteatus* (De Geer).

TABLE IV

Showing the larval period in Syrphus balteatus (De Geer)

Larva No.	Date of hatching of the larva	Date of pupation of the larva	Larval period
			Days
1	17th December 1931 . .	28th December 1931 . .	11
2	18th December 1931 . .	28th December 1931 . .	10
3	23rd December 1931 . .	5th January 1932 . . .	13
4	24th December 1931 . .	6th January 1932 . . .	13
5	26th December 1931 . .	9th January 1932 . . .	14

Pupa (Plate LXIV, fig. *g*)—The pupa is 5.9 mm. in length, 2.1 mm. in breadth and 2 mm. in height. It is flat ventrally, broadly rounded anteriorly and is seen to narrow gradually towards the posterior end on which is situated the respiratory appendage. In colour it is light ochraceous. The inter-segmental spines are microscopic. In some cases there are small black dots on the dorsal surface and the sides of the pupa, the dots being more closely situated on the sides than on the dorsal surface. Besides the dots, there are in this type of pupa, three to four narrow black stripes in the rounded anterior region, and the same number of small black areas mid-dorsally. The respiratory appendage in all the pupae examined is of a pale ochraceous colour.

As a sufficient number of flies were reared from both kinds of pupae, it appears that difference in the markings on the surface of the pupa has nothing to do with the sex of the imago. This difference in the marking of the pupa in one and the same species was also noticed in *Baccha pulchrifrons* and *Sphaerophoria javana*, and in the latter, the difference in marking had a bearing on the sex of the flies which emerged from them.

At the time when the fly is about to emerge, the anterior rounded portion of the pupa becomes red, the middle portion black and the posterior black with orange stripes. These colours correspond to the colour of the head, thorax and abdomen of the imago.

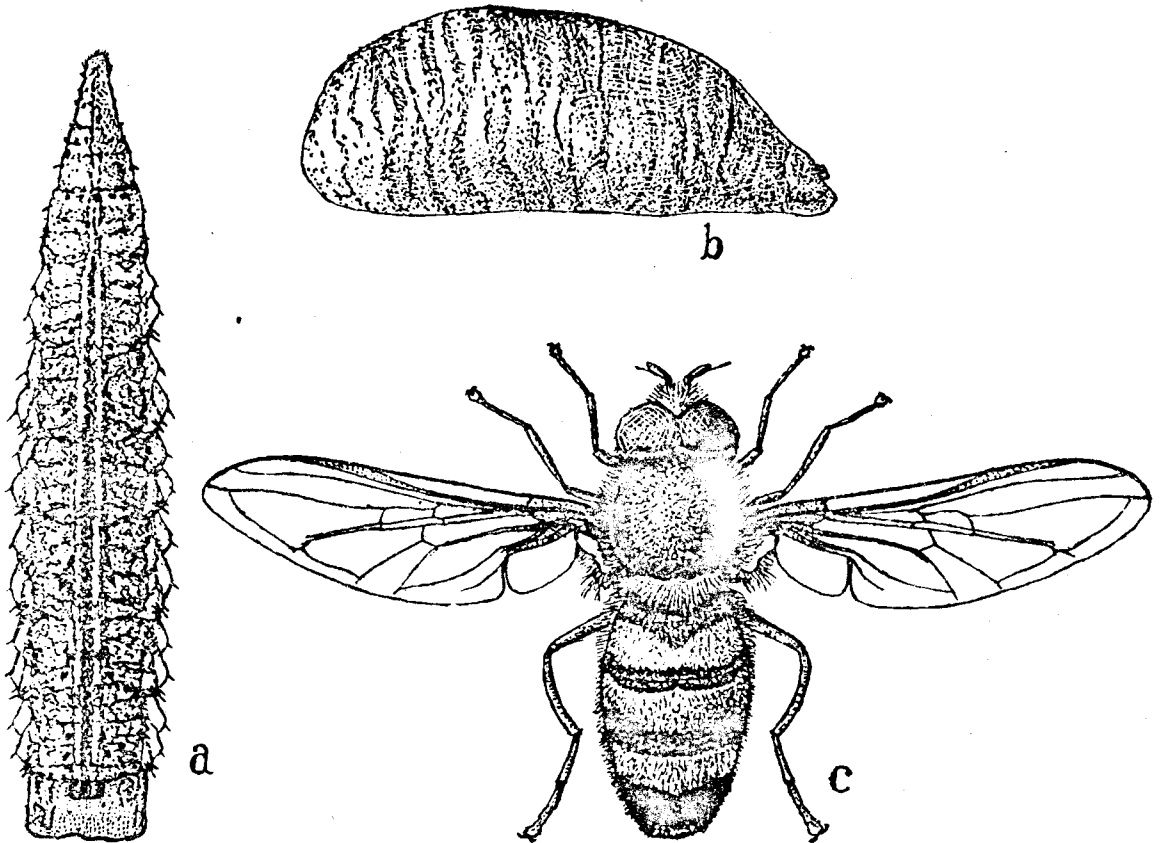
The pupal period varies from 9 to 11 days.

Life-cycle

The whole life-cycle occupies about three weeks. The egg hatches in about 48 hours after it is laid. The larva feeds for about 10 days after which it pupates. The fly emerges 10 days after the pupation of the larva.

Imago (Plate LXIV, fig. *h*)—A number of flies, both male and female, were reared in the laboratory. It was found that the orange colour in the second, third and fourth segments of the abdomen varied in different specimens. Brunetti [1923] in his Fauna Volume on Syrphidae describes the abdomen as "almost linear, slightly broader about the end of the second segment, wholly orange, varying a little in shade, and indistinct black median spot on the first segment united to a black stripe on the hind margin; this does not reach the sides, but is continued on second segment as a transverse basal band joined by a median stripe of varying width to a broad black band on hind margin, this latter band uniformly wide and reaching sides; third segment with a narrow transverse line of uniform width (in Indian specimens), or narrowed to a point on each side and also interrupted in the middle (in European specimens), seldom reaching sides; hind margin with a black band as on the second segment; fourth segment similarly marked except that the hind marginal band leaves the extreme margin pale and a slightly convex anteriorly or straight in some cases and practically or actually terminal; fifth segment orange with an indistinct small black spot above the middle".

In some specimens bred in the laboratory, the orange and black markings on the abdominal segments are just as described above but in others (Plate LXIV, fig. *h*), it differs from the above in following respects:—The second, third, fourth and fifth segments are black with orange spots, a pair in each segment, rectangular in the third and fourth segments and triangular in second and fifth, with their apices directed towards the middle of the segments on which they are situated, third and fourth segments with a pale yellow stripe in the anterior margin and the posterior border of the fourth segment indistinctly pale yellow. The narrow black line on the third and fourth segments of the specimens with abdomen wholly orange yellow can be seen here occupying the same position but not so marked. In all other details these specimens answer perfectly to the description of the species given in the Fauna Volume. This small difference in the markings of the abdominal



Syrphus confrater Wiedemann.

(For explanation please see p. 570.)

segments is only a minor variation within the range of a species and therefore it is not necessary to create a new variety.

LIFE-HISTORY OF *Syrphus confrater* WIEDEMANN

Syrphus confrater Wied., has been reported in India from the Punjab, Bihar, Bengal, Assam and the Madras Presidency. The larva of this species has been reported as feeding on aphids on cotton, wheat, cabbage and chrysanthemum. In Pusa the fly is fairly common from January to March. The larvae of this species were found on mustard plant feeding on aphids. Mr. Fletcher in 1923 found the larvae of this species feeding on *Eriosoma lanigera* (woolly aphid) on pomegranate in Kashmir.

The eggs could not be obtained. The descriptions of larva and pupa are given below.

Full-grown larva (Plate LXV, fig. a)—The adult larva is 16.8 mm. long and 3.5 mm. broad. It is larger in size than any other larva of the aphidophagous species of Syrphidae reared so far in Pusa. The colour of the larva is light orange. The body is uniformly broad for the two thirds of its entire length from the posterior end in front of which it is seen to narrow towards the head. There are 12 segments in the body of the larva, the last bearing dorsally two posterior respiratory tubes each bearing at its end the spiracles by which the tracheal tube opens. The median dorsal blood vessel is darker in colour and its various chambers are seen when the larva is at rest. A pair of fat streaks are seen, one on each side of the dorsal blood vessel, and besides these the fat is distributed irregularly in the form of white spotted areas on all the segments. The dorsal surface is darker in colour than the ventral due to the presence of minute black bristly pubescence which is more pronounced on the sides of the fat streaks. The area around the fat streaks on this account appears darker. The skin is much less translucent than that of the larvae of other species and hence the tracheal tubes cannot be seen through the skin. The inter-segmental spines are quite prominent in the younger stages of the larva but are rather microscopic in the adult larva. There are, as in the larvae of other species, three wrinkles on the surface of each segment in the body excepting the head, the prothoracic and the last segment. The latter appears darker than other segments due to the more conspicuous black bristly pubescence.

Pupa (Plate LXV, fig. b)—The pupa is 8.75 mm. long, 3.5 mm. broad and 3.3 mm. in height. It is of a dark brown colour, the ventral surface being lighter in colour than the dorsal. The body is fusiform, being broadly rounded anteriorly and gradually tapering towards the posterior end bearing the small shining black respira-

tory tubes. The inter-segmental spines are very small and pale ochraceous. The wrinkles in the segments are as in larva. The pupal period is about 12 days.

Betasyrphus
LIFE-HISTORY OF *Syrphus isaaci*, SP. NOV.

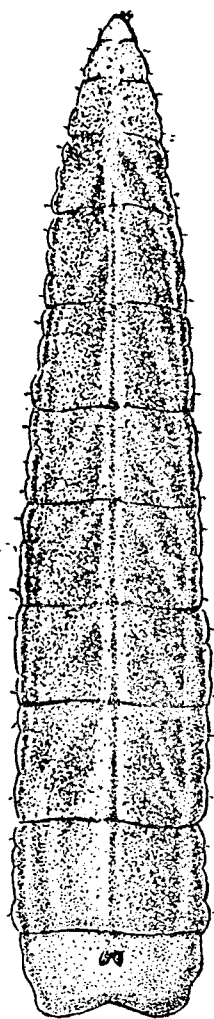
Syrphus isaaci has been recorded from Mangaldai sub-division, Assam [Kemp, 1910]; Nagarkote (Nepal); Masuri; Kumaon and Pusa. A few specimens of this species in the Indian Museum collection and a few in the Pusa collection bear the label *Syrphus instabilis* Brun. The description of *Syrphus instabilis* Brun. has not been published and therefore the senior author has taken the liberty to describe it under a new name as above.

The larvae of *Syrphus isaaci* were found feeding on mustard aphid in Pusa, in February 1932. The description of the adult fly, male and female, is given after that of the larva and the pupa.

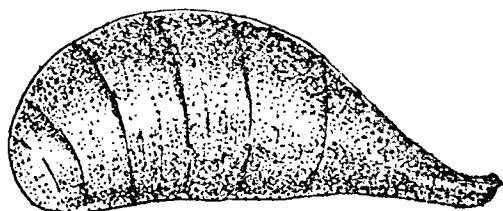
Full-grown larva (Plate LXVI, fig. a)—The adult larva is 14 mm. long and about 2.6 mm. broad. It is of a light pink brown colour, flat ventrally, broad posteriorly and gradually narrowing towards the anterior end. The segments in the body of the larva are marked by inter-segmental furrows which are three in number in each segment excepting the last in which they are absent, and third and fourth segments in which there are one and two furrows respectively. The body is covered dorsally by light brown bristly pubescence hardly visible to the naked eye. The inter-segmental spines are small and ochraceous. The dorsal blood vessel is slightly darker and is surrounded on both sides by fat forming the median dorsal fat streak. Inter-segmentally, from the median fat streak, obliquely placed light coloured fat stripes are seen to arise and meet on each side into a long white fat stripe as shown in the diagram of the larva. This arrangement of fat stripes gives a characteristic appearance to the larva. The tracheal tubes cannot be seen through the tough skin of the larva. The posterior respiratory tubes are brown in colour. They are slightly raised above the dorsal surface of the last segment on which they are situated.

Pupa (Plate LXVI, fig. b)—The pupa is 7.0 mm. long, about 2.7 mm. broad and 3 mm. in height. In shape it is broadly rounded anteriorly where it is high and is seen to narrow gradually towards its posterior end. The ventral surface of the pupa is flat. The dorsal blood vessel is seen as a dark line mid-dorsally. The inter-segmental spines are ochraceous in colour and microscopic. The segmental furrows are as in the larva. The posterior respiratory tubes are small bearing a metallic lustre. The pupal period is about two weeks in February 1932.

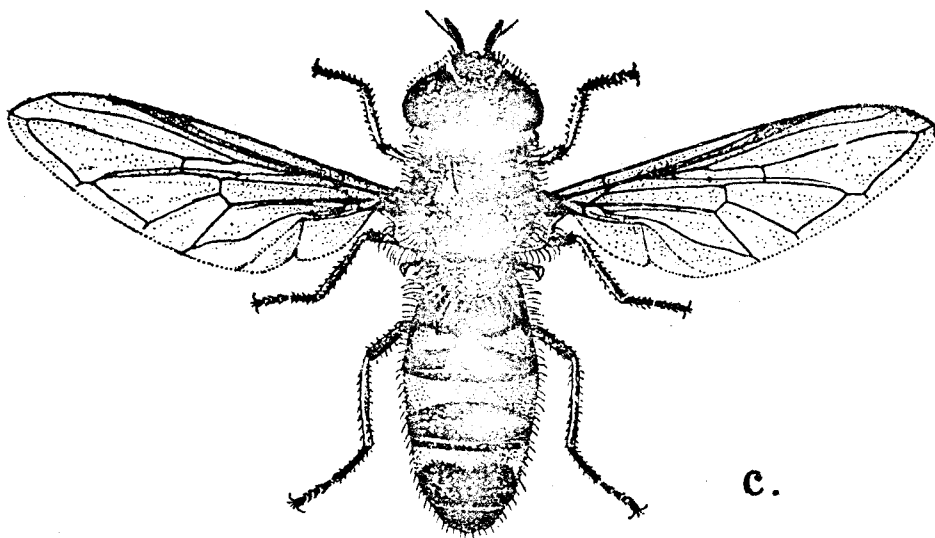
Adult fly, male and female (Plate LXVI, fig. c)—Male: head—eyes brown with dark brown pubescence, whitish at the lower angles; vertical triangle small, black



a.



b.



c.

Syrphus isaaci sp. nov.

(For explanation please see p. 570.)

with black hairs; upper part of the frons yellow with black hairs. Antennal prominence shining black, space around the base of antennae very narrowly orange; face light yellow with white pubescence all over up to the oral margin, the latter with short white hairs on the sides, the central hump dark brown, bare; cheeks very narrow, cinereous with white pubescence. Fringe of hairs on the posterior margin of the eyes orange yellow. Female: vertex shining violet, eyes separated, the space between the eyes greatest at the level of the antennae, narrowing gradually towards the vertex.

Thorax moderately shining black with a slight æneous tinge, with conspicuous yellow pubescence on the sides and dorsum; pleurae, cinereous with light yellow fine hairs. Scutellum translucent, dull yellow, with long black hairs on its dorsal side and yellow hairs fringing the margin.

Abdomen black; first segment shining æneous with a bluish tinge; second segment with a pair of whitish (in the 'Type' specimen) to light orange narrow triangular spots, their apices separated, their bases nearly reaching the side margins of the segment; third segment with a narrow transverse band of orange colour near the anterior margin, the band a little broader near the sides than in the middle; fourth segment anteriorly with a similar band, lighter and narrower than the band in the third segment; posterior portion of the fourth and fifth segments somewhat shining. Hairs on sides of the abdomen light yellow mixed with black at places, prominent on the sides of the segment. Dorsally the pubescence black on black parts and yellow on orange parts with few yellow hairs on the black areas. Venter blackish, slightly metallic and with bands corresponding to those on the dorsal side.

Legs yellowish brown; nearly the basal half of the anterior femora, outer sides of the middle femora, the entire hind femora, an indistinct ring at the middle of the hind tibia, also all tarsi slightly darker. Wings clear, stigma pale yellow; halteres light orange. Lengths: 10 mm., of wing 8.6 mm.

Type male in Indian museum. Type female in Pusa Collection.

LIFE-HISTORY OF *Helophilus bengalensis* (WIEDEMANN)

Helophilus bengalensis (Wied.) is common in Bihar and Bengal. The species is apparently widely distributed throughout India as it has been reported from Katmandu (Nepal), Calcutta, Pusa, Bangalore and Sibsagar.

The flies of this species are available in Pusa during the rainy season. They have been collected in the months of July, August and September. They were observed during these months in the fields hovering over wild plants near the river bank in Pusa. Egg laying was never observed in the field. Males and gravid females, collected in the field in September were brought to the laboratory and liberated together in cages, each consisting of a glass bell jar within which was

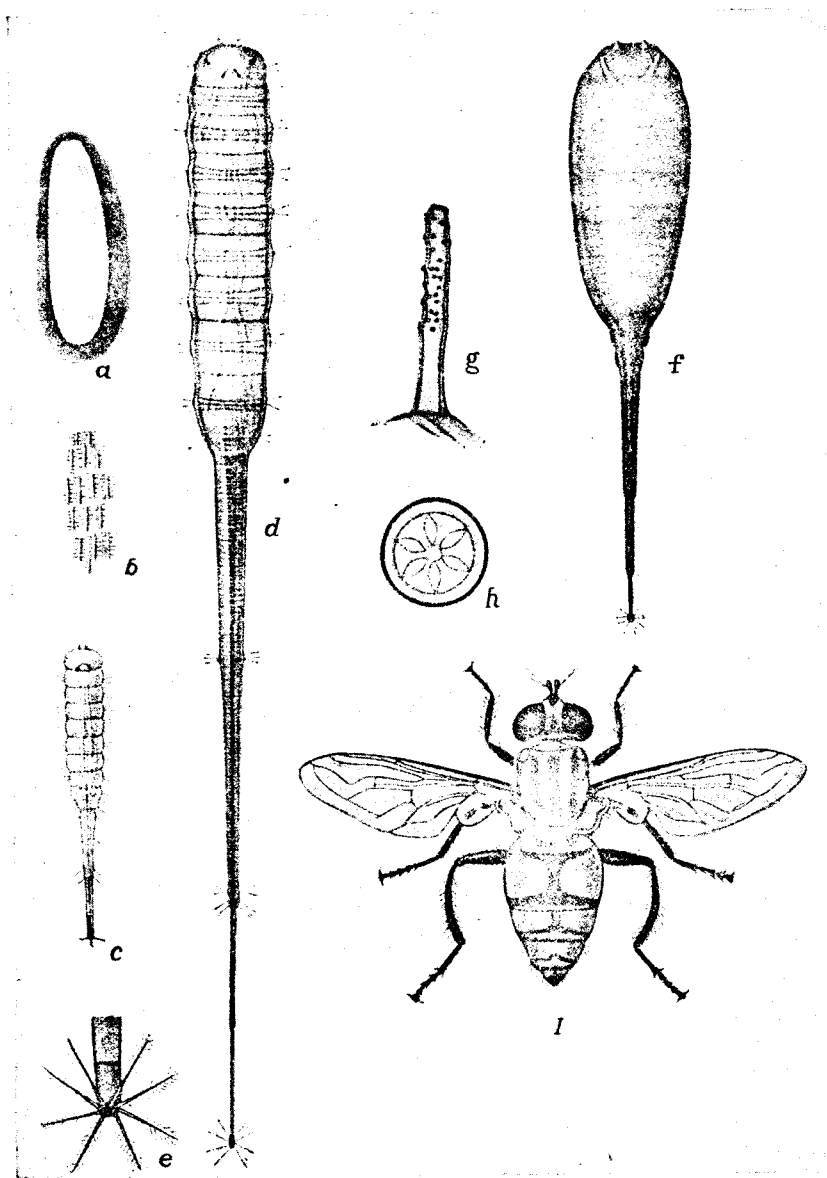
placed a small Petrie-dish containing a piece of cotton soaked in sugar solution and a small leafy branch of a wild plant immersed in a beaker half full of water. Next day, or two days after confinement of the flies in a cage, small masses of white eggs (in some cases a single big mass of white eggs was observed) were observed deposited on the sides of the cage, on a leaf of the branch, or even in the Petrie-dish containing the piece of cotton soaked in sugar solution.

Egg (Plate LXVII, fig. *a*)—Freshly laid eggs are white with a creamy tinge about their middle, each measuring 1.0 mm. in length and .30 mm. in breadth. The egg is elongated oval in outline, rounded at both ends, the anterior bearing the small micropyle being slightly narrower than the posterior end. The ventral surface of the egg is flat and the dorsal a little convex. The chorion is marked all over with elongated rod-shaped areas in longitudinal parallel rows, each such area giving small branches on both the sides. These small branches do not meet one another.

Food of the larva—The larvae were fed on decaying wood in the act of fermentation and freshly killed fly maggots. They were observed to get into the body of the crushed maggots, thereby devouring entirely the inside viscera. They thrive well in this medium and became full-grown in 16 days after their hatching.

Young larva (Plate LXVII, fig. *c*)—The young larva is white in colour, 5.5 mm. long and .68 mm. broad. It conforms to the type of rat-tailed larva to which also belongs the larva of *Eristalis*. Even in the young larva, the tail, which is composed of three apparent segments, is equal in length to the body. The first segment of the tail which is a continuation of the last body segment is as long as its other two segments. The last segment of the tail is darker, bearing at its end the posterior stigmata which are ornamented with eight barbed bristly hairs as shown in Plate LXVII, fig. *e*). The two tracheal tubes are seen through the body from its anterior end to the tip of the tail. They open anteriorly by spiracles placed at the ends of the two anterior larval respiratory cornua which are not clearly visible in the young larva and at the tail end by the posterior stigmata. Ventrally the body of the larva is provided with 6 pro-legs bearing black recurved spines. The oral aperture is situated on the ventral side of the head of the larva. The anal aperture is seen ventrally on the last body segments guarded by a number of radiating digitate processes which are supposed to be renal in function.

Full-grown larva (Plate LXVII, fig. *d*)—The adult larva is 3.5 mm. in length (body and tail), and 2.7 mm. in breadth. It is pale yellow in colour. The tail is nearly twice the length of the body. The body of the larva including the tail is composed of ten segments besides the head. The tail is composed of two segments, its first apparent segment being only a continuation of the last body segment and hence cannot be taken as a separate segment. The segments in the body are marked dorsally by wrinkles in the skin. The head is lined on the margin



(For explanation please see page 570.)

and the dorsal surface by sensory spines. The two lips on the ventro-lateral aspect of the head are provided with pale hairs and weak spines. Ventrally the segments of the body are provided with 6 pairs of pro-legs as in other species of the genus *Helophilus*. The anterior larval respiratory cornua, by which the tracheal tubes open anteriorly at the junction of the first segment in the body, *i.e.*, the prothoracic segment and the head are well seen in the adult larva. They are of an orange yellow colour. The tracheal tubes are light greyish yellow and present a zigzag appearance in the full-grown larva. Throughout their course they are seen to give numerous branches to the skin, the alimentary canal, the salivary glands and anteriorly to the head and the oesophageal frame-work.

It is rather difficult to distinguish between the adult larva of *Helophilus bengalensis* (Wied.) and that of *Eristalis quinquestriatus* (Fabr.) which has also been bred at Pusa. They are very similar in general appearance, size, colour and many other details of external anatomy. The task of distinguishing between the two larvae will not be found difficult if the last segment in the tail of the larvae is examined. In the larva of *Helophilus bengalensis* (Wied.) it is pale yellow with the tip black, while in the larva of *Eristalis quinquestriatus*, it is uniformly pale yellow.

Pupa (Plate LXVII, fig. *f*)—The larva under laboratory conditions feeds for 16 days after which it pupates. For pupation it prefers moist saw-dust.

The pupa is 18.5 mm. in length (body 9 mm., tail 8.7 mm.) and 4 mm. in breadth. It is of a light brown colour dorsally, and pale yellow on the ventral side. The dorsal surface is convex sloping abruptly at the anterior end. The ventral side is flat with paired patches of small spines indicating the retracted pro-legs. Dorsally are seen two small yellow larval respiratory cornua and a little behind them the two pupal respiratory cornua which are of a pale ochraceous colour. Each pupal respiratory cornu is 1 mm. in length. The upper half of its body is studded with small spiracles appearing as dot-like tuberculated structures. Each such spiracle is shown in Plate LXVII, fig. *h*. The pupal period is about 8 days.

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EXPLANATION OF PLATES

PLATE LX, *Baccha pulchrisfrons* AUSTEN

a, The egg $\times 36$; *b*, young larva $\times 24$; *c*, mouth parts of the larva highly magnified; *d*, full-grown larva $\times 12$; *e*, end view of the posterior respiratory appendage highly magnified; *f*, the pupa $\times 12$; *g*, the adult fly, female $\times 6$.

PLATE LXI, *Paragus serratus* FABRICIUS

a, The egg $\times 24$; *b*, full-grown larva $\times 12$; *c*, mouth parts of the larva highly magnified; *d*, end view of the posterior respiratory appendage highly magnified; *e*, the pupa $\times 12$; *f*, the adult fly, female $\times 9$.

PLATE LXII, *Sphaerophoria javana* WIEDEMANN

a, The egg $\times 36$; *b*, chorion of the egg highly magnified; *c*, young larva $\times 21$; *d*, full-grown larva $\times 9$; *e*, end view of the respiratory appendage highly magnified; *f*, the pupa $\times 12$; *g*, the adult fly, female $\times 6$.

PLATE LXIII, *Syrphus serarius* WIEDEMANN

a, Full-grown larva $\times 12$; *b*, mouth parts of the larva highly magnified; *c*, end view of the posterior respiratory appendage highly magnified; *d*, the pupa $\times 9$; *e*, adult fly, female $\times 6$.

PLATE LXIV, *Syrphus balteatus* DE GEER

a, The egg $\times 30$; *b*, chorion of the egg highly magnified; *c*, young larva $\times 30$; *d*, mouth parts of the larva highly magnified; *e*, full-grown larva $\times 12$; *f*, end view of the posterior respiratory appendage, highly magnified; *g*, the pupa $\times 12$; *h*, the adult fly, female $\times 6$.

PLATE LXV, *Syrphus confrater* WIEDEMANN

a, Full-grown larva $\times 6$; *b*, the pupa $\times 8$; *c*, the adult male fly $\times 5$.

PLATE LXVI, *Syrphus isaaci* SP. NOV

a, Full-grown larva $\times 9$; *b*, the pupa $\times 9$; *c*, the adult fly, female $\times 6$.

PLATE LXVII, *Felophilus bengalensis* WIEDEMANN

a, The egg $\times 26$; *b*, chorion of the egg highly magnified; *c*, young larva $\times 6\frac{1}{2}$; *d*, full-grown larva $\times 4$; *e*, terminal portion of the respiratory tube highly magnified; *f*, the pupa $\times 4$; *g*, pupal respiratory cornu $\times 24$; *h*, a small spiracle of the pupal respiratory cornu highly magnified; *i*, the adult fly, female $\times 3$.