

CHAPTER 2

The parasitoids of southern African wild silkmoths (Lepidoptera)

Gonometa postica Walker and *Gonometa rufobrunnea* Aurivillius (Lasiocampidae) are the only two indigenous moth species in southern Africa that are currently used in silk production. *Argema mimosae* de Boisduval (Saturniidae) is, however, another species that has been considered for silk production. The pupal cocoons of *Gonometa* species can be degummed to produce silk of high quality, and presently, the wild silk industry is limited by the supply of naturally harvested cocoons (Veldtman *et al.* 2002). Although aspects of the biology (food plants, distribution etc.) of the two *Gonometa* species and *A. mimosae* are known (Pinhey 1975; Scholtz & Holm 1985; Oberprieler 1995), their population dynamics have not been studied. This has significant implications for silk yields and sustainable harvesting. One component likely to play an important role in the population dynamics of these herbivorous insects is natural enemy-induced mortality, including parasitoids (Walde & Murdoch 1988; Marron & Harrison 1997, Hassell 2000). The research findings of Hartland-Rowe (1992) are currently the only quantitative description (however, without measures of variability) of the importance of parasitism for a southern African *Gonometa* species. His work on *G. rufobrunnea* revealed that three species of egg parasitoids (Table 1) cause 50 % mortality of the eggs, and larval parasitoids 30 % of mortality in late larval instars (Hartland-Rowe 1992).

The first step in establishing the impact of parasitoids on their hosts is to identify the species involved and, if possible, establish a guide to their identification in the field. The use of natural-enemy-specific markings on herbivore insect galls, mines or pupal cases (including emergence hole characteristics) to identify mortality induced by a particular species greatly facilitates estimation of species-specific mortality levels (see for example, Heads & Lawton 1983; Brewer & Gaston 2003). Studying parasitoid attack on the pupal stage of *Gonometa* species is possible in the field because predators (birds and rodents) do not remove the cocoon

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Table 1. List of known parasitoid species of *Gonometa* spp. from southern Africa (*Gonometa postica* (Walker), *Gonometa rufobrunnea* (Aurivillius)), East Africa (*Gonometa podocarpi* (Aurivillius), *Gonometa fasciata* (unknown)), as well as other Lasiocampidae (*Eutricha capensis* (Linnaeus), *Eutricha truncata* (Walker), *Streblote concolor* (Walker), *Bombycomorpha pallida* (Walker) and *Bombycomorpha bifascia* (Distant)) and Saturniidae species (*Argema mimosae* (de Boisduval), *Imbrasia belina* (Westwood), *Imbrasia cytherea* (Fabricius), *Imbrasia bubo* (Bouvier)) known to be parasitised by the same species. Species names of hosts are according to most recent classification (Vári *et al.* 2002).

Order Family	Species ¹	Life stage attacked	Host species
Diptera			
Tachinidae	<i>Pimelimyia semitestacea</i> (Villeneuve) (syn. <i>Sturmia semitestacea</i> Vill.)	larva ²	<i>G. postica</i> ^{7,9,8} , <i>G. rufobrunnea</i> ^{2,8} , <i>B. fasciata</i> ⁹ , <i>B. pallida</i> ⁹
	<i>Tachina convergens</i> ⁹ (Wiedemann) (syn. <i>Sturmia convergens</i> Wiedemann & <i>Sturmia dilabida</i> Villeneuve (Curran))	?	<i>G. postica</i> ⁹ ; <i>E. capensis</i> ⁹ , <i>E. truncata</i> ⁹ ; <i>S. concolor</i> ⁹
	<i>Carcelia evolans</i> ⁹ (Wiedemann) (syn. <i>Zenillia evolans</i> Wiedemann)	?	<i>Gonometa</i> sp. ⁹ (either <i>G. postica</i> or <i>G. rufobrunnea</i>); <i>I. belina</i> ⁸ ; <i>I. cytherea</i> ¹⁰
	<i>Palexorista gilvoides</i> (Curran) ³ (syn. <i>Sturmia gilvoides</i> _Curran ⁴)	larva ^{3,4}	<i>G. podocarpi</i> ^{3,4}
	<i>Palexorista</i> sp. 1* ²	larva ²	<i>G. rufobrunnea</i> ²
	? <i>Palexorista</i> sp.*	larva	<i>G. postica</i> , <i>G. rufobrunnea</i>
	? <i>Tachinidae</i> sp. ⁵	?	<i>G. postica</i> , <i>Gonometa</i> sp. ⁵
Hymenoptera			
Braconidae	? <i>Disophrys</i> sp.	larva	<i>G. postica</i> , <i>G. rufobrunnea</i>
	<i>Meteorus trilineatus</i> (Cameron) ⁴	larva ⁴	<i>G. podocarpi</i>
Ichneumonidae	<i>Pimpla mahalensis</i> (Gribodo) ⁴	larva ⁴	<i>G. podocarpi</i>
Chalcididae	<i>Brachymeria</i> sp. 1**	larva	<i>G. postica</i> , <i>G. rufobrunnea</i>
	<i>Brachymeria</i> sp. 2** ²	larva ²	<i>G. rufobrunnea</i> ²
	<i>Kriechbaumerella</i> sp.	larva	<i>G. postica</i> , <i>G. rufobrunnea</i>

Table 1. continued

Order Family	Species ¹	Life stage attacked	Host species
	<i>Hockeria crassa</i> (Bouček)		<i>I. cytherea</i> ¹⁰
	<i>Hockeria nudaureliae</i> (Bouček)		<i>I. cytherea</i> ¹⁰
	<i>Hockeria</i> sp. 1	larva	<i>A. mimosae</i>
	<i>Hockeria</i> sp. 2 ²	larva ²	<i>G. rufobrunnea</i> ²
	<i>Hockeria</i> sp. 3 ¹⁰		<i>I. belina</i> ¹⁰
Eurytomidae	<i>Eurytoma transvaalensis</i> (Cameron) ²	larva; hyper pars.	<i>G. postica</i> , <i>G. rufobrunnea</i> <i>?Disophrys</i>
Perilampidae	<i>Perilampus</i> sp.	hyper pars.	<i>P. semitestacea</i>
Eulophidae	<i>Pediobius anastati</i> (Crawford) ^{2,5}	egg ²	<i>G. postica</i> ¹¹ , <i>G. rufobrunnea</i> ² , <i>Gonometa</i> sp. ⁵
	<i>Pediobius</i> sp.	egg ⁸	<i>I. belina</i> ⁸ ; <i>I. cytherea</i> ¹⁰ ; <i>I. bubo</i> ⁸
Eupelmidae	<i>Anastatus bifasciatus</i> (Fonscolombe) ²	egg ²	<i>G. fasciata</i> ²
	<i>Anastatus</i> sp. 1 ²	egg ²	<i>G. rufobrunnea</i> ²
	<i>Anastatus</i> sp. 2 ⁸		<i>I. belina</i> ⁶ , <i>I. cytherea</i> ¹⁰
	<i>Anastatus</i> sp. 3 ^{3,4}	egg ^{3,4,6}	<i>G. podocarp</i> ^{3,4}
	<i>Mesocomys pulcriceps</i> (Cameron) ²	egg ⁶	<i>G. postica</i> ¹¹ , <i>G. rufobrunnea</i> ² , <i>Gonometa</i> sp. ⁵ , <i>A. mimosae</i> ⁸ ; <i>I. belina</i> ⁶ , <i>I. cytherea</i> ¹⁰ , <i>I. bubo</i> ¹⁰
	<i>Tineobius gonometae</i> (Ferrière) ²	larva ²	<i>G. postica</i> ¹¹ , <i>G. rufobrunnea</i> ²

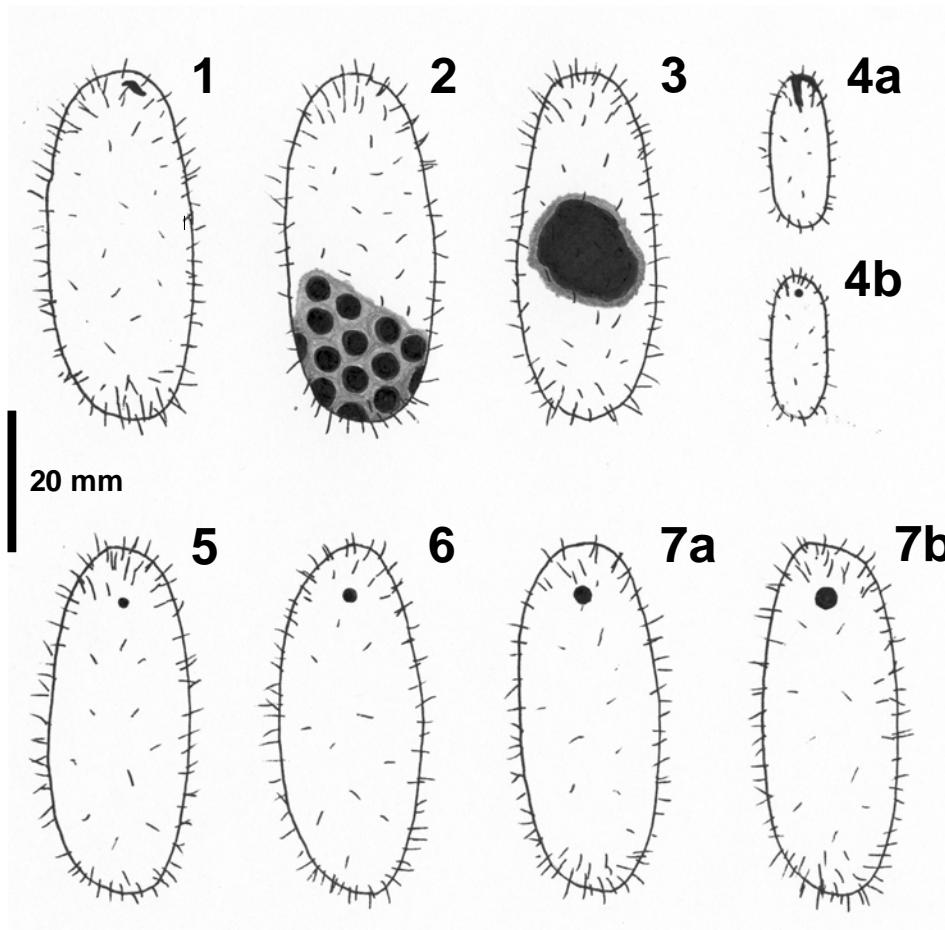
(1) Boldface denotes species recorded in this study. Number 2-11 denote other information sources: (2) Hartland-Rowe 1992, (3) Austara 1971, (4) Okelo 1972, or (5) Esther Kioko (unpublished), (6) Scholtz & Holm 1985, (7) Crosskey 1984, (8) Peigler 1994, (9) Cuthbertson & Munro 1941, (10) Geertsema 1975, (11) Records from the Biosystematics division of the Plant Protection Research Institute, Agricultural Research Council, South Africa. Similar numbers of asterisks indicate that unidentified species are of the same genus, region and have the same host species and may be thus the same species; hyper pars. = hyperparasitoid.

casing during predation, and parasitoids leave species-specific, characteristic emergence holes (Hartland-Rowe 1992). Here, we provide a list of the egg and larval parasitoid species of these southern African wild silk moths, with information on the life stage and host species attacked. The characteristics of emergence holes formed by each larval parasitoid species on the *Gonometa* cocoon is also described.

Information on previously identified parasitoid species of southern African *Gonometa* species was compiled from a few key references (Table 1). However, the results presented are based mostly on collections and surveys made by us in regions where host species are known to reach high abundances (Veldtman *et al.* 2002). Occupied cocoons were collected from localities within the known (historic and recent records) outbreak range of both species (*Gonometa postica* from Vryburg, Hotazel (North-central South Africa), Gabane, Kumukwane, Mogoditshane and Kopong (South-Eastern Botswana) and *G. rufobrunnea* from Shashe and Dumela (North-Eastern Botswana), see Veldtman *et al.* 2002 for co-ordinates). Pupal collections were made during the overwintering and first generation stages of both species (July 2000 and January 2001). Cocoons of *A. mimosae* were also collected in Gabane in July 2000. Collectively, the larval parasitoids of *G. postica* and *G. rufobrunnea* resulted in a median parasitism rate of approximately 30% at sampled localities (Veldtman *et al.* in prep.).

All parasitoids emerging from the collected pupae were recorded, as were the size and shape of their emergence hole(s). The sizes of emergence hole of some species' were also measured. Laboratory-emerged parasitoid species could consequently be linked to characteristic emergence holes (Fig 1-7). Parasitoid species (Hymenoptera and Diptera) were identified by taxonomists at the Biosystematics Division, Plant Protection Research Institute, Agricultural Research Council, Pretoria. Voucher specimens are to be placed in the National Collection of Insects, Plant Protection Research Institute, Pretoria.

The parasitoids of East African *Gonometa* species are also listed (Table 1) to highlight possible patterns in genera responsible for parasitism. Similarly, other Lasiocampidae and Saturniidae species parasitised by the same parasitoid species or genus in southern Africa are also provided (Table 1). Below is an outline of the parasitoid species associated with *G. postica* and *G. rufobrunnea* (as well as one species parasitising *A. mimosae*) and descriptions of their emergence hole characteristics.



Figures 1-7. Characteristic emergence hole(s) left by parasitoid species emerging from *Gonometa postica* and *G. rufobrunnea* pupal cocoons. (1) *Pimelimyia semitestacea*, (2) *?Palexorista* sp., (3) *?Tachinidae* sp., (4) dwarf *Gonometa* species cocoons formed after parasitism by a *?Disophrys* sp. showing characteristic emergence holes a) after successful emergence of parasitoid (cracked open) and b) after hyperparasitism by *Eurytoma transvaalensis*, 5) *Eurytoma transvaalensis* emerging as primary parasite, (6) *Brachymeria* sp. 1, (7) *Kriechbaumerella* sp. a) male and b) female.

Parasitoid species and their emergence holes

Diptera

Pimelimyia semitestacea Villeneuve (Tachinidae) (Table 1) is probably the best-known larval parasitoid of southern African *Gonometa* species, and is described in several key references (Cuthbertson & Munro 1941; Crosskey 1984; Hartland-Rowe 1992). This species differs from others in that it emerges from the host cocoon in the larval stage, pupating in the soil. Upon emergence larvae force themselves through a single, small, irregular, tear-shaped emergence hole of 1-3 mm in diameter at the anterior of the cocoon (Fig. 1). The edge of this hole is usually brittle and may possibly be a result of larvae (which do not have biting mouthparts) forming the emergence hole by enzymatic breakdown of the silk. Larvae have been observed to sequentially force themselves through the same tiny emergence hole, ballooning outwards. Larvae are negatively phototropic and readily tunnel into wood shavings or fine sand to pupate. Up to 16 larvae have been found to emerge from a single female host, but between one and three for male cocoons and five and nine for the larger females are more usual.

?*Palexorista* sp. (Table 1) form multiple emergence holes (usually between 3-15, 3-4 mm in diameter), each of which is covered by an operculum prior to fly emergence (Fig. 2). The puparia are not separated into compartments inside the cocoon. Although no adults emerged in the laboratory, puparia of all parasitised cocoons showed characters similar to those of the genus *Palexorista*. *Palexorista* species have a puparium with each of the paired posterior spiracles in the form of prominent trifold "boss", with simple slits (D. Barraclough pers. comm.). Several cases of cocoon deformation were observed in the field when the emergence holes of this species were present. This may also indicate enzymatic breakdown of the posterior end of the cocoon for larvae to embed themselves in the cocoon wall upon pupation. Hartland-Rowe (1992) mentioned a *Palexorista* sp. as an important larval parasitoid of *G. rufobrunnea*, at Shashe (near Francistown), Botswana. As material collected during this study is also from this area, the species found in this study is likely to be that species (Table 1).

An unknown parasitoid species (Table 1) that leaves a characteristic, large, irregularly shaped, dark brown edged, exit hole in the flank of the cocoon (Fig. 3), has only been observed in the field with no individuals emerging from collected material. The emergence hole of this species can be distinguished from those that would result from bird predation (Hartland-Rowe

1992) because pupal remains are present and bird predation typically results in larger holes. This species may also be of the Tachinidae, as an unidentified Tachinidae species from East Africa evidently leaves a similar-shaped emergence hole (E. Kioko pers. comm.).

Hymenoptera

The ‘dwarfism’ phenomenon observed in *G. postica* cocoons (see Veldtman *et al.* 2002) is caused by a primary parasitoid, possibly a species of *Disophrys* (Braconidae), that parasitises the early larval instars of *G. postica* and *G. rufobrunnea*. ?*Disophrys* sp. was found to be hyperparasitised by *Eurytoma transvaalensis* (Cameron) (Eurytomidae). Successful emergence by ?*Disophrys* sp. is characterised by a dwarf cocoon with a small crack at the anterior end (Fig. 4a), while *E. transvaalensis* leaves a small (usually single) circular emergence hole (Fig 4b). Upon dissection, most dwarf cocoons were found to contain a ?*Disophrys* sp. pupal cocoon (consisting of white silk), as well as the larval head and other remains of the parasitised host. In some dwarf cocoons only the larval remains were found with no emergence holes, possibly indicating unsuccessful primary parasitism. Evidence of hyperparasitism is clear from the similarly sized emergence holes in both the host’s and primary parasitoid’s cocoons, indicating that *E. transvaalensis* emerged from the braconid’s cocoon first. *Eurytoma transvaalensis* also emerged from normal sized cocoons of both *Gonometa* species. However, no Braconidae cocoon or any primary parasitoid remains were found, suggesting that this species is a facultative hyperparasitoid. Hartland-Rowe (1992) described *Eurytoma transvaalensis* as the most abundant Hymenopteran larval parasitoid of *G. rufobrunnea*.

In addition to *E. transvaalensis*, two other parasitoid species (*Brachymeria* sp. 1 and *Kriechbaumerella* sp., both Chalcididae) form smooth (regular), circular emergence holes (Figs. 4b, 5, 6, 7a, 7b). These Chalcidoidea parasitoids escape from cocoons using strong mouthparts to chew a circular smooth hole, with larger individuals forming larger holes. The average emergence hole size and observed variability are provided for each of these species from material that emerged in the laboratory (Fig. 8). Although the shape of the emergence hole of all three species do not differ, the diameter of the holes do (Fig. 8), and it is possible to distinguish them in the field.

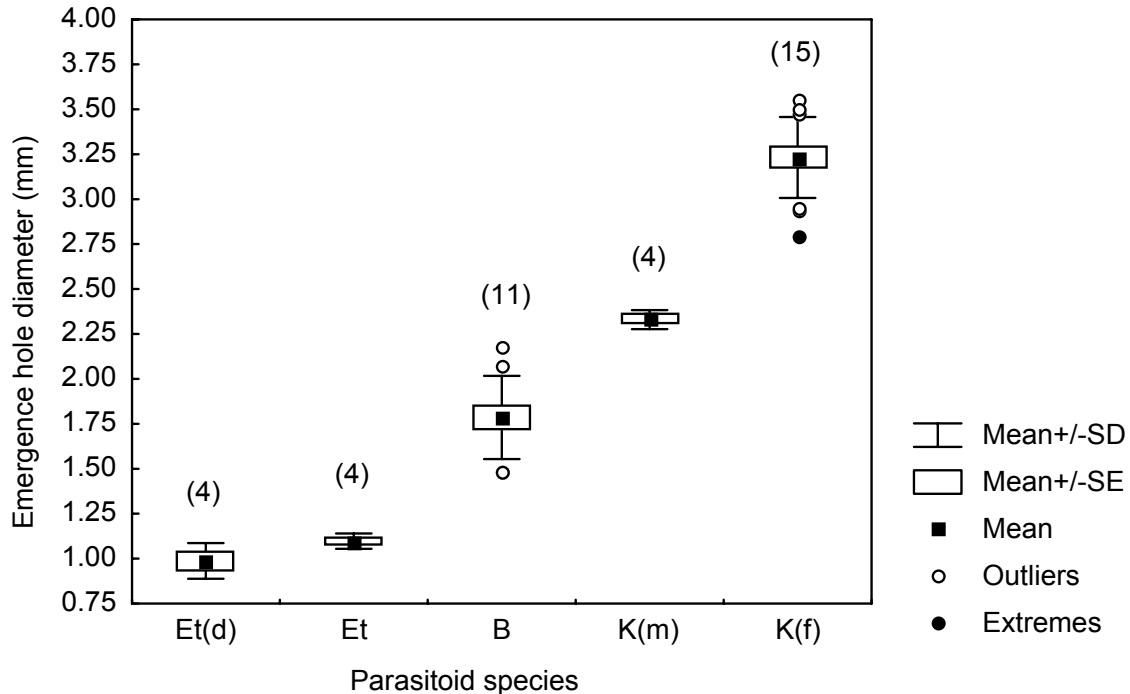


Figure 8. Variability in parasitoid cocoon emergence hole diameter for parasitoid species leaving a circular emergence hole: Et(d) = *Eurytoma transvaalensis* emerging from dwarf cocoons; Et = *Eurytoma transvaalensis*; B = *Brachymeria* sp. 1; K(m) = *Kriechbaumerella* sp. (male); K(f) = *Kriechbaumerella* sp. (female). Numbers in brackets are sample sizes.

Eurytoma transvaalensis emerging from dwarf or normal sized cocoons leaves a hole between 1.0-1.1 mm in diameter, while *Brachymeria* sp. 1, which shows marked intraspecific variability in body length (range in emergence hole diameter represents 33% of the mean), forms emergence holes 1.5-2.1 mm in diameter. The *Brachymeria* species recorded as parasitising both *G. postica* and *G. rufobrunnea* is thought to be the same species previously found to parasitise *G. rufobrunnea* (Table 1). If this species and the *Palexorista* species mentioned earlier are indeed the same species as previously described (Hartland-Rowe 1992), the larval parasitoids recorded to date are shared by all southern African *Gonometa* species.

The emergence holes formed by *Kriechbaumerella* sp. show marked sexual size dimorphism (Fig. 8). Males are smaller and form smaller holes, 2.3-2.4 mm in diameter, while

adult females are larger with emergence holes ranging from 2.9-3.5 mm in diameter. Although sample size was small, species that form circular smooth emergence holes showed no cases of overlap in emergence hole diameter (Fig. 8). Emergence hole diameter is thus an adequate measure for species identification.

Hockeria sp. 1 (Chalcididae) was the only parasitoid (n = 2) to emerge from 31 viable *A. mimosae* cocoons collected. This species forms an emergence hole (diameter approximately 3 mm) just below the ring of mimetic parasitoid emergence holes of the cocoon (see Oberprieler 1995 for host cocoon characteristics). Hartland-Rowe (1992) recorded another unidentified species of this genus emerging from *G. rufobrunnea*. It is not possible to determine if these two species are the same.

Despite Hartland-Rowe (1992) mentioning the value of noting the emergence hole characteristics of *G. rufobrunnea* larval parasitoids for species identification, this is the first time that these characteristics are described and quantified for both *Gonometa* species in southern Africa. The information provided here makes it possible to determine the parasitoid species responsible for parasitism of field parasitised pupa. Future collections of pupae will greatly aid in confirming the identity of the unidentified taxa listed in this study. Most importantly, future research on field parasitism rates of *Gonometa* populations, requiring the identification of parasitoid species, will benefit from the species list, descriptions and figures provided.

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