ENTOMOPHAGA 37 (1), 1992, 91-98

BIOLOGICAL STUDIES OF *BRACHYSERPHUS ABRUPTUS* [*HYM. : PROCTOTRUPIDAE*], A NITIDULID PARASITE

R. N. WILLIAMS, D. S. FICKLE & J. R. GALFORD (*)

Department of Entomology, Ohio Agricultural Research and Development Center
The Ohio State University, Wooster, Ohio 44691 USA
(*) Northeastern Forest Experiment Station's Timber and Watershed Laboratory Parsons, West Virginia 26287, USA

Data are presented on survival, fecundity, and hosts of *Brachyserphus abruptus* (Say), a solitary internal parasite of nitidulid (sap beetle) larvae. In the laboratory these wasps have been successfully reared from *Carpophilus hemipterus* (L.), *C. freemani* Dobson, *C. lugubris* Murray, *Stelidota geminata* (Say), *S. octomaculata* (Say), *S. ferruginea* Reitter, *Glischrochilus quadrisignatus* (Say), *Lobiopa insularis* (Castelnau), and *Haptoncus luteolus* (Erichson). Field collections of *B. abruptus* have been made from *S. geminata, S. octomaculata, C. hemipterus, C. lugubris, L. insularis* and *H. luteolus*. Oviposition continues throughout most of the adult female's lifetime. Under laboratory conditions life expectancy of females was *ca.* 6 days. Mean number of progeny reaching adulthood per female was 57, with a 1 : 1 sex ratio. First and 2nd instar nitidulids were suitable for successful development of *B. abruptus*. Third instars were attacked by *B. abruptus* but were not successfully parasitized. Parasite development required 29 days in 1st instar hosts and 27 d. in 2nd instars. Percent parasitism in 1st instar *C. hemipterus* averaged 65 % and for 2nd instar 45 %. After parasitism, larvae of *C. hemipterus* surviving to become adults averaged 0.6 % for 1st instar, 9.3 % for 2nd instar, and 90 % for 3rd instar.

KEY-WORDS : *Brachyserphus abruptus*, parasite, *Nitidulidae*, biology, behavior.

Larvae and adults of Nitidulidae (sap beetles or souring beetles) are pests of various crops (**Connell,** 1956). Each year the nitidulid complex causes significant economic damage to a multitude of agricultural crops in the field and in storage (**Hinton,** 1944) ; they are also nuisance pests (**Sakimura,** 1966). Chemical control is difficult due to the cryptic behavior of both adults and larvae. Searches for natural enemies have generally been conducted in tropical climes ; *Brachysyrphus abruptus* (Say), was never reported in such endeavors (**Williams** *et al.,* 1984).

There are 10 species in the genus *Brachyserphus* (*Hymenoptera : Proctotrupidae*) worldwide (**Townes & Townes,** 1981). The majority of these are found in the northern hemisphere. Only 2 have been associated with nitidulids ; a single mentioned *B. abruptus*

This article reports the results of research only. Mention of a proprietary product does not constitute an endorsement or a recommendation for its use by The Ohio State University.

from *Stelidota strigosa* (Gyllenhal) (**Ashmead,** 1893), while *B. parvulus* Nees has been reported from *Meligethes aeneus* (F.) and *M. viridescens* (F.) (**Osborne,** 1955 & 1960). A recent monograph of the family (**Townes & Townes,** 1981) clarified the status of the *B. abruptus* listing synonymy. Even though this species was reported only once from a nitidulid host (**Ashmead,** 1893), this information has been repeated frequently in subsequent publications. No other records exist linking *B. abruptus* to a host even though it is known from southern Canada to southern Brazil (**Townes & Townes,** 1981).

We first recovered this parasite in Homestead, Florida from the larvae of several species in several genera of Nearctic and Neotropical sap beetles. Although much is known about the distribution and seasonal abundance of *B. abruptus* based on collections of adults, host associations are mostly unknown (**Townes & Townes,** 1981). The objectives of this paper are to report nitidulid hosts, rearing techniques, and biology, with special attention to possible use in biological control of economically important sap beetles.

MATERIALS AND METHODS

Field collected sap beetle larvae were placed in rearing containers with diet and held for parasite emergence. As parasites emerged they were used to begin parasite cultures (fig. 1). Stock cultures of the parasite were maintained in 450 ml plastic containers utilizing larvae of *Carpophilus hemipterus* (L.) as host. All experiments, unless otherwise stated, were carried out at 28° ± 1 °C, and 70 ± 10 % RH. *C. hemipterus* were reared on artificial diet (**Hall** *et al.,* 1978) as hosts for all experiments, accept where noted.

EFFECT OF DIET REGIMENS ON ADULT PARASITE LONGEVITY

Male and female parasites (< 24 h old) were separated by sex and placed in ventilated 8 × 75 mm plastic snap-seal Petri dishes. Treatments for the adult parasites consisted of the following diet regimes : water ; 10 % honey/water solution ; artificial sap beetle diet ; and no food or water. Liquids were applied daily to cotton dental wicks (11 mm in diameter and 36 mm long) attached to the lids of the dishes with insect pins. Cubes of sap beetle diet (2 cm^3) were placed on a 4 cm^2 germination blotter paper within the Petri dish. Equal numbers of individually confined parasites of each sex were held until death, with 12 replicates per treatment. Containers were examined every 24 h for maintenance and data collection.

FECUNDITY

Parasite pupae were isolated individually in snap-seal Petri dishes in order to obtain virgin females. Upon emergence as adults, individual females were placed in modified 450 ml plastic holding containers with a screened ventilation hole (2 1/2 cm dia.) in the lid. A dental wick saturated with a 10 % honey and water solution was attached to the fiberglass screen as a nutrient source. To compare the fecundity of mated and unmated females, some newly-emerged females were set-up with males for a 24 h period. Others were kept isolated as virgins in individual holding containers for the same period. Detailed studies were conducted on 6 individual females from each group. After 24 h, individual female parasites were placed in a 450 ml container with 30 2^{nd} instar *C. hemipterus* larvae, two 4 cm^2 pieces of moistened blotter paper, and 3 cubes (1 cm^3) of sap beetle diet. Females were transferred to a new exposure container every 24 h until their death.

PARASITE PREFERENCE FOR HOST INSTAR

Adult parasites (< 24 h old) (3 ♂♂ and 3 ♀♀) were confined in a 450 ml container for 24 h. After this mating period, females were removed and placed in another 450 ml

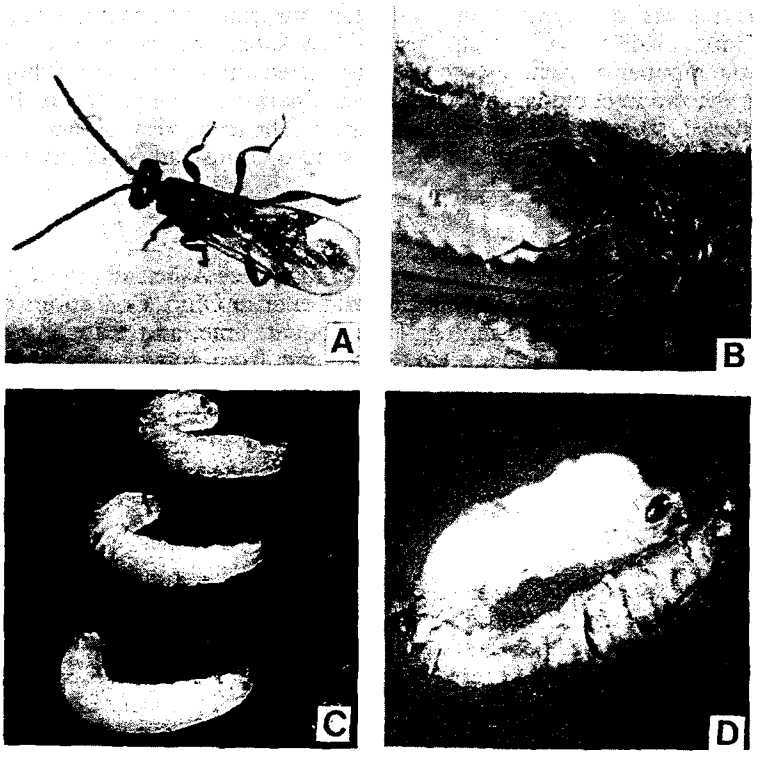

Fig. 1. General appearance of different stages of *Brachyserphus abruptus*.
A. Adult female of *B. abruptus*.
B. Female parasite in the act of ovipositing into larva of *Carpophilus hemipterus*.
C. Various stages of *B. abruptus* protruding from immobile host larva.
D. *B. abruptus* pupa attached to host larva.

container with 5 small pieces of sap beetle diet (*ca.* 1/2 cm^3) and 30 host larvae of the 1st or 2nd instar. Host larval instars were determined by comparing with known instars in a reference collection in our laboratory. Five replicates were set-up in this manner for each host instar. The diet was added to the exposure containers to feed host larvae and provide a more natural substrate for parasite and host. To prevent host larvae from burrowing into or under the diet, small pieces were used. Female parasites were removed after 24 h, and additional diet was added to sustain exposed larvae until they ceased to feed or died.

Immobile, parasitized larvae were transferred to other 450 ml containers with moist germination paper in the bottom and a moist dental wick attached to the vent in the lid. Isolating parasitized larvae in individual pockets reduced disease transmission by eliminating contact between specimens. Moisture was added to the dental wick and germination paper as needed. Larvae were held in this manner until adult parasites emerged or all host larvae died or became adults.

PARASITE HOST-PREFERENCE

Fifteen larvae each of *C. hemipterus* and *S. geminata* (Say) were used per container. First instar larvae of both species were exposed to a single female parasite in the mixed culture

for 1/2 h. The test was replicated 6 times. Simultaneous trials were conducted, one with and another without small pieces of sap beetle diet. Host preference was evaluated by determining the number of each host species parasitized and the number of hosts surviving to adults. Parasitization could be confirmed when a parasite larva protruded from the host larva, 14-21 days after exposure to female parasites. The trial, without diet was conducted using the above procedures, except 2nd instars were used instead of 1st instars.

HOST RANGE

In 1981, *B. abruptus* was recovered for the 1st time, since **Ashmead** (1893), from several genera of nitidulid larvae collected in Florida and later in Ohio. Collections of sap beetle larvae were made from decomposing egg-fruit, loquat, lime, and mango during March-December near Homestead in Dade Co., Fla., and from rotting strawberries, apples, crabapples, peaches, and muskmelon during June-September in Wayne Co., Ohio. In additional laboratory tests, larvae of 8 nitidulid species were exposed to female *B. abruptus* to determine host suitability. Four replicates, containing 10 larvae each, were exposed to the parasite, as before.

MULTIPLE OVIPOSITION BEHAVIOR

To evaluate the possibility of superparasitism by *B. abruptus*, 1st instar larvae of *C. hemipterus* were placed in a 450 ml plastic container along with one *B. abruptus* female. Three treatments of 50 larvae per treatment were set-up for comparison. Once a larva was stung by a female parasite, it was removed from the exposure arena and placed in a 2nd container. The 1st treatment consisted of larvae stung once. Treatment 2 consisted of larvae stung twice, and treatment 3 was composed of larvae stung one and then set up-in groups of 10 larvae (replicate) for an additional 24 h period with small pieces of diet and 2 additional female parasites. After larvae were exposed to the parasites, additional sap beetle diet was added to each replicate to maintain the larvae. Records were kept of the number of host larvae surviving to adulthood, number of larvae that died in the prepupal stage of parasitism, and the number of larvae parasitized that produced an adult parasite.

The data were subjected to analysis of variance. Means were separated, where appropriate, by Duncan's multiple range test ($P = 0.05$) (**Duncan,** 1955).

RESULTS AND DISCUSSION

EFFECT OF DIET REGIMENS ON ADULT PARASITE LONGEVITY

B. abruptus adults survived for an average of 2.9 days when deprived of food and water. Access to water increased survival to an average of 4.3 days, but this increase was not significant. However, parasite survival was significantly increased to an average of 6.6 days when sap beetle diet was supplied to the adults. A 10 % honey solution further increased longevity to an average of 8.8 days, a significant increase above diet alone (fig. 2). Males outlived females on all of the regimes by slightly more than 1/2 day.

FECUNDITY

B. abruptus is a biparental, arrhenotokous species ; unmated females produce only males. Oviposition began one day after eclosion and continued throughout most of the life span.

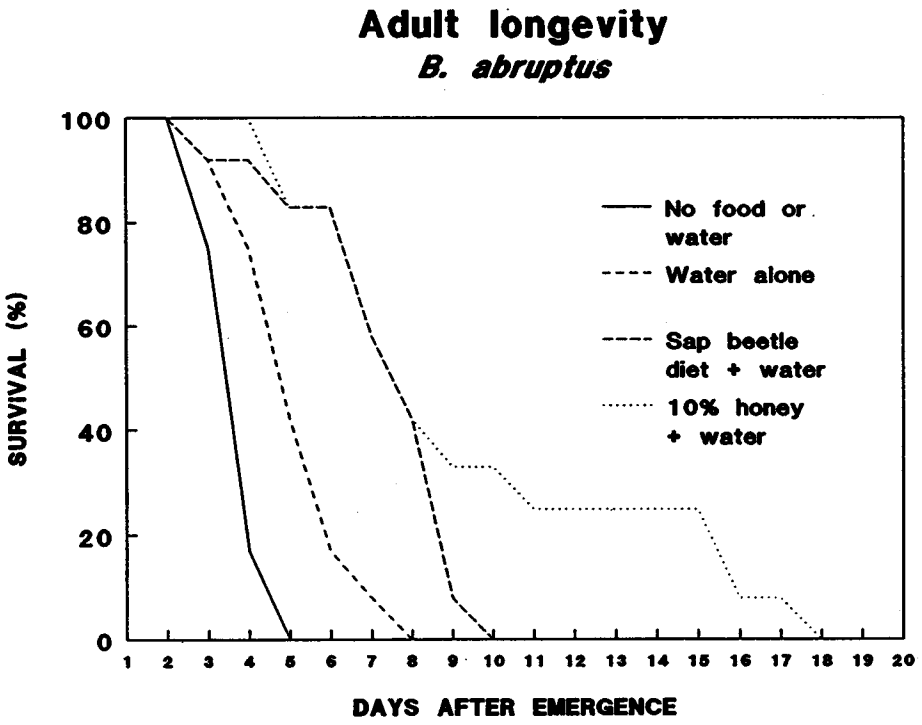

Fig. 2. Effect of diet on the survival of *B. abruptus* adults 28 ± 1 °C and 70 ± 10 % RH.

Mean life span, based on 12 observations, was 6.33 ± 2.53 days and the oviposition period averaged 4.17 ± 1.69 days. The mean number of progeny (new adults produced) per virgin female was 50 (all ♂♂) ; mated females produced an average of 64 offspring. The maximum number of progeny recorded per female for one 24 h period was 30. The sex ratio of progeny from mated parasites was approximately 1 : 1 on average 33 % of the host larvae survived to the adult stage. Percent parasitism based on emerged adult parasites was 28.8 % (18-43). In this study, we experienced an average of 67 % mortality of the host larvae. In the laboratory, actual parasitism, including mortality of host larvae combined with emerged adults, was considerably higher in subsequent studies.

PREFERENCE FOR HOST INSTAR

First and 2nd instar larvae of *C. hemipterus* were suitable for successful development of *B. abruptus*. Parasite development in 1st instar larvae averaged 29 ± 3.09 days (24-38) as compared to 27 ± 2.03 days (24-33) for 2nd instar larvae, this was not a significant difference (P = 0.05). Third instar larvae were included in this trial but were unsuitable for parasite development. We believe this is due to biological changes occurring between the onset of the 3rd instar and pupation, haulting parasite development perhaps through isolation (encapsulation). Percent parasitism of 1st instar larvae was considerably higher

(66 % with a range of 30 to 100 %), compared to 2nd instars which averaged 45 % (range from 20 to 90 %). Host larvae surviving to adult averaged 0.6 % for 1st instar, 9.3 % for 2nd instar, and 90 % for 3rd instar. The number of host larvae surviving to adult was significantly different only for the 3rd instar.

HOST PREFERENCE

In the laboratory, larvae of both *C. hemipterus* and *S. geminata* were readily attacked by *B. abruptus*. Without diet, *C. hemipterus* 1st instar larvae produced an average of 7.33 ± 3.27 parasites per replicate while *S. geminata* produced only 0.50 ± 0.54. With diet *C. hemipterus* larvae yielded an average of 5.83 ± 3.31 parasites per replicate and *S. geminata* larvae 0.50 ± 0.84 parasites. No significant difference in the number of adult parasites produced was found between host larvae with or without diet, however an average of 1.5 additional parasites were produced in treatment without diet from *C. hemipterus* larvae. The number of host larvae surviving to the adult stage without diet averaged 3.0 ± 2.0 or 20 % for *C. hemipterus* and 0 % for *S. geminata*. Where diet was provided an average of 4.5 ± 3.27 or 30 % of the *C. hemipterus* larvae survived and no *S. geminata* larvae survived. In another trial only 2nd instar host larvae were utilized. In this case an average of 3.0 ± 2.97 adult parasites were produced per replicate from *C. hemipterus* larvae and 0.17 ± 0.41 parasites from *S. geminata* larvae. Host larvae surviving to adult averaged 7.17 ± 5.42 for *C. hemipterus* and 0.33 ± 0.52 for *S. geminata*. In comparing the 3 trials, results indicate less parasitism with 2nd instar larvae and a greater percentage of host larvae surviving to adulthood. This substantiated earlier results from the instar preference study. As to whether *C. hemipterus* larvae are preferred over *S. geminata* larvae, results are somewhat mixed. When comparing number of adult parasites produced in all 3 trials, *C. hemipterus* was higher, averaging 36 % successful parasitism with only *ca.* 3 % for *S. geminata*. When comparing percent of host larvae surviving to adult, less than 1 % *S. geminata* were successful as compared to > 32 % survival of *C. hemipterus*. These results indicate that *C. hemipterus* is the preferred host for rearing purposes.

HOST RANGE

First instar larvae of *C. freemani* Dobson, *C. lugubris* Murray, *S. octomaculata* (Say), *S. ferruginea* Reitter, *G. quadrisignatus* (Say), and *G. fasciatus* (Olivier) were attacked by *B. abruptus*, resulting in successful parasitism of all species tested except *G. fasciatus*. *C. hemipterus* and *S. geminata* were included in this trial as known standards for comparison. *C. hemipterus* produced a 60 % parasitism rate with only 10 % of the host larvae surviving to adult; *C. freemani* had a 20 % parasitism rate with 55 % of the larvae surviving to adult; *C. lugubris* had 5 % parasitism and 35 % host survival; *S. octomaculata* had 15 % parasitism and 7.5 % host survival; *S. ferruginea* had 15 % parasitism and 47.5 % host survival; *G. quadrisignatus* produced 4 % parasitism with 10 % of the host larvae surviving; and *G. fasciatus* was the only species tested to yield not adult parasites, yet it produced the lowest percentage of host larvae surviving (2.5 %) to the adult stage except for *S. geminata*, which had no survival.

Field collections of nitidulid larvae made in Ohio and Florida over the past 9 years revealed the following nitidulid species to be suitable hosts for *B. abruptus*, *S. geminata*, *S. octomaculata*, *C. hemipterus*, *C. lugubris*, *L. insularis* and *H. luteolus*.

We have observed that female parasites cue on their host's food source, in this case, the artificial diet. Using their ovipositor, they probe around and through it stinging host larvae with which they come in contact. They are persistent in probing through the food substrate

when searching for hosts. The parasite's ovipositor is capable of extending about twice the length of its abdomen. This capability to extend and manipulate would seem important to this insect's ability to locate suitable hosts in its natural environment.

MULTIPLE OVIPOSITION BEHAVIOR

Fifty host larvae stung once by a female parasite produced 43 adult parasites, resulting in 86 % parasitism. A 2nd group of host larvae stung twice produced 39 adult parasites, or 78 % parasitism. A 3rd group of 50 larvae that were observed stung once and then placed with 2 female parasites for an additional 24 h period, produced 36 adult parasites (72 % parasitism).

Larvae that were stung twice had a slightly higher percentage mortality than those stung once, and also yielded fewer adult parasites. Although, these differences were not great, there is an indication that multiple stings occur. In our observations, we saw no degree of hesitancy in making the 2nd sting in larvae that had been stung previously. The time interval between 1st and 2nd stings was short, from 5 to 15 min. Apparently, in this parasite, a marker is not used at oviposition. We speculate that when 2 eggs were oviposited in a single host, one or both parasites may have been killed in combat. Many of the solitary species possess long piercing mandibles that are used to kill fellow parasites in the same host. **Harvey & Partridge** (1987) describe the course of these fatal encounters in that however many eggs are laid, just one parasite survives to adulthood.

B. abruptus has been successfully reared through the winter months in our laboratory over several years. We feel that it has potential as a biological control agent, since it can be cultured and produced in large numbers on nitidulids reared on artificial diet. It appears in the field too late to be of value in some cases. For example, the earliest it has been found in Ohio is mid-July to early August, yet the problem with strawberry sap beetle, *S. geminata,* occurs in June. Thus, to moderate the populations of this insect, perhaps mass rearing and release of cultured parasites in June would be of value.

ACKNOWLEDGEMENTS

The authors are indebted to Dr. **Norman F. Johnson,** Department of Entomology, The Ohio State University, Columbus for kindly identifying the proctotrupid and to Mr. **Foster F. Purrington** of this Research Center for critically examining the manuscript.

This research was initiated under a grant from the United States-Israël Binational Agricultural Research and Development Fund (BARD). Subsequent salaries and research support were provided by State and Federal Funds appropriated to the Ohio Agricultural Research and Development Center, The Ohio State University. OARDC manuscript number 201-90.

RÉSUMÉ

Etudes biologiques de *Brachyserphus abruptus* [*Hym. : Proctotrupidae*], parasite de Nitidulide

Le parasite *Brachyserphus abruptus* (Say) a été étudié dans les conditions du laboratoire afin de déterminer son potentiel biotique. Cette espèce d'Hyménoptère *Proctotrupidae,* parasite les larves d'au moins 9 espèces de *Nitidulidae.* On ne connaît pas un autre parasite de *Nitidulidae* qui attaque une telle variété d'hôtes. La durée de vie moyenne des femelles est d'à peu près 6 jours, avec une période de reproduction de 4 jours. La longévité des adultes a été prolongée lorsque ceux-ci sont alimentés avec un mélange de 10 pour cent de miel et d'eau. La descendance des femelles fécondées

est approximativement égale entre mâle et femelle. Par contre, les femelles non accouplées produisent uniquement des mâles. Les 1ers stades larvaires ont été choisis comme hôtes même si la vitesse d'évolution est plus rapide dans les 2^{e} stades larvaires. Au 3^{e} stade larvaire, les larves attaquées mourraient sans permettre aux parasites d'achever leur cycle de développement. Nous n'avons jamais obtenu plus d'un parasite d'une larve hôte, même dans le cas où apparemment les larves ont été perforées deux ou même trois fois.

Quand ils ont le choix entre les larves de *Carpophilus hemipterus* (L.) et de *Stelidota geminata* (Say), un nombre plus important de parasites achèvent leur développement dans *C. hemipterus*. Cependant un pourcentage plus élevé de larves de *S. geminata* ont été tuées.

MOTS CLÉS : *Brachyserphus abruptus*, parasite, *Nitidulidae*, biologie, comportement.

Received : 26 July 1990 ; Accepted : 12 November 1990.

REFERENCES

Ashmead, W. H. — 1893. Monograph of the North American Proctotrupidae. — *Bull. U.S. Nat. Mus.*, 45.

Connell, W. A. — 1956. *Nitidulidae* of Delaware, Delaware Agric. — *Exp. Stn. Bull.*, 318, 67 pp.

Duncan, D. B. — 1955. Multiple range and multiple F tests. — *Biometrics*, 11, 1-42.

Hall, R. W., Smilanick, J. M. & Ehler, L. E. — 1978. Laboratory rearing and field observations on *Carpophilus mutilatus*. — *Ann. Entomol. Soc. Am.*, 71, 408-10.

Harvey, H. H. & Partridge, L. — 1987. Murderous mandibles and black holes in hymenopteran wasps. — *Nature*, 326, 129-129.

Hinton, H. E. — 1945. A monograph of beetles associated with stored products. — *Brit. Mus. Nat. Hist.*, 1, 1-433.

Osborne, P. — 1955. The occurrence of five hymenopterous parasites of *Meligethes aeneus* (F.) and *M. viridescens* (F.) [*Col. : Nitidulidae*]. — *Entomologist's Mon. Mag.*, 91, 47.

Osborne, P. — 1960. Observations on the natural enemies of *Meligethes aeneus* (F.) and *M. viridescens* (F.) [*Coleoptera : Nitidulidae*]. — *Parasitology*, 50, 91-110.

Sakimura, K. — 1966. A brief enumeration of pineapple insects in Hawaii. — *Pineapple Res. Tech. Paper, No. 315, 7 pp.*

Townes, H. & Townes, M. — 1981. A revision of the *Serphidae* [*Hymenoptera*]. — *Mem. Am. Entomol. Inst. ;* No. 32, Ann Arbor, Mich.

Williams, R. N., Weiss, M. J., Kehat M. & Blumberg, D. — 1984. The hymenopterous parasites of *Nitidulidae*. — *Phytoparasitica*, 12, 53-64.