Pacific Insects Vol. 19, no. 1-2: 53-64 20 October 1978

THE BIOLOGY OF A SPECIES OF *DOLESCHALLA* (DIPTERA: TACHINIDAE), A PARASITE OF *PANTORHYTES SZENTIVANYI* (COLEOPTERA: CURCULIONIDAE)[1]

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Abstract: The biology of an undescribed species of tachinid (*Doleschalla* sp.) is presented. The tachinid is one of the most abundant parasites of late-instar larvae of *Pantorhytes szentivanyi*, a serious pest of cacao in the Northern Province of Papua New Guinea. Parasitism rates of up to 4.45% were recorded in a cacao planting heavily infested by *P. szentivanyi*. The female *Doleschalla* is larviparous, the larvae being deposited on the frass exuding from the larval channel of the host. Development of the parasite within *P. szentivanyi* larvae takes from 8 to 10 days. As many as 3 larvae may develop within a single host. The *Doleschalla* larvae emerge from the host to pupate in the host larval channel. The pupal period ranges from 10 to 14 days; sexual maturation of the female takes a further 5 to 8 days. Three hymenopterous hyperparasites, *Exoristobia philippinensis* (Encyrtidae), *Zaplatycercus* sp. (Encyrtidae), and *Trichopria* sp. (Diapriidae), were bred from field collected *Doleschalla* puparia. None was recorded at a frequency which would significantly reduce the effectiveness of *Doleschalla* as a parasite.

This paper deals with the biology of an undescibed species of *Doleschalla*, a common parasite of *Pantorhytes szentivanyi* Marshall larvae and the only endoparasite recorded from *P. szentivanyi* larvae (Baker 1976). Specimens have been lodged in the following institutions: Central Reference Collection, Department of Primary Industry, Konedobu, Papua New Guinea (Listed number 16374); Australian National Insect Collection, C.S.I.R.O., Canberra, Australia; and the British Museum (Natural History), London, England.

The genus *Doleschalla* is widely distributed throughout Papua New Guinea, being represented by several species. There has been no previous biological information published on this genus (Crosskey, pers. commun.). The type locality of the type-species, *Doleschalla cylindrica* Walker, is New Guinea (Crosskey 1967).

The host, *P. szentivanyi*, is a serious pest of cacao in the Northern Province of Papua New Guinea. The larvae bore channels in the sapwood and hardwood of the cacao trees, frequently causing extensive damage and often resulting in the death of the trees (Anon. 1961, 1971, Smee 1963). *Doleschalla* sp. was first recorded as a parasite of *P. szentivanyi* in August 1968 (Bourke et al. 1973).

An examination of approximately 1500 *Pantorhytes plutus* (Oberthür) larvae (collected from cacao in the Warangoi area of E New Britain in December 1971) failed to indicate parasitism of this species by tachinids. Extensive studies on the biological control agents of

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Pantorhytes biplagiatus (Guerin) in the British Solomon Islands by Friend (1973) and of *Pantorhytes batesi* Faust in the Markham Valley of Papua New Guinea by Ardley (unpubl. data) also failed to reveal any indication of parasitism by tachinids. Tachinids of the genus *Doleschalla*, therefore, appear not to be general parasites of the genus *Pantorhytes*.

P. szentivanyi is restricted to the coastal lowlands of the Northern Province of Papua New Guinea (Gressitt 1966) and the extent of the distribution of the species of *Doleschalla* dealt with in this paper (hereafter referred to simply as *Doleschalla*), may be the same.

In a study of the biological control agents of *P. szentivanyi*, a cacao planting of 0.75 hectares on "Bisi" plantation in the Northern Province was regularly scored for host numbers and the incidence of predators and parasites. The trial, which was commenced in December 1966, was continued for 5 years.

INCIDENCE AND ABUNDANCE

Doleschalla was first recorded from the trial area in August 1968. This was 2 years after *P. szentivanyi* had initially infested the block (late 1966). Parasitism rates subsequent to August 1968 were low, ranging from 0 to 4.54% over the planting (FIG. 1). However, subsamples from fixed sampling sites, the full results of which are not given in this paper, revealed parasitism rates as high as 12.5%. The parasitism rate within subsamples increased with increased number of host larvae. The results of the December 1968 scoring typify this density dependence and are given in TABLE 1.

However, when consideration is given to the results for the entire trial area there is very little change in the parasitism rate with changes in the number of host larvae. Density dependent fluctuations in the parasitism rate appeared, therefore, to be localized and masked by variations in the intensity of the infestation throughout the trial area. It should be noted that *Doleschalla* was not recorded during 1967 and early 1968, nor again during late 1969 and early 1970, when only low numbers of host larvae were present. It therefore appears as if the occurrence of *Doleschalla* is dependent on a threshold host density being reached before parasitism is detectable. The threshold appears to be much lower once *Doleschalla* has become established than in the early phase of the host infestation.

The results of sampling over a 5-year period did not indicate any seasonal differences in the abundance of *Doleschalla* (FIG. 1).

TABLE 1. Effect of host density on parasitism rate (data from December 1968 scoring).

Subsampling sites (10 cacao trees each)	Total *P. szentivanyi* larval channels examined	Host larvae present	Number of parasitized host larvae	Parasitism %
A	112	77	7	9.09
B	112	51	5	9.80
C	54	32	1	3.12
remaining sites (D-J)	300	130 (range 3–28)	0	0

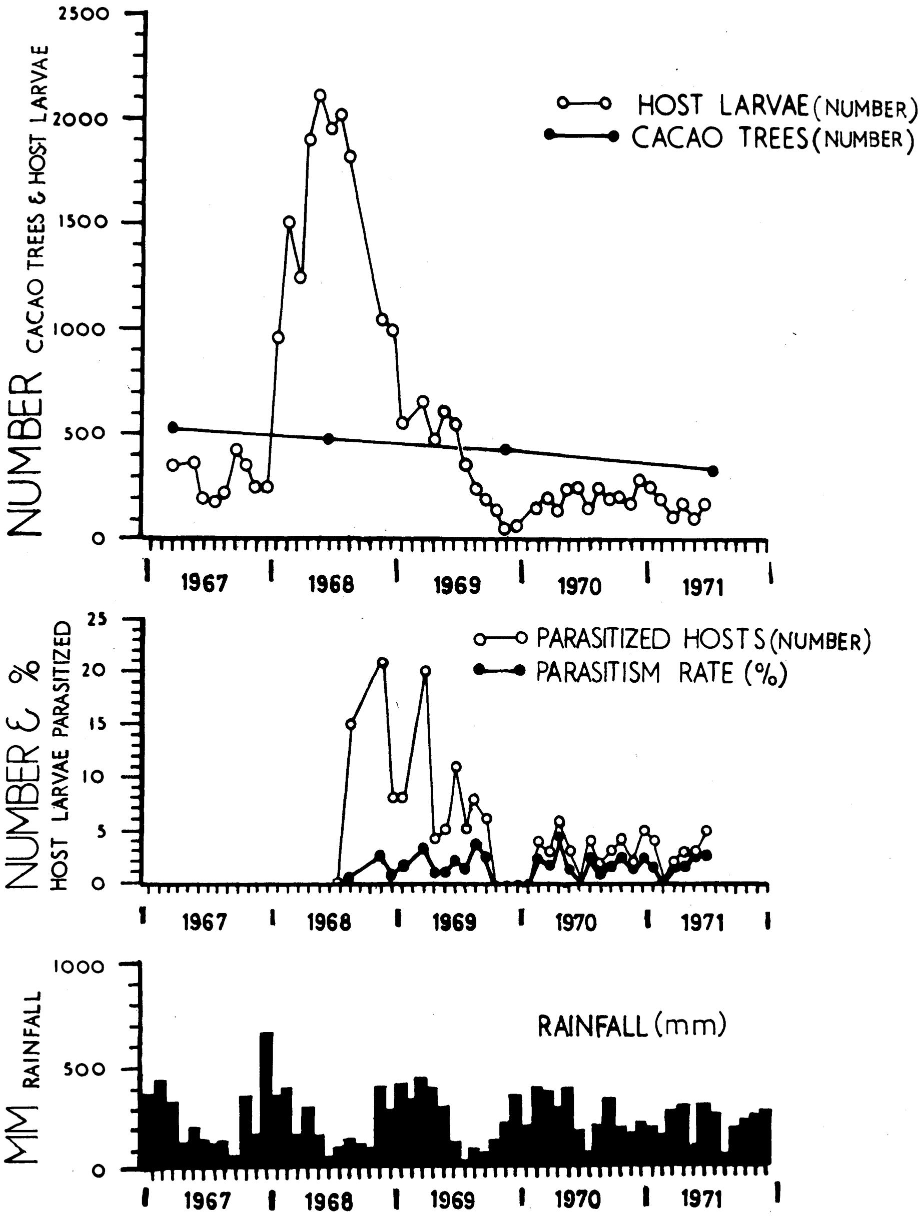

FIG. 1. The incidence of parasitism of *P. szentivanyi* larvae by *Doleschalla* in an observation cacao block (number of parasitized hosts and parasitism rate) in relation to age of the host infestation and rainfall. The decline in the number of cacao trees during the trial period is also shown.

HYPERPARASITES

Three hymenopterous hyperparasites have been bred from *Doleschalla* puparia collected in the field.

Exoristobia philippinensis Ashmead (Hymenoptera: Encyrtidae)

E. philippinensis (FIG. 2) was the most commonly encountered hyperparasite in the observation cacao block. From a sample of 37 *Doleschalla* puparia collected over the trial period, 6 were parasitized by *E. philippinensis* (16.2%). These were bred in December 1968, September 1969 and November 1971; however, as no consistent attempt was made to rear hyperparasites from parasitized *P. szentivanyi* larvae sampled during the trial, no seasonal record of incidence is available.

In 4 instances where a complete determination could be made of the sex of adult *E. philippinensis* emerging from host puparia, the following results were obtained: 15 ♂♂; 143 ♂♂; 15 ♀♀ and 11 ♂♂; 12 ♀♀. The hyperparasites all emerged within 8 days of collection though it is not known when hosts had pupated.

In Papua New Guinea, *E. philippinensis* has been recorded as a hyperparasite of several tachinid species, including *Ceracia aurifrons* Aldrich, a parasite of *Locusta migratoria* (L.) (Orthoptera: Acrididae) and an unidentified tachinid parasite of *Spodoptera exempta* Walker (Lepidoptera: Noctuidae) (Baker, unpubl. data). It has also been bred from the puparia of a sarcophagid, *Blaesoxipha pachytyli* (Skuse), a parasite of *L. migratoria* (Baker, in prep.).

Zaplatycerus sp. (Hymenoptera: Encyrtidae)

A single female *Zaplatycerus* (FIG. 3) was bred from a *Doleschalla* puparium collected in the observation cacao block at Sangara in the Northern Province on 13.V.1971.

Trichopria sp. (Hymenoptera: Diapriidae)

Trichopria (FIG. 4) was bred on 2 occasions from puparia of *Doleschalla* collected in the observation cacao block at Sangara in the Northern Province. Five males and 3 females emerged from a *Doleschalla* puparium collected on 2.VI.1971 and 8 males and 3 females from a *Doleschalla* puparium collected on 15.V.1971. The adult *Trichopria* emerged 15 and 33 days, respectively, after collection of the host puparia.

BIOLOGY OF ADULTS

EMERGENCE

Adult *Doleschalla* emerged from puparia between 0900 hr and 1100 hr. Adults broke away the ventral 1/2 of the operculum during emergence and by alternately expanding and contracting the ptilinum, moved through the frass to the entrance of the channel of the host

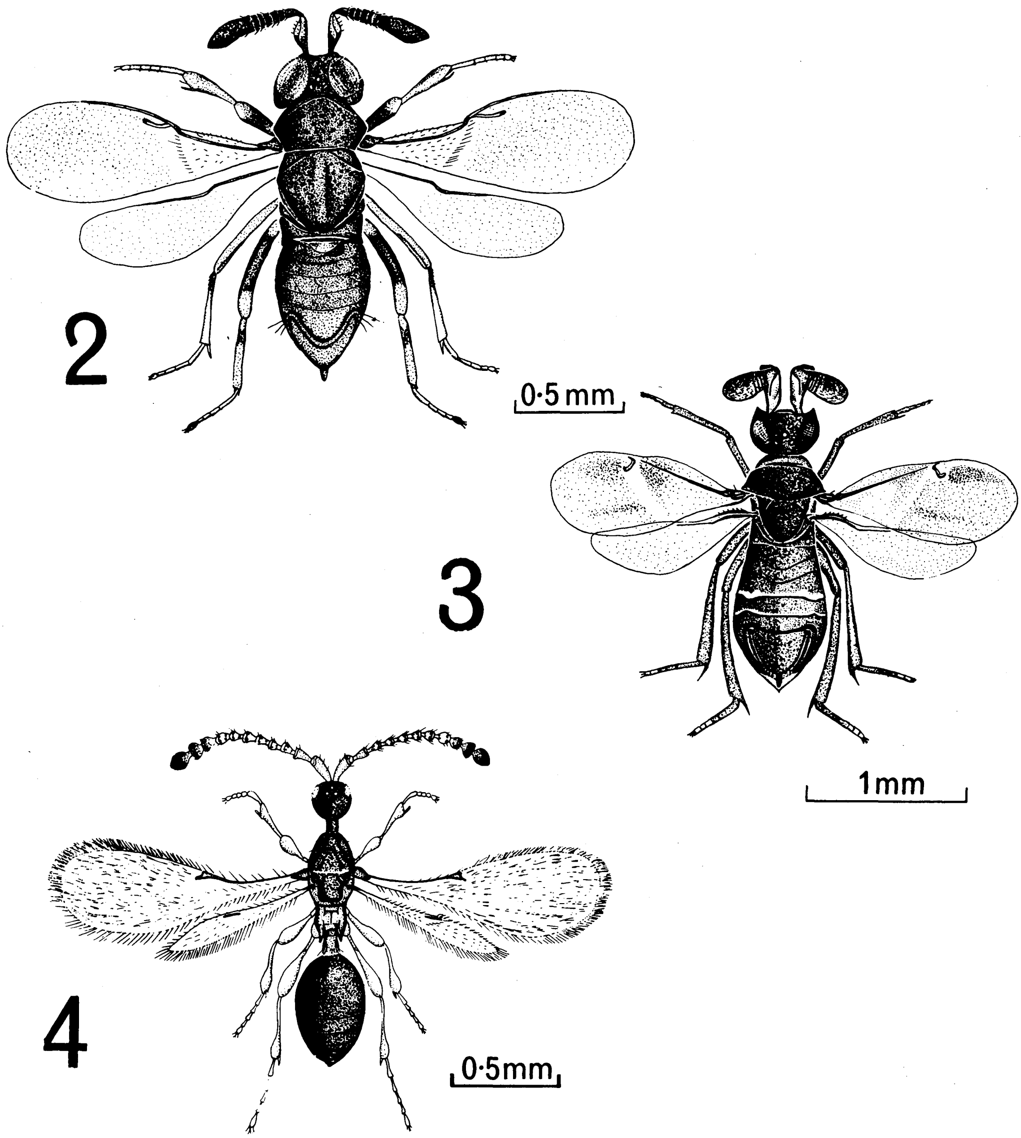

FIG. 2-4. Hyperparasites of *Doleschalla* puparia: 2, ♀ *Exoristobia philippinensis* Ashmead (Hymenoptera: Encyrtidae); 3, ♀ *Zaplatycercus* sp. (Hymenoptera: Encyrtidae); 4, ♀ *Trichopria* sp. (Hymenoptera: Diapriidae).

larva. The ptilinum only remained in use for up to 1 hr before it hardened. If an adult was not free of the puparium or the frass before the ptilinum hardened then it died *in situ*. Instances of adults so killed were not observed in the field, but mortality from this cause was frequent in the laboratory.

The adult male is much smaller than the female, with a body length ranging from 9.0-13.5 mm (mean 11.21 mm, n[3]=7♂♂). The female body length ranges from 13.0-17.0 mm (mean 14.01 mm, n=8 ♀♀).

SEXUAL DEVELOPMENT

Mating has been observed in the laboratory on the day following emergence.

In the laboratory *P. szentivanyi* larvae placed with female *Doleschalla* were not parasitized during the first 5 days. Adult female *Doleschalla* have been observed larvipositing on frass at the entrance to host channels from 5 to 8 days after emergence. This would appear to be a relatively short gestation period for a larviparous species of tachinid (cf Clausen 1940).

One female, dissected when 8 days old after having been observed larvipositing 5 larvae, was found to contain 142 embryos in 6 ovarioles, the number per ovariole ranging from 10 to 59. All embryos were of approximately the same size and were presumably fully developed.

LARVIPOSITION

The gravid *Doleschalla* female, on locating a host channel with frass and sap present at the entrance, alights on the frass and then proceeds to probe the frass. The female adopts a stance over the frass with the forelegs stretched out in front of her body until they are straight. Keeping the head, thorax and abdomen in a straight line, the female tilts the body through an angle of approximately 45°, the head passing between the outstretched forelegs to come in contact with the frass (FIG. 5). The prementum extends; the labellum expands laterally; fluids within the frass are presumably being taken up by the mouth-parts, either for ingestion or for tasting to derive the stimulus necessary to initiate larviposition. This activity often continues for extended periods of 2 to 5 min., the head at times being deeply embedded in the frass.

The attitude of the body of the female does not change during larviposition. The head remains in contact with the frass; however, the abdomen is arched strongly downwards, enabling the tip to contact the frass and, as it touches, the larvae are ejected. The larvae burrow into the frass immediately after ejection.

The number of larvae ejected at any 1 time was counted on only 2 occasions, once when 5 and once when 7 larvae were deposited.

In the laboratory, gravid females were frequently observed probing frass exuding from host channels in cacao pods, but larviposition did not follow in most instances despite the fact that host larvae were present in the channels. The probing of frass by females has been observed in the laboratory within 2 days of emergence, which is a considerable time before the conclusion of the preoviposition period, and may indicate that probing of frass during the preoviposition period is for feeding.

3. n=number of observations on which range and mean are based.

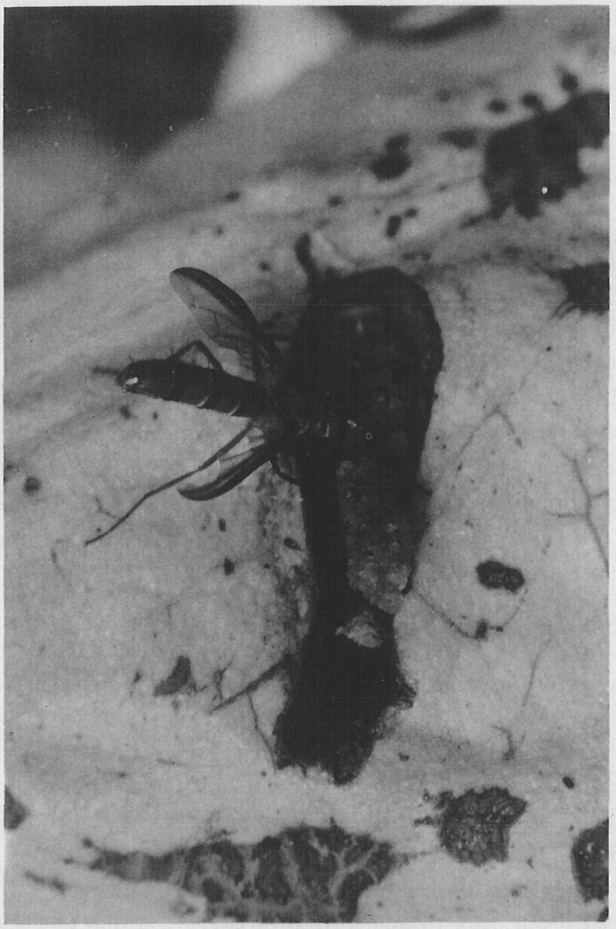

FIG. 5. Adult ♀ *Doleschalla* in characteristic probing attitude over a host channel in a cacao pod.

Activity

Adult *Doleschalla* do not appear to be very active. They are difficult to disturb and when disturbed tend to alight again after a very short flight of rarely more than 3 m. Specimens have been observed in the field resting in 1 position without movement for as long as 35 min. In the laboratory, adults are most active during mid-afternoon. Probing and larviposition by females has been observed only after 1400 hr.

Longevity

Under laboratory conditions, the longevity of adult males ranged from 8-22 days (mean 11.80; n=4) and for females from 3-15 days (mean 9.66; n=6). The conditions under which adults were held in the laboratory proved unsatisfactory for breeding, possibly due to unsatisfied food or mating requirements, and the same adverse conditions could be expected to have adversely affected longevity.

LARVAL DEVELOPMENT

METHOD

Parasitized *P. szentivanyi* and *Doleschalla* puparia were collected in the field and cultured in the laboratory in individual petri dishes containing moist sawdust. All adults emerging on any 1 day were transferred to an insect cage. Water and sugar solution were provided as food. Cacao pods in which late-instar *P. szentivanyi* larvae had been established were placed in the cages with the newly-emerged adult parasites. The pods were replaced daily. Three days after removal of each day's pods the host larvae present were transferred from the cacao pod to petri dishes containing a mixture of sawdust and homogenized cacao pod exocarp. The host larvae were examined each day for signs of parasitism. Records were made of the time a respiratory funnel appeared and the time host activity ceased. Following the emergence of the *Doleschalla* larvae from the host, the time of pupation, adult emergence and longevity were recorded.

RESULTS

At the time of larviposition the 1st-instar larvae are elongate-ovoid in shape, very broad at the caudal end and tapered to a fine point at the cephalic end. The buccopharyngeal armature is not clearly visible. The dimensions of larvae are given in TABLE 2.

The mode of entry of the 1st-instar larvae into the host larva is not known.

Respiratory funnels (FIG. 6 & 7) are first observed in host larvae approximately 3 days after larvae have been deposited at the entrance to the host channel (TABLE 3). *Doleschalla* larvae at this stage vary considerably in size and shape from those larviposited. The dimensions of larvae at the time of respiratory funnel formation are given in TABLE 2. The larvae at this stage are ovoid with a respiratory funnel approximately 0.5 mm long covering the caudal

TABLE 2. Dimensions of developmental stages of *Doleschalla*.

	LENGTH (mm)		WIDTH* (mm)		SAMPLE SIZE
	Range	Mean	Range	Mean	
Larvae					
1st-instar					
At time of larviposition	1.1–1.2	1.17	0.1–0.2	0.15	5
At time of respiratory funnel formation	1.1–2.3	1.76	0.4–0.8	0.58	8
2nd-instar	6.2–8.4	6.80	1.4–2.0	1.80	7
3rd-instar	12.5–16.4	15.30	3.2–4.4	3.60	18
Puparia					
♂♂	6.5–8.8	8.20	2.0–3.7	3.20	7
♀♀	9.2–11.2	9.70	3.4–4.2	3.70	9

*Measured caudad.

end of the body (FIG. 7). The respiratory funnel is visible through the integument of the host as a black cone protruding slightly from the body (FIG. 6). The duration of the 1st-instar larval stage is not known.

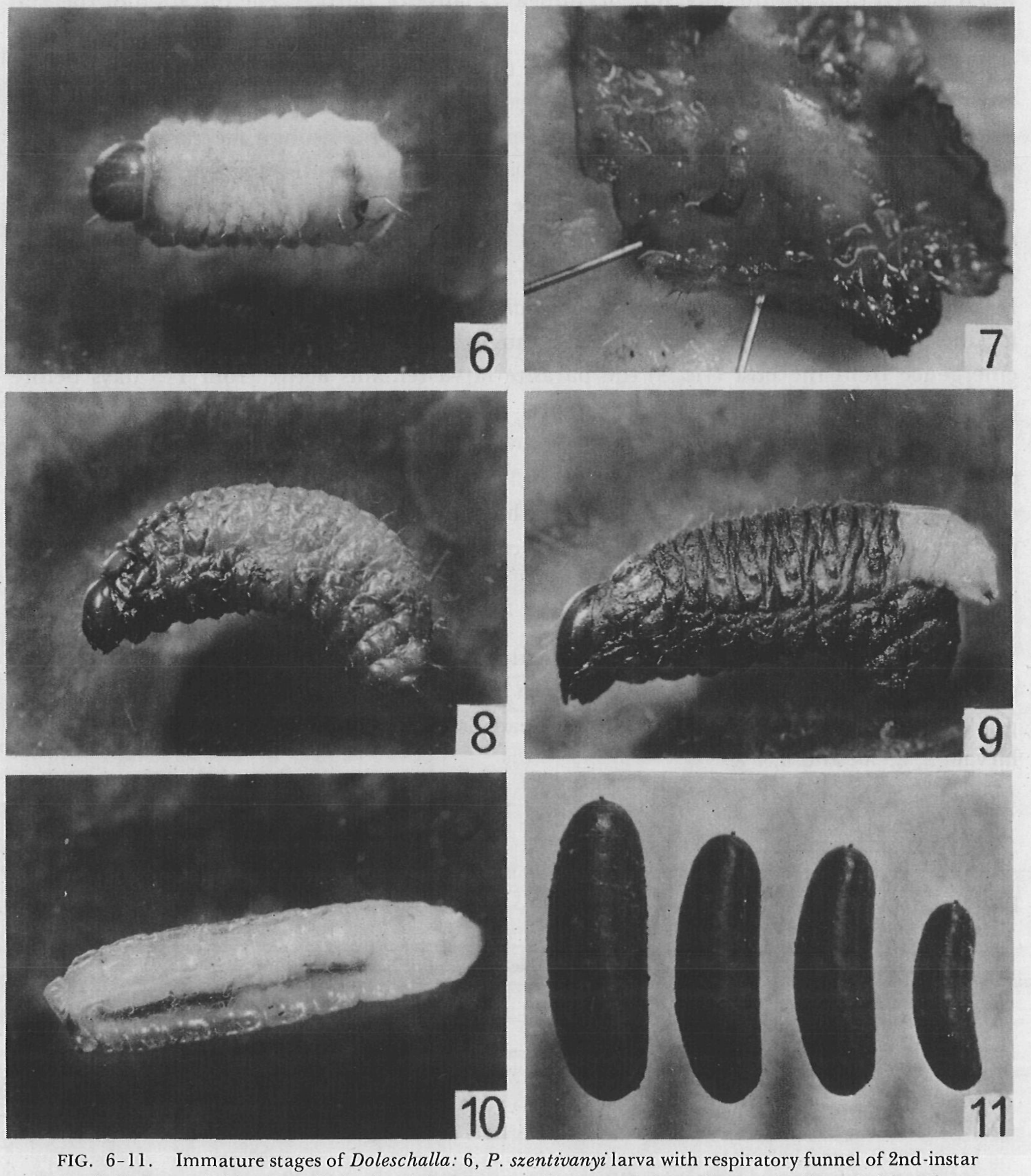

FIG. 6–11. Immature stages of *Doleschalla:* 6, *P. szentivanyi* larva with respiratory funnel of 2nd-instar *Doleschalla* larva visible through the host's integument; 7, internal view of same; 8, distended host larva containing a fully grown parasitic larva; 9, 3rd-instar larva emerging from host; 10, 3rd-instar larva; 11, puparia.

Second-instar larvae are similar in shape to 1st-instar larvae but are much larger (TABLE 2); the buccopharyngeal armature is distinctly visible. The respiratory funnel covering the caudal end of the body measures 1.5-2.0 mm in length and is clearly visible through the integument of the host. The apex of the respiratory funnel is black while the remainder, when viewed through the integument, appears mauve or purple. The duration of the 2nd instar is not known.

Third-instar larvae are several times larger than 2nd-instar larvae (TABLE 2). The fully-fed 3rd-instar *Doleschalla* larva becomes quite active inside the host, and the host's integument is expanded and smoothed, giving a bloated appearance, as a result of the parasite's activity. At the same time the integument darkens and begins to dry (FIG. 8). The fully-fed *Doleschalla* larva makes an exit hole in the host's integument but does not always immediately vacate the host. The larva, at this stage, frees itself from the respiratory funnel and can be found at large within the host. Frequently *Doleschalla* larvae remain inside the host for 10 hr or more after making an exit hole. The total duration of the larval stage from larviposition to emergence from the host ranges from 8-10 days (mean 8.66; n=3). On emergence from the host (FIG. 9) the parasite larva remains active from 1-3 days before pupating (mean 1.93; n=14).

The duration of the 3rd instar is not known. However, the time interval between the death of host larvae and the emergence of 3rd-instar parasite larvae from them is fairly constant (TABLE 3). The time of death of the host may correspond to a change in the parasite's feeding habits soon after it enters the 3rd instar.

MULTIPLE PARASITISM

Multiple parasitism is not uncommon, with up to 3 larvae capable of successfully completing development within a single host larva. During sampling, the number of *Doleschalla* puparia found associated with individual dead host larvae was 1 puparium, 64% of host larvae: 2, 29%: and 3, 7%.

PUPAL STAGE

Fully fed larvae pupate in the frass within the channel of the host larva, usually in close proximity (1-3 cm) to the abandoned host. Occasionally pupation takes place within the

TABLE 3. Duration of observable change during parasitism of host.

CHANGE IN HOST LARVA	DURATION (DAYS)		SAMPLE SIZE
	Range	Mean	
Period from larviposition (a) to appearance of respiratory funnel (b)	2–5	3.06	4
Period from (b) above to cessation of activity by host (c)	2–7	4.66	9
Period from (c) above to death of host and discoloration (d)	1–2	1.12	8
Period from (d) above to emergence of parasite from host	1–2	1.22	9

body of the host (3 out of 34 instances of parasitism in 1 series of field observations).

Puparia are light brown or rose colored and remain so for approximately 4 days. Between days 5 and 7, puparia darken to burgundy. The dimensions of puparia collected in the field differ between the sexes and there is also considerable variation within each sex (TABLE 2). The puparia are elongate and curved at both ends (FIG. 11).

The pupal period varies between the sexes. The male has a pupal period of 10–14 days (mean 11.88; $n=9$) and the female of 11–14 days (mean 12.71; $n=14$).

DISCUSSION

P. szentivanyi is the most important species of *Pantorhytes* attacking cacao in Papua New Guinea (Gressitt 1966). This is because a short larval development period and relatively high fecundity enables populations to develop to damaging levels very rapidly (Baker et al. 1974).

Doleschalla have been observed to play an insignificant role during the initial rapid development of an infestation of *P. szentivanyi*. In the trial area it was not until after peak larval numbers were achieved (13–18 months after the infestation established) that *Doleschalla* was recorded as a parasite. Other parasites which attack the larval stage of *P. szentivanyi*, such as the bethylid *Pristocera rufa* Kieffer (Baker 1976), exhibit a similar delayed response to a build-up in host numbers. Consequently, there are no parasites which have any significant effect in limiting an infestation during the early stage of the population's rapid development. The only biological control agent which is important in this respect is the ant *Anoplolepis longipes* (Jerdon) (Baker 1972).

It should be noted that the time at which the *P. szentivanyi* larval population commenced to decline (August 1968; FIG. 1) coincided with the first appearance of *Doleschalla*, but no causal relationship is proposed. The mean parasitism rate for *Doleschalla* recorded after the peak infestation period was only 1.6%. Although low, this rate does produce significant mortality in a generation of host larvae. This is because of the relatively long duration of the susceptible stage of the host in relation to the short duration of the parasite's development within the host (the stage on which the parasitism rate is based). The parasitism rates given in FIG. 1 represent parasitism over a 4- to 11-day period, whereas the duration of the susceptible stage of the host is 90 to 120 days (instars 4 to 9). This implies that if the mean parasitism rate recorded was maintained over the duration of the susceptible stage of the host, then mortality over this period could amount to as much as 20% to 27%.

However, despite the potentially high mortality (which could be caused by *Doleschalla*), many other factors are implicated in producing the characteristic loss of impetus of the infestation after the peak larval numbers. The most important are changes in the microclimate and physiological status of the cacao trees following damage to the cacao planting by *P. szentivanyi* itself. Feeding by *P. szentivanyi* adults on the shoots of the cacao trees and the loss of trees through *P. szentivanyi* larval damage produce a discontinuous canopy with important consequences for the suitability of the habitat for further utilization by *P. szentivanyi*.

The natural habitat of *P. szentivanyi* is secondary regrowth forest where its main host is *Pipturus argenteus* (Urticaceae). The importance of *Doleschalla* as its parasite in this habitat has not been studied. *P. argenteus* responds to *P. szentivanyi* larval damage by producing a copious flow of sap which frequently results in the ensnarement and expulsion of larvae with the sap. This copious sap flow would also be expected to hinder newly deposited *Doleschalla* larvae in locating their hosts and could result in a lower rate of parasitism in the natural habitat of the host than that recorded in cacao plantings.

Acknowledgments: The author would like to thank Dr R. Crosskey of the British Museum (Natural History), London, for identifying *Doleschalla*, and members of the Commonwealth Institute of Entomology, London, for identifying the hyperparasites. Thanks are also extended to Mr T. Bourke, formerly of the Department of Primary Industry, Papua New Guinea, for critical reading of an early draft of the manuscript and Mr C. Mayoh of "Bisi" plantation for his cooperation in allowing trials to be conducted on his plantation. The technical assistance of Mr B. Keoro and Mr D. Tago of the Department of Primary Industry, Popondetta, Papua New Guinea, is gratefully acknowledged.

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