Biology of *Sturmiopsis parasitica* (Diptera: Tachinidae) and Suitability of Three Cereal Stem Borers (Lepidoptera: Crambidae, Noctuidae) for Its Development

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**ABSTRACT** The development of *Sturmiopsis parasitica* (Curran) (Diptera: Tachinidae) and levels of parasitism of its hosts, *Busseola fusca* Fuller, *Sesamia calamistis* Hampson (Lepidoptera: Noctuidae), and *Chilo partellus* (Swinhoe) (Lepidoptera: Crambidae), were studied. The highest rates of parasitism were 83.3 and 15% of *B. fusca* and *C. partellus*, respectively. No development occurred on *S. calamistis* due to maggot encapsulation. At 25 ± 0.5°C, *S. parasitica* larval development on non-diapausing *B. fusca* larvae took 14.2 d (range 10–34) and the pupal period 13.7 d for males and 15.8 d for females. Adult females that developed on *C. partellus* were smaller than those from *B. fusca* but had a similar lifespan (=4 wk). Although first observed at 6 d after mating, maggot production peaked at 848 per female after a 12-d gestation period. Inoculation of diapausing *B. fusca* larvae resulted in an extended larval period of the tachinids, indicating that the seasonal carryover of *S. parasitica* in diapausing *B. fusca* larvae in Zimbabwe could be a hormone-induced physiological response. The potential of *S. parasitica* as a biological control agent is discussed.

**KEY WORDS** *Sturmiopsis parasitica*, *Busseola fusca*, larval development, gestation period, diapause, biological control

The Tachinid Fly, *Sturmiopsis parasitica* (Curran) (Diptera: Tachinidae), is an important larval parasitoid of gramineous stem borers in Africa (Harris 1998). Described from Zimbabwe (Crosskey 1980), *S. parasitica* is found in abundance within the Harare area where it parasitizes *Busseola fusca* Fuller (Lepidoptera: Noctuidae) (Smithers 1960, Rose 1962, Chinwada and Overholt 2001). The species also has been recorded in West and East Africa on various stem borers, including *B. fusca*, *Sesamia calamistis* Hampson, *Sesamia nonagrioides* botanephaga Tams & Bowden (Lepidoptera: Noctuidae), *Chilo orichalcociliellus* (Strand), *Chilo partellus* (Swinhoe), *Coniesta ignefusalis* (Hampson) (Lepidoptera: Crambidae), and *Eldana saccharina* (Walker) (Lepidoptera: Pyralidae) (Mohyuddin and Greathead 1970, Nagarkatti and Rao 1975, Harris 1998).

Using a colony initiated with individuals recovered from stem borers sampled in Ghana, Nagarkatti and Rao (1975) described the life history of *S. parasitica*. Harare, Zimbabwe, is the type locality of *S. parasitica*, but apart from field data on parasitism (Smithers 1960, Rose 1962, Chinwada and Overholt 2001), there does not seem to have been any attempt to study its biology in the country. With the tachinid having been suggested as a candidate for redistribution within Africa (Mohyuddin and Greathead 1970), population-specific biological information for this parasitoid is important. This article reports on biological studies conducted on the Zimbabwean population of *S. parasitica* and discusses its potential as a biological control agent.

**Materials and Methods**

**Insects.** Third and fourth instars of *B. fusca*, *C. partellus*, and *S. calamistis* were used for the experiments. These were reared on artificial diet (Ochieng et al. 1985, Onyango and Ochieng-Odero 1994). A laboratory colony of *S. parasitica* was initiated from pupariating maggots that emerged from *B. fusca* larvae and pupae collected in maize (*Zea mays* L.) fields in the Harare area. Rearing procedures were adapted from Nagarkatti and Rao (1975). Parasitoid puparia were held singly in vials until adult emergence. Each newly emerged female, distinguished by the presence of a whitish frons (smoky gray in males) (Nagarkatti and Rao 1975), was confined singly with one to three males (2–3 d old) in a vial. The vial was then shaken under bright light to stimulate mating (Smith et al. 1993).
Once mating commenced, the pair was isolated from the other males and placed away from light. However, when the number of newly emerged females at any one time was at least 10, mating was allowed to take place inside Perspex cages (11 by 11 by 8 cm). In this case, a few males were introduced into cages in which the females were held, and pairs removed when mating was observed. New males were introduced to replace the ones that had mated or those that showed no inclination to mate. At the end of each day, males were removed and returned to their own cages. Males that had mated were held separately from unmated ones. Mated females were sometimes used for one additional mating attempt when necessary. Once mated, females were held in cages without males (12 by 12 by 12 cm). All females mated on the same day were held in one cage. Honey (100%) and distilled water were provided as food for the cage. Honey (100%) and distilled water were provided to the adults. The honey was changed every 5 d and water replenished as often as necessary. Shredded paper strips were crumpled and placed on the bottom of cages to provide a resting platform for the adults.

Development on Different Stem Borer Hosts. The development of *S. parasitica* on *B. fusca* (nondiapause), *C. partellus*, and *S. calamistis* was studied using the following procedure. At 18 d after mating (Nagarkatti and Rao 1975), gravid females were dissected and their uteri ruptured in distilled water to release the maggots. Using a fine camel’s-hair-brush, active maggots were transferred to the ventral surface of the abdomen of a host larva that had been previously wiped clean using cotton wool soaked in distilled water. Host larvae were inoculated using two and four maggots or an undetermined number transferred in two brush strokes. For each of the three inoculation methods, at least 100 larvae of each host species were used. Irrespective of the number of maggots dissected out of each female, maggots from an individual female tachinid were used to inoculate no >20 host larvae of each species. Inoculated larvae were then reared individually on artificial diet inside glass vials (2.5 by 7.5 cm) at 25 ± 0.5°C, 65–80% RH, and a photoperiod of 12:12 (LD) h.

Larvae were checked daily until pupation, death, or parasitoid emergence. Parasitoid puparia were weighed and then held individually inside 12-ml vials for adult emergence. To maintain adequate humidity inside the vials, each puparium was placed on a bed of moistened frass. However, as the highly humid environment inside the vials favored the growth of saprophytic fungi, the surface of each puparium was periodically wiped clean using a fine hairbrush and the frass replaced. The larval development period, pupal period, and sexes of emerged adult parasitoids were recorded. Eight weeks after inoculation, all larvae that were still alive were dissected and examined under a microscope for live maggots.

Development on Diapausing Larvae. This experiment was conducted by inoculating diapausing *B. fusca* larvae and then subjecting them to different rearing conditions. The aim was two-fold: 1) to determine the typical parasitoid larval development period inside diapausing hosts under a diet and temperature regime simulating natural field conditions in Zimbabwe, and 2) to see whether a deliberate alteration of the host-rearing conditions could shorten this period of arrested parasitoid development. For this study, a total of 160 larvae were initially inoculated using the “two brush-stroke” method on 11 April 2001. The stem borers used were from a colony that was initiated and maintained until diapause in a glasshouse on potted maize plants. For the first 6 wk, host larvae were reared individually on green maize stems inside plastic vials (4 by 10 cm) at room temperature (18–26°C). Stems were dissected every 2 d and the number of larvae that pupated, died, or from which pupariating maggots emerged was recorded. After this period, 20 larvae were transferred to artificial diet and incubated at 25 ± 0.5°C, 65–80% RH, and a photoperiod of 12:12 (LD) h. The remaining host larvae were maintained on dry stems at room temperature (18–26°C) for the remainder of their life span. Larvae placed on artificial diet were checked daily for mortality, pupation, or parasitoid emergence by poking through the diet by using a sterile glass rod. Similar data records were taken for host larvae that were maintained on natural diet. However, these were examined every 2 d by dissecting the dry stems and replenishing them with new ones. Larval tunneling in dry stems was assisted by placing caterpillars in holes made using a cork borer.

Fecundity and Gestation Period. The fecundity and gestation period of *S. parasitica* were determined by dissecting uteri of mated female flies. Starting at 4 d after mating and thereafter at 2-d intervals up to day 20, females were dissected to check for active maggots. Four females were dissected at each interval. At each dissection, the number of eggs and active maggots was counted. The number of active maggots as a percentage of the total egg load was then determined and plotted against time. The number of days after mating when the mean percentage of maggots was at its highest was noted and used as an indication of the gestation period at which dissection should be conducted to obtain the optimum number of maggots.

Adult Longevity. Adult longevity was determined by holding freshly emerged females inside 350-ml plastic jars at 25 ± 0.5°C and 65–80% RH until they died. Flies that emerged on the same day were held in one jar, with a maximum of five flies per jar. The mouth of each jar was closed using netting material held in place by a rubber band. Shredded paper strips, honey, and distilled water were provided to the adult flies as described previously.

Relative Sizes of Adult Flies. The relative sizes of *S. parasitica* adults emerging from different host species were compared by measuring wing and hind tibia lengths of female flies. The wings and hind tibiae were mounted on a microscope glass slide and their lengths determined under a binocular microscope equipped with an ocular micrometer. To reduce variability among flies from the same host, only adults resulting from puparia that emerged singly or in groups of two per host were used. Both left and right hind tibia and
wings were measured and a mean measurement determined.

Data Analyses. Data were analyzed with t-tests or analysis of variance (ANOVA) (PROC TTest, PROC GLM, SAS Institute 1990) followed by the Student–Newman–Keuls multiple range test when ANOVAs were significant (P < 0.05). Proportions were arcsine transformed (Sokal and Rohlf 1981, Fowler et al. 2000) before being subjected to analysis.

Results

Of the three species inoculated, S. parasitica developed only on B. fusca and C. partellus (Table 1). No parasitoids emerged from S. calamistis. Dissections made at 7 d after inoculation showed that although maggots were still alive in this host, they were enshaved within thick fatty-like tissue. By the 10th d, however, the enshaved maggots were dead and had been melanized. For the two hosts in which S. parasitica could develop, the levels of parasitism and parasitoid puparia recoveries were dependent on species and inoculation method. Parasitism of B. fusca larvae was higher than that of C. partellus by using two and four maggots (Table 1).

The mean S. parasitica puparium weight was generally dependent on the number of pupariating maggots emerging from each host. With B. fusca, larval inoculations by using two or four maggots resulted in fewer (Table 2) but large-sized (Fig. 1) puparia being formed. However, the two brush-stroke method resulted in many small-sized puparia forming per host, suggesting that more maggots were transferred with this method. Although single pupariating maggots emerged most often from C. partellus (Table 2), the resultant puparia weighed much less (Fig. 2) than those from B. fusca.

The larval development period of S. parasitica was dependent on host species and inoculation method. On B. fusca, although larval development took 14.2 d overall, development was shortest (13.6 ± 0.3 d) when the two brush-stroke method was used and longest (15.3 ± 0.7 d) when two maggots were used for each inoculation (Table 3). However, on C. partellus, larval development was longest (17.8 ± 1.1 d) when the two brush-stroke method was used. The pupal stadium was dependent upon the sex of the adult fly. On B. fusca, the male pupal period was 2 d shorter than for females (Table 4). Percentage of adult emergence was high, but sex ratios were variable, ranging from 20.0 to 71.4% male (Table 5). However, due to the small sample size

Table 1. Comparative parasitization of different stemborer species by S. parasitica

<table>
<thead>
<tr>
<th>Stem borer host</th>
<th>No. of maggots used for inoculation</th>
<th>No. of larvae inoculated</th>
<th>Parasitism at 4 wk postinoculation (%)</th>
<th>No. of additional larvae ascertained to be parasitized by dissection at 8 wk postinoculation</th>
<th>Adjusted total parasitism (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B. fusca</td>
<td>2</td>
<td>91</td>
<td>40.7 (37)</td>
<td>0</td>
<td>40.7</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>86</td>
<td>51.2 (43)</td>
<td>2</td>
<td>53.4</td>
</tr>
<tr>
<td></td>
<td>Two brush strokes</td>
<td>96</td>
<td>76.0 (73)</td>
<td>7</td>
<td>83.3</td>
</tr>
<tr>
<td>C. partellus</td>
<td>2</td>
<td>96</td>
<td>5.2 (5)</td>
<td>0</td>
<td>5.2</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>93</td>
<td>8.6 (5)</td>
<td>0</td>
<td>8.6</td>
</tr>
<tr>
<td></td>
<td>Two brush strokes</td>
<td>120</td>
<td>15.0 (18)</td>
<td>0</td>
<td>15.0</td>
</tr>
<tr>
<td>S. calamistis</td>
<td>2</td>
<td>48</td>
<td>0 (0)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>45</td>
<td>0 (0)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Two brush strokes</td>
<td>44</td>
<td>0 (0)</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

* Larvae that died during rearing were excluded.

Table 2. Frequency distribution per host of S. parasitica puparia developing from maggots emerging at different host stages

<table>
<thead>
<tr>
<th>Host stage emerged from</th>
<th>No. of maggots used for inoculation</th>
<th>Stemborer species</th>
<th>No. of hosts each yielding given no. of puparia</th>
<th>Total no. of puparia recovered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Larva</td>
<td>2</td>
<td>B. fusca</td>
<td>23 4</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>C. partellus</td>
<td>1 1</td>
<td>1</td>
</tr>
<tr>
<td>Two brush strokes</td>
<td>12</td>
<td>B. fusca</td>
<td>18 12 5 4</td>
<td>73</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C. partellus</td>
<td>1 - - -</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>S. calamistis</td>
<td>10 2</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C. partellus</td>
<td>9 1</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td></td>
<td>S. parasitica</td>
<td>4 1</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C. partellus</td>
<td>7 - - -</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>S. calamistis</td>
<td>6 - - -</td>
<td>6</td>
</tr>
<tr>
<td>Pupa</td>
<td>2</td>
<td>B. fusca</td>
<td>22 30 13 3 1 1</td>
<td>144</td>
</tr>
<tr>
<td>Two brush strokes</td>
<td></td>
<td>C. partellus</td>
<td>10 2</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td></td>
<td>S. parasitica</td>
<td>9 1</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C. partellus</td>
<td>4 1</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>S. calamistis</td>
<td>7 - - -</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>S. parasitica</td>
<td>6 - - -</td>
<td>6</td>
</tr>
</tbody>
</table>

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of flies emerging from *C. partellus*, the sex ratios recorded from this host may not be representative. Unmated adult females lived for \( \sim 4 \) wk at 25 ± 0.5°C (Table 6), and there were no significant differences \((t = 0.1638, P = 0.8710)\) in longevity between those that had developed on either host. However, significant size differences \((P < 0.05)\) between the two sets of females were noted.

When diapausing *B. fusca* larvae were inoculated, the parasitoid larval period was lengthened. From the surviving inoculated host larvae that were reared on artificial diet at 25 ± 0.5°C, pupariating maggots emerged from three larvae at 56 d (6 June), 104 d (24 July), and 136 d (25 August) after inoculation. Two larvae that had not exhibited signs of parasitism were dissected 150 d after inoculation and found to have live maggots. From the larvae that were maintained continuously on dry stems at room temperature (18–26°C), maggots eventually emerged from seven starting at 182 d (10 October) and ending at 226 d (23 November) after inoculation.

The egg maturation period of flies reared from *B. fusca* was extended over several days. Active maggots were first observed 5 d after mating (DAM) (Table 7), and increased until 10 DAM before leveling off. The number of active maggots found in flies reared on *B. fusca* and *C. partellus* at 10 DAM did not differ \((t = 0.1243, P = 0.09052)\). There was no difference \((P > 0.05)\) in the mean percentage of active maggots per female from 8 to 20 DAM (Fig. 3).

**Discussion**

A thorough understanding of the biology of natural enemies is a prerequisite for biological control programs. Described from Harare, Zimbabwe (Crosskey 1980), *S. parasitica* occurs over a much wider area of sub-Saharan Africa, attacking several species of noctuid and pyralid stem borers (Harris 1998). Using a population collected in Ghana, Nagarkatti and Rao (1975) provided an account of the biology of *S. parasitica*. At 26°C, they reported a larval period of 12–14 d and a pupal period of 12–19 d. In the current study, the larval and pupal periods recorded at 25 ± 0.5°C (Tables 3 and 4) are in agreement with those reported by Nagarkatti and Rao (1975). The shorter larval period obtained with the two-brush stroke method on *B. fusca* was most likely a result of the rapid depletion of host food resources by many maggots, which necessitated their earlier egression. However, this was not the case with *C. partellus*, where the shortest developmental time was found in the four-maggot inoculation treatment. Because of the relatively low suitability of this host, the sample sizes for flies developing in the two- and four-maggot inoculation are relatively small, however, making the biological rele-

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**Fig. 1.** Frequency distribution of weights of *S. parasitica* puparia formed from maggots emerging from *B. fusca*.

**Fig. 2.** Frequency distribution of weights of *S. parasitica* puparia formed from maggots emerging from *C. partellus*.
vance of this difference unclear. Differences in parasitoid development in the two hosts may be related to length of association between the species; *B. fusca* is an old association host of *S. parasitica*, whereas *C. partellus* represents a recent new association.

Only *B. fusca* and *C. partellus* were suitable for the development of *S. parasitica*. Parasitoid recoveries were, however, much higher on *B. fusca* than *C. partellus*. *C. partellus*, although successfully parasitized in the current study, may only be a partially suitable host due to its smaller size. Fourth instars of *B. fusca* are ~4 times heavier than fourth instars of *C. partellus* (Mochiah et al. 2001). The larger sized *B. fusca* was more suitable, providing enough food to support the development of more parasitoid immatures, and, hence up to six puparia were recovered from a single host (Table 2). Chinwada and Overholt (2001) also reported recoveries of one to six puparia from a single *B. fusca* larva collected in Zimbabwe during the 1995–1996 and 1996–1997 summer seasons. *C. partellus* is rare in the highveld area (>1200-m altitude) of Zimbabwe where *S. parasitica* occurs (Chinwada and Overholt 2001), although there is evidence that it is displacing *B. fusca* in similar highland areas of South Africa (Kfir 1997). If this displacement should occur in the Harare area, *S. parasitica* may provide some level of mortality to *C. partellus*. Alternatively, the *S. parasitica* population may decline due to low host quality of *C. partellus*.

*Sesamia calamistis* was an unsuitable host as all maggots were encapsulated. In contrast, Nagarkatti and Rao’s (1975) work did not include the suitability of *B. fusca* for development of *S. parasitica*, even though *B. fusca* is widely distributed in West Africa (Bosque-Pérez and Schultz, 1998). The current study, though limited in the number of stem borer species tested, showed that the Zimbabwean population does not develop on *S. calamistis*. *E. saccharina* is, however, a suitable host because the South African Sugar Association has, since 2000, been importing *S. parasitica* from Zimbabwe and successfully maintaining a colony on the borer (D. E. Conlong, personal communication).

Considering that *S. calamistis* occurs sympathetically with *S. parasitica* in the Harare area of Zimbabwe, albeit at low densities (Chinwada and Overholt 2001), encapsulation may explain why this parasitoid has never been recovered from the particular stem borer species in this area (Smithers 1960, Rose 1962, Chinwada and Overholt 2001). The lack of development of *S. parasitica* on *S. calamistis* raises questions as to whether, at least in Zimbabwe, the parasitoid has a host recognition mechanism by which it avoids depositing its maggots on non-*B. fusca* stem tunnel entrance holes. However, because *S. calamistis* density throughout Zimbabwe is low, selection pressure to develop an ability to discriminate between hosts may be low.

Parasitoid puparia recoveries were dependent on the stem borer species, inoculation method and host stage (larva or pupa) at which egression of pupariating maggots occurred. More puparial recoveries were made on *B. fusca* than on *C. partellus*. Generally, the larger the number of maggots used for inoculation, the better the chances of parasitization. Also, for *B. fusca*, more puparia were recovered per host when maggot egression occurred at the larval as opposed to the pupal stage. This difference in the number of recoveries is of importance. Interestingly, Nagarkatti and Rao’s (1975) work did not include the suitability of *B. fusca* for development of *S. parasitica*, even though *B. fusca* is widely distributed in West Africa (Bosque-Pérez and Schultz, 1998). The current study, though limited in the number of stem borer species tested, showed that the Zimbabwean population does not develop on *S. calamistis*. *E. saccharina* is, however, a suitable host because the South African Sugar Association has, since 2000, been importing *S. parasitica* from Zimbabwe and successfully maintaining a colony on the borer (D. E. Conlong, personal communication).

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erable puparia suggests that optimal rearing of *S. parasitica* in the laboratory requires restricting inoculations to third and early fourth instars of host larvae to ensure that the parasitoid completes its development before the host pupates, thus resulting in an enhanced puparial yield.

Adult female parasitoids that developed on *C. partellus* and *B. fusca* did not differ in their lifespan (Table 6). Both sets of flies lived for ≈4 wk. Differences were only noted in their sizes, with those that developed on *C. partellus* having smaller wing and hind tibia lengths. Nonetheless, when mated and dissected after a 12-d gestation period, adult females that had developed on *C. partellus* were found to be as fecund as those that developed on *B. fusca* (Table 7). We studied only the longevity of unmated flies. From a point of view of the population dynamics of insect parasitoids, a study of the longevity of mated females would give a better indication of how long each can live and thus lay eggs.

In the current study, active maggots were observed starting from the 6th day after mating. There was a rapid rise thereafter followed by a leveling off at 10–12 DAM (Fig. 3). Thus, for rearing purposes, dissections can be initiated at 10–12 d after mating to recover the highest number of active maggots. This result differs from the 18–19-d gestation period reported by Nagarkatti and Rao (1975). However, the 758–848 maggots dissected from each female at 10–12 DAM compares well with the 500–900 maggots reported by Nagarkatti and Rao (1975).

Chinwada and Overholt (2001) reported that *S. parasitica* is carried over from one cropping season to the next in Zimbabwe by synchronizing its larval development with that of diapausing *B. fusca* larvae. However, they were not able to determine the exact length of this synchronized diapause because their observations were based on field-collected larvae whose parasitization status only became evident at diapause termination. In the current study, the inoculation of already-diapausing larvae was an attempt to show that the physiological state of host larvae at the time of parasitoid ingression, or shortly thereafter, determined whether parasitoid development would be completed in under 30 d or deferred to later. Still, the study gave only an estimate of the length of the parasitoid larval period inside diapausing hosts because inoculations were done when the latter were already in diapause. In natural field situations, larv-
position by *S. parasitica* would be expected to occur on larvae that are actively feeding and thus producing the necessary host–habitat location cues. Although we have no evidence, it would seem unlikely that *S. parasitica* females can locate diapausing larvae in the field, because they are not actively feeding and stimulating the production of volatile signals found to be important for other stem borer larval parasitoids (Mbapila and Overholt 1997, Ngi-Song and Overholt 1997).

This study also examined termination of parasitoid diapause. When parasitized diapausing stem borer larvae that were transferred to artificial diet and incubated at 25 ± 0.5°C and 65–80% RH, the arrested development seemed to have been interrupted as puparia emerging at 56 d (early June) to 136 d (end of August) after inoculation. However, when inoculated larvae were left on dry stems that were incubated at room temperature (18–26°C), parasitoid emergence occurred from 182 d (beginning of October) to 226 d (end of November). The latter observations were comparable to findings by Chinwada and Overholt (2001) who reported emergence of *S. parasitica* between October and December from diapausing *B. fusca* larvae collected in the field some 7 mo previously.

In general, our study revealed several important aspects of the biology of *S. parasitica* that could be critical in stem borer biological control programs. First, the host range of the Zimbabwean population seems to differ from that of the population collected in Ghana by Nagarkatti and Rao (1975). This stresses the need to conduct rigorous host suitability tests before the Zimbabwean population can be considered for introduction outside its type locality. Ideally, all potential release areas of the Zimbabwean population of *S. parasitica* should have *B. fusca* as the predominant stem borer species. In addition, such areas must have a climate that closely matches that of Harare. Unfortunately, there could be a particular microclimatic element that is critical; there are several areas in Zimbabwe with a climate and stem borer species composition virtually identical to that of Harare, but in which *S. parasitica* has not been found (Chinwada and Overholt 2001). Also, niches are dynamic in terms of stem borer species composition. In both South Africa and Kenya, there is clear evidence of competitive displacement of *B. fusca* by *C. partellus* (Kfir et al. 2002). Second, our results showed that egg maturation in *S. parasitica* is extended over several days. This has an important advantage in field situations where low stem borer infestation levels may require the parasitoid to forage for several days. Combined with a long life span and high mobility, a gravid female can live long enough to deposit its full complement of planidia at several stem borer tunnel entrances over a wide area. Ultimately, this enhances the parasitoid’s survival chances.

In conclusion, the present studies provide new information on the biology of *S. parasitica* in Zimbabwe. However, we still have little insight into why the impact of *S. parasitica* is limited to the Harare area. This parasitoid occurs over a large part of sub-Saharan Africa (Harris 1998), but its abundance is highly variable. For example, *S. parasitica* has been reported to be abundant in central and southern Tanzania, but not in neighboring Kenya (Oloo 1989, Skovgard and Pats 1996, Songa 1999, Zhou and Overholt 2003) or Uganda (Matama-Kauma et al. 2001). Redistribution of the Harare population to other areas where *B. fusca* is the dominant stem borer may have potential, but only if it is shown that this population has certain attributes that other populations are lacking. It would seem more likely that there are unknown abiotic or biotic factors that favor this parasitoid in the Harare area. Thus, further studies to elucidate these factors are required. Additionally, it would be interesting to examine the larvivory of different areas in the field. Being highly fecund and with an egg maturation period extending over several days, it is clear that a single female distributes its maggots over several borer tunnel entrances. However, we do not know how maggots are distributed in such a way as to minimize competition between immature, and inbreeding among adult offspring. Moreover, it would be interesting to see whether *S. parasitica* avoids larviposition on plants infested by the unsuitable host, *S. calamistis*, and/or the partially suitable host, *C. partellus*. If the parasitoid has the ability to discriminate between suitable and unsuitable hosts, then its value as a biocontrol agent will be higher.

**Acknowledgments**

We thank J. O. Ochieng for assisting in the rearing of the parasitoids at ICIPE. This work was supported by the German Academic Exchange Service (DAAD) and the Directorate General for International Cooperation (DGIS), The Netherlands. This is Florida Experiment Station Research Journal Series no. R-09354.

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Received for publication 10 March 2003; accepted 12 September 2003.