

Preliminary observations on the nesting biology of *Trypoxylon petiolatum* Smith, 1858 (Crabronidae, Trypoxylini) in Hong Kong

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ABSTRACT

Four nests comprising 16 cells of *Trypoxylon petiolatum* were reared from trap nests. The content was noted at trap opening and development of larvae recorded. In general the biology of this species agrees well with what is known about the genus (Nambu 1966, 1967; Krombein 1967; Bohart and Menke 1976; O'Neill 2001). It was noted that: the wasp is a cavity nester; this species is relatively specialised in its prey choice, with 72% of prey items being salticid spiders; the apparent requirement for very moist partition and plug construction material might impose restrictions on the possible nesting sites; and, by inference, the species is at least bivoltine if not trivoltine in Hong Kong.

Key words: *Trypoxylon petiolatum*, Crabronidae, Salticidae, Oxypodidae, sex ratio, voltinism.

INTRODUCTION

Trypoxylon petiolatum Smith, 1858 is a widely distributed species from India to the Far East and South East Asia, but little is known about the nesting behaviour of this crabronid, most of the literature on *Trypoxylon* concentrating on New World species. The status of *Trypoxylon petiolatum* Smith 1858 was revised by Tsuneki (1978, 1979 & 1981). Nambu (1966, 1967, in Japanese) produced detailed biological accounts on the species occurring in Japan including *T. obsonator* Smith, a junior synonym of *T. petiolatum* Smith.

The genus is cosmopolitan but poorly represented in Australia and some Pacific islands. To date 633 species have been described not including fossil taxa (Pulawski 2009), with certainly more to be discovered, particularly in central and south America where the genus attains its greatest diversity (Bohart and Menke 1976). It is divided into two subgenera, *Trypargilum* and *Trypoxylon*, the former only distributed in the Old World while the latter is distributed worldwide. In Hong Kong the author has recorded two species (*T. petiolatum* and *T. formosicola* Strand, 1922) and possibly a third one (pending identification).

All members of the tribe Trypoxylini hunt spiders for larval food, unlike most other species of Crabroninae, which generally provision their nests with various insects, either imago or larvae¹. In the genus *Trypoxylon* there appears to be no general specificity in prey selection with a wide range of spider families being used.

Trypoxylon nests are fashioned out of mostly pre-existing cavities such as burrows left by wood-boring beetle larvae and bees, but also in hollow plant stems or in the ground. Near human habitats, any artefact presenting a tubular cavity will be used. Nests are composed of a linear set of cells divided by mud partitions and a final nest plug. Some species in the subgenus *Trypargilum* are known to fabricate free-standing mud structures, long cemented tubes bundled together on a suitable substrate, these are collectively known as the "pipe-organ wasps". A few species in the same subgenus have been reported to be gregarious, females building nests in close proximity to each other without any aggressive competition over the nesting site. One aspect deserves mention, the well documented behaviour of males in some species of *Trypargilum* actively guarding the nesting site in the absence of the female (Krombein 1969; Bohart & Menke, 1976; O'Neil 2001). Males are also reported to assist the females in nest preparation and construction, placing prey items in the cells and helping with the closure of the cell.

Observations of this common, medium sized but elusive species were carried out on trap nests at the end of May and beginning of June 2009, at Pak Sha O, Sai Kung Country Park, Hong Kong.

METHODS

The traps consisted of hollow bamboo canes that were cut so that one end was closed by a nodal septum, they were of various length and diameter, four to seven segments bundled together and hung from low branches on various bushes and trees. Six bundles totalling approximately 40 segments with diameters of 3 to 6 mm were set between May and July 2009. Traps were inspected regularly and those with obvious wasp activity were either kept for rearing – sealed in a plastic "Ziploc" bags – or replaced in-situ if brood/prey were lacking. The four bamboo traps were collected between 22 and 31 May 2010. The traps were located in and collected from the author's garden, Hong Kong, Pak Sha O; UTM: 50Q KK 237 850, alt. 70m asl. The garden is situated on an old and abandoned *Citrus* spp. orchard, adjacent to a mature secondary forest, at the bottom of the north slope of a small hill.

Detailed analyses of trap content were carried out on four reared nests, comprising 16 cells, in June 2009. Quantitative data pertaining to brood, parasites, prey provisioning, cell dimensions, etc. were obtained upon trap opening, as well as through regular inspection of the brood development. The

identification of spider prey to species level was undertaken visually based on photographic plates provided by Tsim (2007).

Field observations of nest construction and provisioning were also recorded on two traps. Presence of adults in the study area was monitored continuously by one resident Malaise trap.

RESULTS

The data are presented in Tables 1, 2 & 3.

Nest description

Table 1 summarises the data pertaining to the dimensions and content at opening of each occupied trap-nest from which *T. petiolatum* emerged.

The cells were separated by cemented partitions, convex and smooth towards the entrance, irregular posteriorly. The partitions were composed of mixed material (sand grains, clay and possibly organic material). The plug was composed of the same material but applied in a much thicker layer. On all nests dissected, I systematically recorded the following characteristics:

- each nest had a vestibular cell defined by the last cell partition and the nest plug;
- all the first cells started directly from the bottom of the tube with no adjunction of material; and
- no empty intercalary cells were present.

Nests were made inside small diameter segments, as could be expected from “key-hole wasps”. The recorded diameters varied from 3.7 to 5.7 mm (mean = 4.35, $n = 4$). The mean cell number per trap was found to be four ($n = 16$) for trap lengths varying from 155 to 195 mm (mean = 176.3, $n = 4$). Cell length varied from 14 to 55 mm (mean = 24.88, $n = 16$) (Table 3).

Figure 1 shows the typical content of a nest trap at opening.

Prey items

Table 2 shows the record of prey for each of the 16 cells analysed. Each cell was mass-provisioned with three to six prey items. An overwhelming majority of these were jumping spiders, Salticidae (72%), while a little less than a third were crab spiders, Oxyptodidae (28%), the latter only represented by immature specimens of apparently the same species. In the Salticidae there was a visible preference for two species: Unidentified sp1 (25%) and *Epocilla calcarata* Karsch, 1880 (20%).

All specimens were lightly paralysed; able to move some appendages (pedipalps and legs) and spin some silk. Typical prey content of one trap is shown in Figure 1.

Cell 1 of trap PSO-046.A4 had a full prey provision but no eggs. The tube was kept after emergence of adult wasps until 5 July; although dead, the prey had remained in a remarkable state of freshness, with no sign of decay.

Brood development

Development of the brood was observed in four traps, comprising 14 active cells. Two cells (12.5% of the total) contained prey but no eggs, for reasons that were not related to parasitism (no instances of brood parasitism were in fact recorded). Each active cell contained a single egg, larva or pupa. The eggs were laid latero-ventrally on the abdomen of the prey, attached anally close to the abdominal cephalothoracic junction (Figure 3). From observations at trap opening, it appears likely that the eggs were laid on the last prey item brought into each cell.

Upon hatching, the grub remained fixed to its attachment and fed externally on the latero-ventral side of the abdomen of the prey. After almost completely consuming the first item (leaving only parts of the appendages), the larva sought another provisioned prey item and continued feeding, this time devouring the prey from any angle. As the grub developed it became darker save for the anal end filled with light-coloured meconium, later discharged in the cocoon.

The pre-pupal larva spun a single-layered cocoon not adherent to the tube sides. The cocoon material was cream in colour, very thin and easily crumpled, like paper. However, a fine silk diaphragm was woven on the anterior end of the cell, either right against the cell partition or before it, depending on the length of the cell. All 12 adults from the four traps emerged between 18 and 22 June.

The eggs hatched in approximately two days (mean = 2.5, $n = 4$). The mean development time from oviposition to last instar larva was seven and a half days ($n = 9$) or five days of larval stage. The mean time from oviposition to emergence was 25.5 days ($n = 11$) equating to 18 days of pupation time.

Sex ratio

Sex ratio information was obtained from 11 cells in four traps (Table 1). A male bias was evident (58% to 42% females).

Larval mortality

Eggs and larvae may experience mortality during the developmental stages for reasons unrelated to parasitism. This was noted (Table 1) in two instances over 14 active cells upon opening (14.29%).

Voltinism

Nesting was observed only at the end of May on one bundle. The traps that had not been occupied by then remained empty during the rest of the summer or were occupied either by ant colonies (mainly in the genus *Crematogaster*), a common

sphecid, *Isodontia diodon* (Kohl 1890) and some undetermined Eumeninae. It took a little less than four weeks to complete the development of one generation. Adult specimens were, however, caught continuously in one Malaise trap in the study area from the end of March to early October.

Field observations

Only fragmentary field observations of transportation, application of plug and cell partition material were obtained. Unfortunately, prey provisioning was observed only once (Figure 4). Therefore, it has been impossible to assess precisely the time necessary to complete (build and provision) one cell and consequently the time necessary to complete a nest. However, the limited data suggest that a nest of four cells may be completed in two days.

Construction material foraging trips were time-recorded for two traps used by the same adult female, who made 12 trips over a period of 13.55 minutes (mean = 67.75 seconds per trip). The ball of material – a coarse wet assemblage of sand grains, soil and clay – was carried ventrally with the aid of the mandibles and the forelegs. The wasp spent 20–30s inside the nest applying the material. In doing so, she produced a stridulating noise, similar to that of larger sphecids.

In transporting prey, the wasp grasped the pedipalps and/or the front legs of the prey with her mandibles while locking the load ventrally with the forelegs, flying to the nest entrance. The spider was carried venter up and dragged between the wasp legs into the nest.

For both construction material and prey provisioning the wasp entered the nest head-first and exited metasoma first, unable to rotate inside the small cavity. Upon leaving for foraging the wasp never closed the nest entrance.

A graphical summary of these on-nest behaviours is given in Figure 5.

CONCLUSION

The nesting biology of this species agrees well with what is known generally about the genus (Nambu 1966, 1967; Krombein 1967; Evans 1970; Bohart and Menke 1976; O'Neill 2001). However, it should be noted that:

- *T. petiolatum* was clearly a cavity nester in Hong Kong, and therefore can be assumed to use pre-existing cavities in plant material as nesting sites, although members of this genus have been recorded from a variety of sites, both natural and man-made as well as being able to construct complete mud nests as with other Aculeata (Bohart & Menke, 1976; O'Neill, 2001). In particular *Trypoxylon rejector* Smith, synonymised with *T. petiolatum* by Tsuneki (1979), has been observed to construct free-standing, upright nests affixed to straw (Richards 1934). Another slight difference with the known biology of this species appears in the mean nest diameter of 4.35mm, noted to be smaller by approximately one third to the mean value of 6.3mm recorded for *T. obsonator* (Nambu 1966).
- The wet material used for partitions and plugs implies that it was extracted from a wet source. Additionally, the short foraging trips (approximately 60s) may indicate that this source was close to the nest. This may be a limiting factor in nesting site selections, to where suitably moist material is available (O'Neill 2001).
- All the prey items were foliage dwellers that Krombein (1967) calls the wandering or vagabond group of spiders, as opposed to ground dwellers, and none of them were web spinners. In fact *T. petiolatum* was found to be rather specialised in prey item selection, which is consistent with Nambu's (1966) observations for *T. obsonator*, where over 70% of the prey were from the Salticidae family, a near specialisation that is not well documented for most species in the genus.
- A rather short development time of 25 days from egg laying to emergence of adults, coupled with persistence of adults from March to October and the known voltinism of species in this genus in North America (Krombein, 1967), suggests that in Hong Kong *T. petiolatum* could have at least three generations yearly. However, Nambu (1967) reported that in the Tokyo region *T. obsonator* was bivoltine with the second generation overwintering. He also observed that the development time was on average 32 days, one week longer than that observed during the present study. Additionally, it should be noted that trap nests were only colonised once in the current study, in late May. This was probably the consequence of poor selection of trapping sites, superseded and occupation by other Aculeata and a relatively small number of set traps. Further investigation is necessary to establish the true voltinism of the species.
- Although brood parasitism was never recorded it has to be noted that the sample size is small and therefore, results are certainly biased. Instances of parasitism and/or nest associates are certainly present in this species, particularly as it does not close the nest entrance when departing for foraging trips, leaving the "door open" to a number of parasites, and nest associates as recorded in the genus (Krombein 1967) are well documented for *T. obsonator* where nests could be infested by Tachinid flies (Nambu 1967).
- For possibly the same reason (small sample size), the sex ratio obtained is male-biased² although this bias is confirmed for *T. obsonator* in the Tokyo region (Nambu 1967) with 73% males for 23% females.

- Larval mortality (not related to brood parasitism) was noted in 14% of active cells, which if combined with the presumed effect of parasitism would amount to significant mortality of egg and larva in the natural populations. This has been well documented for New World species with total mortality attaining nearly 60% of all cells in some species (O'Neill 2001).
- The pre-pupal larva spun a pupating chamber defined by the posterior partition and a silk operculum on the anterior side of the cell.

Further detailed field and laboratory studies will allow for a finer understanding of the biology of this species and genus particularly with regard to nesting behaviour, brood development, parasitism, sex ratio and voltinism.

Endnotes

¹ Although some members of the tribe Miscophini (Crabronidae) also provide spiders as larval food.

² Jon Seger proposed in 1983 (Seger 1983) a model by which the sex ratio could be predicted to be 1:1 (female : male) for univoltine wasps and male biased if the wasp species was bivoltine or more. Unfortunately, the small sample size of the study does not permit confirmation of the applicability of Serger's model for *T. petiolatum* in Hong Kong.

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Table 1a. Trap content

Trap ref.	Trap set	Collected	Diam. (mm)	Length (mm)	Cells	Eggs	Larvae	Pupae	No. of prey	Mean no. prey/cell	Cells with no eggs
PSO-046.A3	6-May-09	31-May-09	4.3	195	5	3	1	0	25	5	1
PSO-046.A4	6-May-09	22-May-09	5.7	195	5	4	0	0	19	3.8	1
PSO-046.A6	6-May-09	26-May-09	4	160	4	2	2	0	18	4.5	0
PSO-046.A7	6-May-09	31-May-09	3.4	155	2	2	0	0	7	3.5	0
Total					16	11	3	0	69		2
Mean			4.35	176.25	4.00				17.25	4.31	
%											12.50%

Table 1b. Brood death, parasitism and sex ratio

Trap ref.	Larval death, excl. parasitism		Parasitism			Sex ratio	
	Active specimens at opening	Dead specimens	No. of cells	No. of cells parasitised	No. of active cells	Female	Male
PSO-046.A3	4	1	5	0	3	2	1
PSO-046.A4	4	1	5	0	3	1	2
PSO-046.A6	4	0	4	0	4	1	3
PSO-046.A7	2	0	2	0	2	1	1
Total	14	2	16	0	12	5	7
Mean							
%		14.29%		0.00%		41.67%	58.33%

Table 2. Prey

Trap ref.	No. of cells	No. of prey	Prey details							Oxyopidae
			Salticidae							
			<i>Epocilla calcarata</i>	<i>Chryzilla versicolor</i>	<i>Carrhotus sannio</i>	<i>Rhene flavigera</i>	<i>Cytaea</i> sp1	<i>Salticidae</i> sp1	<i>Salticidae</i> sp2	<i>Oxyopidae</i> sp1
PSO-046.A3	5	25	1	0	1	2	0	6	7	8
PSO-046.A4	5	19	9	1	1	1	1	3	0	3
PSO-046.A6	4	18	4	0	2	0	0	2	3	7
PSO-046.A7	2	7	0	0	0	0	0	6	0	1
Total	16	69	14	1	4	3	1	17	10	19
%			20.29%	1.45%	5.80%	4.35%	1.45%	24.64%	14.49%	27.54%
								% Salticidae	72.46%	

Table 3. Cell dimensions

Trap ref.	Max. diameter (mm)	Segment length (mm)	Number of cells	Length Cell 1 (mm)	Length Cell 2 (mm)	Length Cell 3 (mm)	Length Cell 4 (mm)	Length Cell 5 (mm)	Mean cell length (mm)
PSO-046.A3	4.3	195	5	44	27	17	24	21	
PSO-046.A4	5.7	195	5	20	20	20	20	20	
PSO-046.A6	4	160	4	25	20	30	55	—	
PSO-046.A7	3.4	155	2	21	14	—	—	—	
Mean	4.35	176.25	4.00	27.50	20.25	22.33	33.00	20.50	24.88

Figure 1. Trap PSO-046.A6. Trap inside view and prey content at opening. (Photo author).



Figure 2. Trap PSO-046.A6 six days later. Cell 1 & 2 contains freshly spun cocoons (top). Cell 3 & 4, contains mature larvae consuming the last prey (bottom). (Photo author).



Figure 3. Oviposition site on prey. (Photo author)



Figure 4. Left, cell partition material provision. Right, prey provisioning. (Photos author).



Figure 5. *Trypoxylon petiolatum*, nesting activity diagram.

