Life history of the white grub *Dasylepida* sp. (Coleoptera: Scarabaeidae), a new and severe pest on sugarcane on the Miyako Islands, Okinawa

Akira Oyafuso, Norio Arakaki,1,* Yasutsune Sadoyama,1 Mitsunobu Kishita,1 Futoshi Kawamura,1 Masato Ishimine, Masayo Kinjo1 and Yoshio Hirai2

Okinawa Prefectural Agricultural Experiment Station, Miyako Branch, Hirara, Okinawa 906–0012, Japan
1 Okinawa Prefectural Agricultural Experiment Station, Naha, Okinawa 903–0814, Japan
2 National Institute of Agrobiological Science, Ohwashi, Tsukuba, Ibaraki 305–8634, Japan

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Abstract

The life history of the white grub *Dasylepida* sp. was surveyed in a sugarcane field in Miyako Is., Okinawa, Japan. Adult flights were observed from early February to mid-March in 2001. Adults commenced flight just after sunset (at around 18:30) and mated. Sampling from the pots placed in the field on 19 April yielded 41.8% eggs and 58.2% first stadium larvae. Larvae sampled on 20 June, 2000 were found to consist of 33.3% and 66.7% of the first and second stadium larvae, respectively. On 22 August, 87.5% of larvae were second stadium and the remainder (12.5%) were third stadium larvae. The proportion of third stadium larvae increased and attained 100% by 30 November. In an excavation survey on 26 November, 2001, 11 adults (three females and eight males) and five pupae were found in the soil at a depth of around 45 cm. Pupae were found in the tunnel cavities. We believe that adults remain in the tunnels until the next February. In the rearing experiments at 25°C in the laboratory, the egg period was 23.6 d and the larval periods of the first, second and third stadia were 80.9, 91.8 and 335.8 d, respectively. These facts indicated that *Dasylepida* sp. has a two-year life cycle.

Key words: White grub, *Dasylepida* sp., Scarabaeidae, life history, sugarcane

INTRODUCTION

In the autumn of 1997, many sugarcane fields on Miyako and Irabu Islands, Okinawa, Japan, showed symptoms similar those seen during drought. Dead leaves and wilted stalks were prevalent in an area of more than 200 ha, immediately before the harvesting season (Sadoyama et al., 2001). Damaged stools were easily pulled from the ground, i.e. apparently the roots were damaged. The dead plants were piled in heaps at the edges of fields and were not harvested.

At first, this damage was thought to have been caused by attack of the white grub *Anomala albopilosa sakishimana* Nomura, which had brought severe damage to the sugarcane fields on Miyako and Ishigaki Iss. from the late 1970’s to the early 1980’s. Although the outbreaks of *A. a. sakishimana* have been relatively infrequent since then, local damage in sugarcane fields has continued to be periodically observed, especially at the sandy-loam soils near the coast. Surveys of these fields from November 1997 to January 1998 clarified that two white grub species, *A. a. sakishimana* and an unknown species, had attacked the sugarcane (Sadoyama et al., 2001). Larval density of the unknown species on damaged stools was greater than that of *A. a. sakishimana*.

This unknown species was identified as *Dasylepida* sp. by Miyake (unpublished) in late 1999. The adults are reddish-brown in color and the body length is about 16 mm. Since then, urgent development of pest control methods has been required for this pest. The timing and method of applying insecticide to prevent the white grubs from injuring the roots is influenced by several factors such as the life cycle and behavior of the species, and its seasonal occurrence in relation to the time of land preparation and planting. For improvement of pest management programs, we have to clarify the life cycle of *Dasylepida* sp. Sadoyama and Nakamori (2001) reported that most overwintered third sta-
dium larvae occurred at shallower soil depths near cane roots until March, and then they moved to deeper soil layers after spring. However, the information on their life cycle is scanty, especially during the first year.

In this paper, we will roughly outline the life history of *Dasylepida* sp., on the basis of data obtained from the field surveys and laboratory cultures. In addition, morphometric data for each developmental stage and the brief morphometric characters of third stadium larvae are shown.

**MATERIALS AND METHODS**

**Adult emergence.** Adult emergence from the soil was surveyed at a sugarcane field in Gusukube, Miyako Is. from 27 January to 19 March, 2001. In this field (90 m × 36 m), the sugarcanes had been seriously infested by *Dasylepida* sp. in previous years. Adult flights were checked by visual observations in the field along the pavement (90 m) from 17:30 to 19:00. Weather data during the survey periods were obtained from the Okinawa Meteorological Observatory. Air temperature data at 18:30 were used, because the beetle flights occurred mostly at around this time.

**Egg hatching.** To identify the season of egg hatching of *Dasylepida* sp., a total of 16 mated females were collected at a sugarcane field in Gusukube, Miyako Is. on 26 February and 6 March. Two mated females were confined in individual pot (36 cm diam., 41 cm ht.) with a sugarcane seedling in the field on 10 March 2001. The upper side of the pot was covered with a net to prevent the beetles from escaping. A total of eight pots were prepared for this experiment and these pots were kept in the shade. The contents of two or three pots were carefully examined at the time of survey on 19 April, 27 April, and 2 May. The numbers of eggs and first stadium larvae were counted.

**Field survey.** Monthly larval population densities and the proportions of larval stadia were surveyed at the sugarcane field in Gusukube, Miyako Is. from June to December 2000. Five to eight stools were excavated with a soil sample (30 × 30 cm width and 30 cm depth) using a shovel. These samples were individually placed on a water pan, brought back to the laboratory, and carefully sorted with a spatula. The number of larvae was counted and larval stadia were identified by head capsule width (see Appendix).

To clarify the season of pupal molting to adult and the soil depth of the pupation sites in *Dasylepida* sp., a survey was conducted in a sugarcane field at Hirara, Miyako Is., on 26 November 2001. In this field, the crop had been seriously infested by *Dasylepida* sp. the previous year. After the removal of the dead canes from the field in January 2001, the cane was replanted in September. Thus, canes (about 10 cm stalk length) in this field were young. At first, a trench (50 cm width × 350 cm length × 90 cm in depth) was made by digging the soil with a power shovel to allow access. We carefully scraped one side wall with a spatula to survey the insects in the soil of a cavity of 30 cm width × 350 cm length × 70 cm depth. When adults or pupae appeared, the depth of the pupation site was measured.

Soil temperatures at 20 and 40 cm depth were automatically measured in the sugarcane field at the Okinawa Prefectural Agricultural Station Miyako Branch located in the central area of Miyako Is., from September 1998 to January 2000.

**Laboratory rearing.** Adults were collected from the fields in Irabu Is. (7 km from Miyako Is.) in February 2000. To obtain the eggs, the beetles were confined individually in plastic cups (80 ml) with soil. Fresh laid eggs were counted and transferred into plastic cups (80 ml) and kept at 25°C under a photoregime of 14L–10D until hatching. The bottom of each cup was lined with a slightly moistened filter paper to prevent desiccation. The newly hatched larvae were individually reared on pieces of potato or sweet potato (1 cm × 1 cm × 1 cm) in plastic cups (80 ml) containing a mixture of soil and leaf mold (1:1 in volume) at 25°C under the same photoregime. The diets were exchanged every 15 d.

Morphometric data were measured microscopically and are presented in Appendix.

**RESULTS**

**Adult emergence**

Adult flights were observed at the sugarcane field on Miyako Is. from 4 February to 15 March in 2001 (Fig. 1). Daily air temperatures at 18:30 ranged from 14.1 to 23.7°C during the study periods, the average being 19.1°C. Adult flights were detected when the air temperature was above 19°C. Adults commenced flight just after sunset (at
around 18:30) but flew for about 30 min. Several mated pairs were found in the evening.

Egg hatching
Sampling on 19 April and 27 April showed that 58.2% and 93.2% of eggs hatched, respectively, and all eggs hatched by 2 May (Fig. 2).

Field survey
The mean larval density was 1.8 individuals/stool on 20 June, and gradually increased, attained the maximum level of 17.3 individuals/stool on 17 October and then decreased gradually (Fig. 3). Sampling on 20 June showed that 33.3% of the specimens were first instars, and the remainder (66.7%) were second instars. On 22 August, 87.5% of larvae were second instars and the remainder (12.5%) were third instars. The proportion of the third instars reached 100% by 30 November.

The third stadium larvae were found directly beneath cane stools. The larvae were usually observed feeding on the cane roots and occasionally fed on the cane stalk before tunnelling into it. Infested cane showed symptoms of water stress. Severe damage was observed during the period when the third stadium larvae fed vigorously.

In the survey on 26 November 2001, eleven adults (three females and eight males) and five pupae (including one dead pupa) were found. Mean soil depth for pupation site was 44.9 ± 6.5 cm (mean ± SD, n = 16, range 33–62 cm). Four of these pupae molted to adults within two days after the excavation.

Laboratory rearing
Developmental periods of various stages of Dasylepida sp. reared at 25°C are shown in Table 1. Mean egg period was 23.6 d. Mean larval periods were 80.9, 91.8 and 335.8 d for the first, second and third instars, respectively. Mean pupal period was 31.0 d.

DISCUSSION
Appearance of adults on the ground surface was observed at the sugarcane field in Gusukube, Miyako Is. from early February to mid-March in 2001 (Fig. 1). As copulated pairs were frequently observed in the field in the evening during this period, they apparently commenced with mating soon after their emergence from the ground. These mated females commenced oviposition three or four weeks after their copulation under laboratory rearing. Therefore, females may begin oviposition

Fig. 1. Daily records of occurrence or absence of adult flights of Dasylepida sp. in the sugarcane field on Miyako Is. and daily air temperature at 18:30. Solid arrows indicate dates of flights.

Fig. 2. Life stage distribution of Dasylepida sp. per pot on different days.
from late February in the field. The egg period was 23.6 d when reared at 25°C (Table 1). Because the mean temperatures of soil at 20 cm below the ground on Miyako Is. were slightly lower than 25°C (March: 21.8°C and April: 23.1°C), the egg periods in the field are slightly longer than 23.6 d. Sampling on 19 April showed that 58.2% of specimens in pots were first instars and that the remainder were eggs (Fig. 2). Therefore, egg hatch probably occurs from early April to late April or early May and should peak around mid-April. Sampling in the field on 20 June showed that 33.3% of the population were first instars, and that the remainder were second instars (Fig. 3). Therefore, molting from the first to the second stadium should peak around mid-June. First and second larval stadium periods were 80.9 and 91.8 d when reared at 25°C, respectively (Table 1). In sampling on 19 September, 39.6% of the population were second instars, and the rest were third instars (Fig. 3). Therefore, molting from the second to the third stadium should peak around mid-September. In many fields, visible signs of damage with patches of yellowing leaves were observed after September, because the third stadium larvae feed voraciously on roots. Third stadium larvae were therefore considered to cause the greatest damage to the sugarcane. Although harvesting is conducted from the following January to March, the third stadium larvae still remain in the vicinity, because the roots still remain underground. Although about 70% of the third stadium larvae were captured in shallow (20 cm) soil depth in late March, more than 70% of the third stadium larvae were found at deeper soil layers (30–50 cm) in July and August (Sadoyama and Nakamori, 2001). These facts indicate that over-wintered third stadium larvae burrow down to deeper soil layers after spring. The third stadium larval period was 335.8 d when reared at 25°C (Table 1). Regarding the duration of larval stages, we may conclude this period to be 1.5 year, which would allow six months for the pupal, egg and adult stages.

After excavating a sugarcane field on 26 November 2001, 11 adults and five pupae were found at a soil depth of about 45 cm. Pupal molting to the adult stage appears to finish at around late November in the field. The pupal period was 31.0 d when reared at 25°C (Table 1). Because the mean temperature of the ground at the 40 cm depth (24.8°C) in November was almost 25°C, pupation should occur between late October and early November in the field. Pupation took place in tunnel cavities and then transformation to the adult stage occurred. The beetle remains in the cavity until early February of the following year. The life cycle of Da-

Table 1. Developmental period of *Dasylepida* sp. at 25°C, a photoregime of 14L–10D

<table>
<thead>
<tr>
<th>Stage</th>
<th>n</th>
<th>Developmental period (d; mean ± SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Egg</td>
<td>155</td>
<td>23.6 ± 1.7</td>
</tr>
<tr>
<td>First stadium larva</td>
<td>36</td>
<td>80.9 ± 14.0</td>
</tr>
<tr>
<td>Second stadium larva</td>
<td>22</td>
<td>91.8 ± 13.7</td>
</tr>
<tr>
<td>Third stadium larva</td>
<td>6</td>
<td>335.8 ± 25.5</td>
</tr>
</tbody>
</table>
| Pupa                   | 3  | 31.0 ± 2.0                         

Fig. 3. Seasonal changes of the numbers in each larval stage of *Dasylepida* sp. per sugarcane stool.
Why did the population density of this species recently increase? Changes in the cultivation style of sugarcane on the Miyako Iss. in recent years may be an important factor. The sugarcane is planted in spring (from February to April) and summer (from August to October). Summer planting occurred on about 30–40% of the fields on the Miyako Is. until 1980, and then rapidly increased, attaining a frequency of more than 90% after 1983 (Nakamori and Kawamura, 1997). Because of this, many of the newly planted cane fields faced ratooning failures due to severe damage to the underground buds of the sugarcane caused by the wireworm *Melanotus sakishimensis* Ohira (Hokyo, 1980). Therefore, the farmers gave up ratooning, and shifted exclusively to summer planting. This appears to be favorable for the completion of the life cycle of *Dasylepida* sp., because this species has a two-year life cycle parallel to the two-year rotation cycle. Most of the summer planting is conducted from August to October. During this period, however, two-year-old 3rd stadium larvae move to deeper soil layers. Even with the disturbance of the upper soil layer by plowing for land preparation and planting, the white grubs are safe in the deeper soil layer (about 45 cm) below plow depth (about 30 cm). In the following February, emerged adults mate and lay eggs on the open young sugarcane field. These young fields are ideal places for mating and oviposition by *Dasylepida* sp. adults. Thus the prevalence of summer planting on Miyako and Irabu Iss. might be one of the factors that promote the increase of the *Dasylepida* sp. population.

In this study, we clarified that *Dasylepida* sp. has a two-year life cycle, although it occurs in a subtropical region. The third stadium larval period is quite long, requiring more than 300 d. This insects may be in a state of quiescence when in the deeper soil layer and not feeding. The life cycle of Scarabaeids varies with climate, and is longest in more temperate regions and shorter in tropical areas with no climatic seasons (Ritcher, 1957). Species belonging to the subfamily Melolonthinae tribe Sericini usually have a one-year life cycle, but some species in more temperate climates have a two-year life cycle (Ritcher, 1957). In the tribe Rhyzotrogini, *Holotrichia parallela* (Motschulsky) (= *Lachnosterna morose*) has a one-year life cycle in Ehime Prefecture, Japan, however this species requires two years to complete the life cycle in Korea (Yoshioka and Yamasaki, 1984). The Melolonthini tribe has rather long life cycles, especially in temperate regions. In North America, the many species of *Phyllophaga* have two- or three-year life cycles (Ritcher, 1957). In the tribe Lecopholini, *Dasylepida* is the only genus, however, there has been no record of the life cycle.

According to Azuma and Oshiro (1967) and

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**Fig. 4.** Schematic diagram of the life cycle of *Dasylepida* sp. A(u): adults underground, A(s): adults above ground, E: egg, L: larva, L(s): larva living in shallow soil depth, L(d): larva living in deep soil depth, P: pupa.
Nagamine (1980a, b), 10 or more species of Scarabaeidae have been recorded as sugarcane pests in the Ryukyu Islands of Japan. However, *Dasylepida* sp. was not included in the list. According to the morphological examination of this beetle by a taxonomist, this species shows a close resemblance to *Dasylepida ishigakiensis* (Niijima et Kinoshita), which occurs on Ishigaki and Iriomote Iss. of Okinawa. But there are slight differences in characters such as body color, density of hair, and density of punctures covering the elytra (Y. Miyake, pers. comm.). Hirai (2001) mentioned the great differences between the habitats of the Miyako and Ishigaki populations: *Dasylepida* sp. adults occurred in the sugarcane fields on the Miyako Iss. while *D. ishigakiensis* adults were captured mostly in or around the evergreen broad-leaved forests of Ishigaki and Iriomote Iss. The larvae of the *Dasylepida* sp. feed mainly on the roots of the sugarcane, while we have no evidence that the larvae of *D. ishigakiensis* feed on any part of the plant. In addition, emergence and flight of *Dasylepida* sp. on Miyako Is. were observed from early February to mid-March (Fig. 1), while *D. ishigakiensis* adults on Ishigaki Is. were observed from late March to early April (Y. Hokama, pers. comm.). Biochemical and molecular approaches are needed to clarify the geographic-taxonomic relationships of both *Dasylepida* spp.

The field population density of *Dasylepida* sp. larvae gradually increased from June, attaining the maximum level in October (Fig. 3). There are two possible explanations for the increase: 1) a sorting error because of the small size of younger larvae, 2) movement of young larvae around the cane roots. The first possibility should be excluded since the creamy white larvae are conspicuous and the body size of the first stadium larvae was too large to be overlooked in our careful sorting. Ritcher (1957) described that in the larvae of Melolonthini or Sericini, first stadium larvae feed, in part, on organic matter in the soil; second and third stadium larvae feed on roots or underground stems. Larvae of *Holotrichia consanguinea* Blanchard (= *Lachnosterna consanguinea*) feed initially on tender roots of grass and then move to cane. They are associated with the main roots (Kalra and Kulshreshtha, 1961). As for the second possibility in *Dasylepida* sp., younger larvae may distribute more widely than our expectation, and feed not only on cane roots but also on the roots of weeds or organic matter in the soil. Second and third instars then move to the sugarcane roots. Further studies on the movements of younger larvae of *Dasylepida* sp. are needed.

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**REFERENCES**


APPENDIX

Morphological characters of Dasylepida sp.

Egg: The egg is milky white in color and ovoid in shape when newly laid, 2.4±0.2 mm (mean±SD) in length and 1.8±0.1 mm in width (n=58) (Fig. 5A). During incubation, the eggs increase in size and become more spherical in shape.

Larva: The larva is creamy white in color. Grayish gut contents show through the skin in the swollen posterior segments (Fig. 5B). The head is glossy yellowish brown, with long black-tipped mandibles. The mean head widths of the first, second and third stadium larvae were 1.69±0.09 mm (mean±SD, n=152), 2.68±0.13 mm (n=33) and 4.41±0.21 mm (n=23), respectively. Legs are stout. The tips of the third (hind) legs are slightly swollen with reduced claws. The ventral surface of the last abdominal segment has two parallel rows of short spines on the raster. This character differentiates it from other white grubs occurring in the sugarcane fields of the Miyako Iss. such as A. a. sakishimana and Holotrichia loochooana loochooana (Sawada) (Kawamura et al., 2001). The larvae are unable to walk when placed on a flat surface.

Pupa: This species does not make an earthen cell for pupation, which occurs in tunnels. The pupa pushes the larval skin to the rear, and leaves its exuviae on the abdominal tip. Color is brownish-yellow (Fig. 5C).

Adult: The adults are reddish-brown in color (Fig. 5D). The body length of females (15.8±0.7 mm, mean±SD, n=25) and males (15.8±0.8 mm, n=25) was almost equal (t-test, p>0.05). Mean elytra length of females (10.6±0.6 mm, n=25) was significantly longer than that of males (10.1±0.5 mm, n=25) (t-test, p<0.05). Mean body width of females (7.0±0.3 mm, n=25) was significantly larger than that of males (6.6±0.3 mm, n=25) (t-test, p<0.05).

Fig. 5. Developmental stages of the white grub Dasylepida sp. A: Egg, B: Larva, C: Pupa, D: Adult.