

PAPÉIS AVULSOS

DO

DEPARTAMENTO DE ZOOLOGIA

SECRETARIA DA AGRICULTURA — SÃO PAULO - BRASIL

BIOLOGICAL OBSERVATIONS ON SOME MASIPHYINI
(DIPTERA, TACHINIDAE) PARASITES OF MANTODEA

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INTRODUCTION

Tachinid larvae have been recorded as endoparasitic of several groups of insects particularly Lepidoptera, Tenthredinidae (Hym.) larvae, adult Coleoptera and Hemiptera. Among the Orthopteroidea cases have been cited in almost all orders. Nevertheless, nothing was known, up to the present, about the parasitism of Mantodea by Tachinids except for a small note published by Travassos F.^o & Carrera (1946:128). Consulting the published host-lists, such as Thompson's date and Brauer & Bergenstamm's which deal with the subject on a world-wide basis, we found no other records, this was later confirmed by Dr. W. R. Thompson of the Entomology Research Institute, Canada Department of Agriculture, Ottawa, Canada (personal communication), to whom we are deeply obliged.

In the course of observations on the biology of Mantodea at the laboratories of this Department by Drs. L. Travassos F.^o and the senior author, we had the opportunity to study some occasional cases of parasitism of mantids by tachinid larvae. Since the relationships between host-selection and phylogeny among the Tachinidae have been of great theoretical and practical importance, the elaboration and publication of these preliminary results seem desirable. The adult flies were reared from hosts collected in the field and their development was completed in the laboratory. The rearing of hosts and parasites and the collecting of breeding records were undertaken by the junior author. The systematic position of the reared flies was given in a preceding paper (Guimarães, 1966).

EXTERNAL EVIDENCES OF PARASITISM

In the parasitized hosts the external opening of the respiratory funnel of the fly larva can be seen with the naked eye as a black

point. This structure is resulting from a reaction of the host at the penetration site of the parasite, which embraces the posterior segments of the fly larva, which is thus able to breathe during the endoparasitic phase. The funnel here described belongs to the category "sopirail primaire" of Pantel (1910). Among the many references on the development of respiratory funnels, the descriptions of Nielsen (1909), Pantel (1910) are probably the most informative. The recent paper of Salt (1963) included an extensive review of the previous literature and provided new informations in the light of more recent physiological knowledge.

The funnel is always inserted in the abdomen on the pleural region, and in some rare instances, dorsally or ventrally in the intersegmental membrane.

The external appearance of the respiratory funnel at first sight, resembles parasitism by Strepsiptera. Oglobin (1939) observed in Argentina a very interesting case of a specimen of *Acontiothespis maculatus* (Saussure) parasitized by a female Strepsiptera, belonging to the family Strichotrematidae. From the photograph presented, one can see the extreme similarity of the external appearance with one of the cases here described, where the host, *Acontiothespis bimaculata* (Saussure) was parasitized by larvae of *Masiphya brasiliiana* Brauer & Bergenstamm.

The abdomen of the mantid can be seen to be swollen and voluminous, as a gravid female when about ready to lay oothecae. The behaviour of the parasitized mantid was not disturbed during larval development, and in a general way we have not observed any disturbance in the mantid's reflexes.

INCIDENCE OF PARASITISM

From data obtained during the studies of biology of Mantodea between March 1944 to March 1958, by L. Travassos F.^o and subsequently until March 1964, by T. J. H. F. we have obtained the following percentages of parasitism by the masiphynes in the diverse subfamilies of mantid:

Mantidae Subfamily (*)	N. ^o of specimens collected	N. ^o of specimens parasitized	% of para- sitism
Vatinae	356	5	1,4
Photinae	160	9	5,6
Oligonicinae	78	4	5,1
Acontiothespinae	195	12	6,1
Thespinae	68	0	0,0
Miopteriginae	75	2	2,6
Liturgousinae	41	3	7,3
Eremiaphilinae	30	0	0,0
Total	1003	35	3,4

(*) The system of classification of the Order Mantodea, here adopted, is that proposed by Giglio-Tos (1927).

During these twenty years of observations only 35 cases of parasitism by Tachinidae were seen.

- a) In 14 cases the adults were obtained;
- b) in 10 the parasite died in the pupal stage, and in one were found fragmentary remains of a Microhymenoptera inside the puparium;
- c) in 8 the parasite did not emerge from the host;
- d) in one the parasite died in the larval stage;
- e) in one the parasite was fixed in Dietrich's fixative soon after its emergence from the host; and finally;
- f) in one case there were no data.

From table it can be seen that the incidence of parasitism in the several subfamilies is very low, Liturgousinae, Acontiothespinae and Photininae presenting the highest percentages.

Due to the fact that the flies were killed and preserved almost immediately after emergence from the puparia and to the present impossibility of obtaining laboratory matings, we could not examine in much detail the larval biology of this group. As stated above, a large proportion of the specimens died in the pupal stage and were unidentifiable.

REARING RECORDS

SUBFAMILY VATINAE

1. *Zoolea* sp. (n.º 28), nymph from Cocaia, Santo Amaro, São Paulo, collected on 11.V.1958. Parasite: *Mystacomyia rubriventris* (Wulp), (n.º 28.748). Emergence from host: 23.VII. Death of the host: 24.VII. Length of the pupal stage: 30 days. Obs. The host moulted on 12.VI..
2. *Zoolea* sp. (n.º 237), nymph from Cocaia, Santo Amaro, São Paulo, collected on 5.IV.1953. Parasite: *Mystacomyia rubriventris* (Wulp), (n.º 28.749). Emergence from host: 18.VII. Death of host: 20.VII. Length of the pupal stage: 39 days. Obs.: The host moulted three times (respectively on 9.IV., 30.IV., and 31.V), regenerating the middle right leg.
3. *Zoolea* sp. (n.º 251), nymph from Barueri, São Paulo, collected on 1.IV.1961. Parasite: *Mystacomioidea spinosa* Guimarães, (n.º 28.747). Emergence from host: 7.VI. Death of host: 7.VIII. Length of pupal stage: 39 days. Obs.: The host moulted on 22.IV and 7.VIII. The fly larvae emerged after the first moult.
4. *Oxyopsis* sp. (n.º 61). Adult female, from Cocaia, Santo Amaro, São Paulo. Emergence of larvae: 1.VI.1951. Death of the host: 12.VI. Obs.: The parasite died at the pupal stage.
5. *Oxyopsis* sp. (n.º 915). Adult female, from Rolândia, Paraná, collected on III.1963. Parasite: not identified. Death of host: 20.VIII. Obs.: The fly larvae did not emerge from the host.

SUBFAMILY PHOTININAE

6. *Photinella* sp. (n.º 1356), nymph from Itu, São Paulo (cerrado), collected on 3.XII.1960. Parasite: not identified. Death of host: 18.XII. Obs.: The larvae did not emerge from the host.
7. *Photina vitrea* (Burm.) (n.º 90.013). Adult male from Angra dos Reis, Rio de Janeiro, collected on 28.VIII.1945. Parasite: not identified. Death of host: 8.IX. Obs.: The larvae emerged after the host's death. The parasite perished in the larval stage.
8. *Photinella brevis* Rehn (n.º 108.502), nymph from Pôrto Cabral, São Paulo, collected on 8.IV.1944. Parasite: *Phasiopsis manteophaga* Guim. (n.º 28.746). Emergence of larvae: 20.V. Death of host: 20.V. Parasite pupal length: 31 days.
9. *Photinella brevis* Rehn (n.º 108.503), nymph from Pôrto Cabral, São Paulo, collected on 8.IV.1944. Parasite: not identified. Larvae emergence: 27.IV. Death of host: 27.IV. Obs.: The larvae was put on Dietrich's fixative after its emergence.
10. *Photinella brevis* Rehn (n.º 108.506), nymph from Pôrto Cabral, São Paulo, collected on 26.III.1944. Parasite: *Prophasiopsis lopesi* Guim. (n.º 28.745). Larvae emergence: 20.V. Death of host: 1.VI. Parasite pupal length: 31 days. Obs.: After the larvae emerged, the host still took food.
11. *Photinella brevis* Rehn (n.º 108.508), nymph from Pôrto Cabral, São Paulo, collected on 8.IV.1944. Parasite: not identified. Death of host: 11.VI. Obs.: The host moulted once (9.IV). The parasite died within the host.
12. *Photinella brevis* Rehn (n.º 108.510), nymph male from Pôrto Cabral, São Paulo, collected on 25.III.1944. Parasite: *Neomasiphya lenkoi* Guimarães (n.º 28.740). Emergence of larvae: 13.VII. Death of host: 3.I. Parasite pupal length: 47 days. Obs.: The host moulted twice before the emergence of larva (1.IV and 23.V) and three times after on 1.IX, 26.IX and 20.X) became adult. This male copulated the female n.º 108.515, producing offspring (343 nymphs).
13. *Photinella brevis* Rehn (n.º 108.522), nymph from Pôrto Cabral, São Paulo, collected on 12.IV.1944. Parasite: not identified. Emergence of larvae 6.VIII. Death of host: 29.XI. Obs.: The parasite died the pupal stage. Inside the puparia were found fragmentary remains of a microhymenopteron.
14. *Photinella brevis* Rehn (n.º 108.531), nymph from Pôrto Cabral, São Paulo, collected on IV.1944. Parasite: not identified. Obs.: Data lacking.

SUBFAMILY OLIGONICINAE

15. *Mionicella* sp. (n.º 1533), nymph from Ilha S. Sebastião (Ilhabela), São Paulo, collected on 14.XII.1952. Parasite: not identified. Emergence of larvae: 19.XII. Death of host: 20.XII. Obs.: The parasite died in the pupal stage.

16. *Mionicella* sp. (n.º 1544), nymph from Ilha S. Sebastião (Ilhabela), São Paulo, collected on 2.1.1954. Parasite: not identified. Emergence of parasite: 13.I. Death of host: 14.I. Obs.: The parasite died in the pupal stage.
17. *Mionicella* sp. (n.º 1546), nymph from Ilha S. Sebastião (Ilhabela), São Paulo, collected on 29.XI.1952. Parasite: not identified. Emergence of parasite: 12.XII. Death of host: Emergence of parasite: 13.XII. Parasite pupal length: 22 days.
18. *Thesprotia* sp. (n.º 108.507), nymph from Pôrto Cabral, São Paulo, collected on 3.IV.1944. Parasite: *Neomasiphya thompsoni* Guimarães. Emergence of parasite: 19.V. Death of host: 30.IX. Parasite pupal length: 32 days. Obs.: The host moulted to adult (21.VI) after the emergence of the larvae and was with the male n.º 108.511 (15.VIII to 5.IX). Copulation was not observed. The host laid 3 oothecae (dates not registered) the last one after contact with the male. No offspring was obtained.

SUBFAMILY ACONTIOTHESPINAE

19. *Acontiothespis concinna* (Perty) (n.º 1005), adult female, from Boracéia, São Paulo, collected on 10.VI.1955. Parasite: not identified. Death of host: 8.VII. Obs.: Emergence of the larvae was not registered. The parasite died in the pupal stage.
20. *Acontiothespis concinna* (Perty) (n.º 1031), nymph from Cocaia, Santo Amaro, São Paulo, collected on 18.X.1953. Parasite: not identified. Emergence of larvae: 25.X. Death of host: 25.X. Obs.: The host died in the pupal stage.
21. *Acontiothespis concinna* (Perty) (n.º 1088), nymph from Barueri, São Paulo, collected on 1.IV.1961. Parasite: *Masi-phyoidea chaetosa* Thompson, 1963 (n.º 28.741). Emergence of parasite: 15.IV. Death of host: 15.IV. Parasite pupal length: 30 days.
22. *Acontiothespis concinna* (Perty) (n.º 1.162), nymph from Barueri, São Paulo, collected on 9.IV.1961. Parasite: *Manteomasiphya brasiliensis* Guimarães (n.º 28.744). Emergence of larvae: 22.V. Death of host: 26.V. Parasite pupal length: 39 days.
23. *Acontiothespis concinna* (Perty) (n.º 108.501), female from Pôrto Cabral, São Paulo, collected on 25.III.1944. Parasite: not identified. Emergence of parasite: 19.IV. Death of host: 19.IV. Obs.: The parasite died in the pupal stage.
24. *Acontiothespis concinna* (Perty) (n.º 108.504) male from Pôrto Cabral, São Paulo, collected on 25.III.1944. Parasite: not identified. Death of host: 1.V. Obs.: The fly larvae died inside the host.
25. *Acontiothespis concinna* (Perty) (n.º 108.509), adult female, from Pôrto Cabral, São Paulo, collected on 23.III.1944. Parasite: not identified. Emergence of parasite: 6.IV. Death of host: 6.IV. Obs.: The host died with the abdomen ruptured by the larvae. The parasite died in the pupal stage.

26. *Acontiothespis bimaculata* (Sauss.) (n.º 1.182), nymph from Jataí, Goiás (Faz. Nova Orlândia), collected on I.1964. Parasite: not identified. Death of host: 30.III. Obs.: The parasite did not emerge from the host.
27. *Acontiothespis bimaculata* (Sauss.) (n.º 1.192), nymph from Faz. Nova Orlândia, Jataí, Goiás, collected on I.1964. Parasite: not identified. Death of host: 7.V. Obs.: The larvae did not emerge from the host.
28. *Acontiothespis bimaculata* (Sauss.) (n.º 1.193), nymph from Faz. Nova Orlândia, Jataí, Goiás, collected on I.1964. Parasite: not identified. Obs.: The parasite perished inside the host.
29. *Acontiothespis bimaculata* (Sauss.) (n.º 1.194), nymph from Faz. Nova Orlândia, Jataí, Goiás, collected on I.1964. Parasite: *Masiphya brasiliiana* Brauer & Bergestamm (n.º 28.743). Emergence of the larvae: 4.II. Death of host: 6.II. Parasite pupal length: 26 days. Obs.: The host still fed after the emergence of the larvae. This larvae was approximately of the same size as the abdomen of the host.
30. *Acontiothespis bimaculata* (Sauss.) (n.º 1.195), nymph from Faz. Nova Orlândia, Jataí, Goiás, collected on I.1964. Parasite: not identified. Death of host: 21.VII. Obs.: The larvae did not emerge from the host.

SUBFAMILY MIOPTERIGINAE

31. *Antimiopteryx* sp. (n.º 1.922), nymph from Ilha S. Sebastião (Ilhabela), São Paulo, collected on 1.II.1953. Parasite: not identified. Emergence from host: 27.II. Death of host: 27.II. Obs.: The host moulted before the larvae emerged (10.II). Since it was badly preserved, the fly was discarded and the length of pupal stage not registered.
32. *Antimiopteryx* sp. (n.º 1.938), nymph from Cocaia, Santo Amaro, São Paulo, collected on 12.IV.1953. Parasite: *Oromasiphya urbanae* Guimarães, 1966 (n.º 28.739). Emergence from host: 7.V. Death of host: 9.V. Length of the pupal stage: 31 days.

SUBFAMILY LITURGOSINAE

33. *Liturgousa* sp. (n.º 1.831), nymph from Cocaia, Santo Amaro, São Paulo, collected on 25.IV.1954. Parasite: *Micromasiphya curta* Townsend, 1934 (n.º 28.742). Emergence from host: 26.IV. Death of host: 27.IV. Length of pupal stage: 37 days.
34. *Liturgousa* sp. (n.º 1.832), nymph from Cocaia, Santo Amaro, São Paulo, collected on 8.VIII.1954. Parasite: not identified. Emergence from host: 26.VIII. Death of host: 5.IX. Obs.: The parasite died in the pupal stage.
35. *Liturgousa* sp. (n.º 1.833), nymph from Cocaia, Santo Amaro, São Paulo, collected on 15.VIII.1954. Parasite: not identified. Emergence from host: 27.VIII. Death of host: 28.VIII. Obs.: The parasite died in the pupal stage.

SEASONAL INCIDENCE OF PARASITISM

Our data do not afford a precise idea of the season of greatest incidence of parasitism, since only one locality — Cocaia, in Santo Amaro, SP, was systematically explored the year round. The remaining localities were explored sporadically during collecting trips of the staff of the Departamento de Zoologia, and do not have monthly samples.

From the above data, it can be seen, however, that the greatest incidence of parasitism occurs between the months of March and April (autumnal months, still relatively hot), and later, with lower percentage in the hot months of December and January. From a total of 35 observations, 18 have occurred in the period between the second half of March and the second half of April. Between December and January we have 8 cases, and in the remaining months (1 or 2 cases). In July, September and November we have no observations. We should take into consideration that the periods of greatest incidence correspond to the largest numbers of collected mantids.

Analysing separately the locality of Cocaia, we have 8 observed cases distributed thusly: 3 in April, one in May, 2 in August, 1 in October, and one case for which the date of collection was not recorded, but very possibly falling between April and June.

The emergence of the parasitic larva occurs, with greater frequency, between the months of April and July. The larva pupates in the soil, some hours after the emergence and has a pupal period of 22 (December) to 47 days (July). The parasite reaches the adult stage principally during the cold months (12 cases between May and August against 1 case in the summer, December).

Since the mantids collected at the field were already parasitized, we cannot make any comments on the length of the larval period of the parasite because we do not have data related to its penetration into the host. In the laboratory, the longest larval stage took 116 days, from April 12 to August 6 (specimen n.º 108.522).

NUMBER OF PARASITES PER HOSTS

We have never succeeded in rearing more than one fly from each host. This, however, does not indicate that the host has been initially parasitized by a single larva. So, in *Acontiothespis bimaculata* (Saussure), in 5 observed cases the number of parasites varied from 1 to 3 larvae per host (indicated by the presence of respiratory funnels), but only one host, which had a single larva, survived. The remaining hosts died before the emergence of the larvae.

HOST-PARASITE RELATIONSHIPS

Not much can be said here in view of the relative scarcity of detailed records. We have found a single case of two hosts belonging to the same genus (*Zoolea*), n.º 28 and 237, collected at

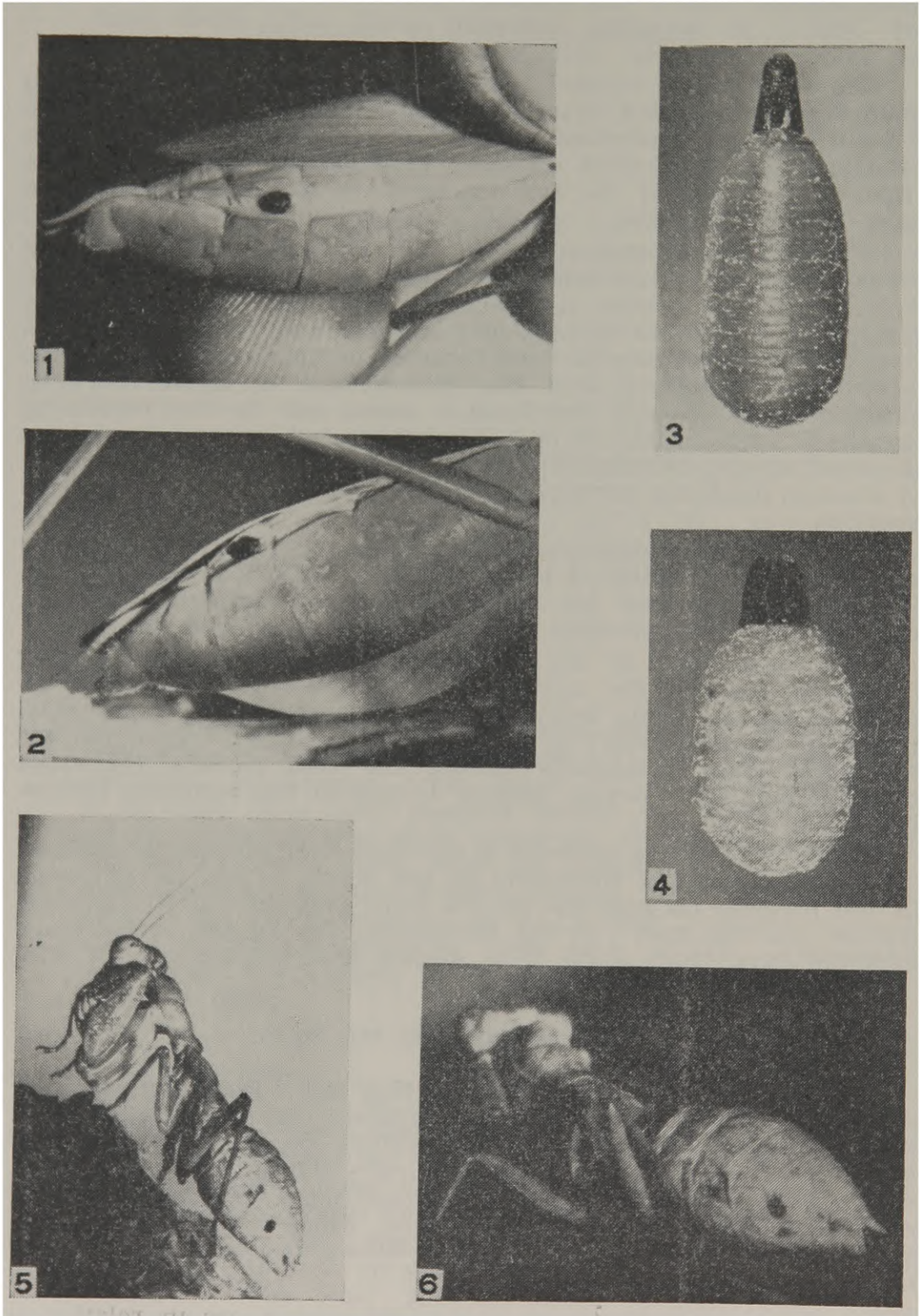


Fig. 1: Female of *Oxyopsis* sp., showing the external feature of the respiratory funnel, of an unidentified larva of Masiphyini. (Obs. nº 915); fig. 2: same, with the abdomen compressed; fig. 3: Pupa of *Neomasiphya thompsoni* Guimarães; fig. 4: same of *Phasiopsis manteophaga* Guimarães; fig. 5: Female nymph of *Acontiothespis bimaculata*, showing the external feature of the respiratory funnel, of *Masiphya brasiliiana* B. & B., larva; fig. 6: same, posterior view.

the same locality, and at the same time of year although in different years, being parasitized by the same species of fly, *Mystacomyia rubriventris* (Wulp) (n.º 28.748 and 28.749). On the other hand, there are two mantids of the same species, *Acontiothespis concinna* (Perty), (n.º 1.088 and 1.162), collected at the same locality month and year, parasitized by different genera of flies: *Masiphyoidea chaetosa* Thompson (n.º 28.741) and *Manteomasiphya brasiliensis* Guimarães (n.º 28.744).

An interesting case occurs with *Masiphyoidea chaetosa* Thompson. This fly was originally described from Trinidad and found afterwards in Brasil (Guimarães, 1966). We found it parasiting *Acontiothespis concinna* (Perty), which ranges all over South America from Paraguay to the Guianas, but does not reach Trinidad according to present knowledge. On that island there are other species of the genus *Acontiothespis*.

The genus *Neomasiphya* Guimarães has two species which parasitize two completely different subfamilies of mantids, both with respect to general appearance and body proportions: one is *Thesprotia* sp. (Oligonicinae) relatively large, but very slender, resembling more a phasmid, and the other is *Photinella brevis* Rehn, (Photininae) with a relatively strong and large body.

In *Liturgousa*, in three cases from the same locality, only one parasite reached the adult stage, being identified as *Micromasiphya curta* Townsend; in two other cases we obtained only pupae, the puparia being typical of the genus *Micromasiphya*.

STAGES OF THE HOST PARASITIZED BY THE TACHINIDS

In most of the observed cases the host was in the nymphal stage, when collected. In the above table we have 27 hosts in the nymphal stage and 8 adults (6 ♀ and 2 ♂) which may possibly have been in the nymphal stage when parasitized. This high incidence of parasites attacking the hosts in the nymphal stage might be explained by one of the following reasons:

1. The nymphal stage is longer than the adult stage allowing for higher parasitism indices. On the other hand, we cannot rule out the hypothesis of a natural tendency of the fly to attack certain of the younger stages. Olsoufieff (1929), studying the dipterous parasites of the asian locust (*Locusta migratoria* L.), observed remarkable differences of behaviour among the species of *Blaesoxypha* Loew. (Sarcophagidae) in relation to the parasitism of certain nymphal stages. Rukavishnikoff (1930), studying the same problem, confirmed these observations.
2. Less capacity of defense of the younger stages in relation to the adult, and also to the volume of the fly. According to Holling (1964:337), predators are particularly responsive to a specific size of prey and less readily attack prey smaller or larger than this optimum. So, the nymphs cannot grasp large prey such as an adult tachinid, which may then parasitize it.

SURVIVAL OF THE HOST AFTER LARVAL EMERGENCE

Parasitism is not always fatal to the mantids. Death occurs generally after 1 or 2 hours, to 1 or 2 days. In only 5 observations the host lived more than a week. Specimens n.º 1.832 (*Liturgousa* sp.), 61 (*Oxyopsis* sp.) and 108.506 (*Photinella brevis* Rehn) survived respectively 10, 11 and 12 days. Specimen n.º 108.522 (*Photinella brevis* Rehn) survived for 115 days, moulting once before and 3 times after the emergence of the larva and becoming an adult male. Unfortunately, by accident, the vial with the mantid was invaded by ants, which killed and partially devoured it. Specimen n.º 108.507 (*Thesprotia* sp.) moulted once after the emergence of the larva, becoming an adult female. She was put in a vial with a male, n.º 108.511, from August 15 to September 5, but no mating occurred. The female laid three oothecae, two before and one after being put together with the male, but no offspring was obtained.

Specimen n.º 108.510 (*Photinella brevis* Rehn) moulted twice before and twice after the larval emergence, becoming adult male. It copulated on November 1st, with a female (not parasitized), n.º 108.515, collected still young at the same locality, and having completed its development in the laboratory. The virgin female which emerged paired and laid two fertile oothecae on November 23 and December 19, leaving 343 descendants.

Death after the larval emergence may be due to mechanical injury as in specimen n.º 1.194 (*Acontiothespis bimaculata*); the larva which emerged had approximately the size of the host's abdomen. In specimen n.º 108.509 (*Acontiothespis concinna*) the abdomen was ruptured by the emerging larva. Another cause of the host's death could have been bacterial attack.

Many aspects of the larval biology of this group of flies still need further investigations, since some important points remain entirely unknown. Many more definite conclusions would have been possible if breeding records had always been gathered with sufficient detail to judge their individual reliability.

The survival of the host, as pointed out above, seems to be related to its size and stage of development. Specimens parasitized in their younger nymphal stages, and specimens of normally small-sized species do not resist, as a rule, the attack. When this occurs, the fertility may be much altered. According to Greathead (1963), the parasitism of Acrididae (Orthoptera) by tachinid larvae rarely kills the host, but its reproductive potentials become greatly altered by the reduction of the fat-bodies.

Pantel (1898) demonstrated the degeneration of the reproductive system of a female phasmid resulting from parasitism by a tachinid of the genus *Thrixion* was temporary and that in some cases those female could produce and lay eggs after the larvae had abandoned their body.

We have noticed that the damage done by the dipterous larvae may be moderate, especially in the last phases, and that death of the host is not invariable. The percentage of surviving mantids in all observed cases, was about 14%.

Mellini (1962) reviewing the data in the literature on the survival of hosts parasitized by tachinid larvae, says that this survival is rare among the victims of these flies. This same author concludes that the host survives there is not an intense final destructive phase by the larva, or when the differences in size between host and parasite are significantly great. Such a fact, according to Mellini, is less rare among the heterometabolous hosts rather than among the holometabolous.

ACKNOWLEDGEMENTS

We acknowledge the valuable collaboration of Drs. P. E. Vanzolini and L. R. Guimarães for reading and criticizing this work, of Dr. L. Travassos F.^o, who furnished us data and material collected as well as the photographs here published, taken with instruments obtained from FAPESP. Also, our gratitude to Mrs. Helga Urban and Dr. Karol Lenko, for the parasitized material given, and to Mr. W. D. Edmonds and Nelson Papavero, for their help in the preparation of the manuscript.

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