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Observations on Resource Partitioning Among Ants (Hymenoptera: Formicidae) and Lycaenid Larvae (Lepidoptera: Lycaenidae) Associated with *Pueraria phaseoloides* in South Thailand

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ABSTRACT: Inflorescences of the leguminous vine, *Pueraria phaseoloides* (Roxb.) Bth. were surveyed for the presence of associated ants and lycaenid butterfly immatures on Khao Khaw Hong, near Hat Yai City, Songkhla, Thailand, during January and February 2001. Fifteen ant species in 12 genera and three species of lycaenid larvae and eggs were found on 934 of 1202 inflorescences. Two ants, *Oecophylla smaragdina* (Fabricius, 1775) and *Dolichoderus thoracicus* (Smith, 1857), were present on approximately 60% of all ant-occupied inflorescences, and were associated exclusively with larvae of the lycaenid butterflies *Rapala pheretima* (Hewitson, 1863) and *Catochrysops panormus* (Felder, 1860), respectively. Larvae of *Jamides celeno* (Cramer, 1775), which comprised approximately 2/3 of all lycaenid larvae, were associated with six ant species, but most frequently with *Anoplolepis gracilipes* (Smith, 1857) and *Tapinoma indicum* Forel, 1895. Seven ant species not associated with any lycaenid larvae collectively occupied approximately 10% of all ant-occupied inflorescences.

KEYWORDS: Formicidae, Lycaenidae, myrmecophily, *Pueraria phaseoloides*.

INTRODUCTION

Many members of the butterfly family Lycaenidae have symbiotic relationships with ants in the subfamilies Dolichoderinae, Formicinae, and Myrmecinae. Myrmecophilous lycaenid larvae recruit ant body guards by means of semiochemical attractants and/or nutritious secretions[1-4] and substrate-borne vibrations.[5,6] Many plants also attract ants by means of floral and extra-floral nectaries and other food bodies. Both lycaenid larvae and plants may benefit from the presence of ants, which kill or drive away potential predators.[7,8]

The degree of ant-larval association can vary from obligate to facultative, depending on the species involved. Obligate myrmecophiles are usually associated with a single ant species,[4,9] which they strongly attract, and oviposition may occur only where that ant species is present.[9-12] Facultative myrmecophiles may occur in association with multiple ant species and are not necessarily dependent on ants for their survival.[12] When multiple lycaenid species compete for the same plant resource, their abundances and distributions may be linked to those of the ant species which actively tend them or at least tolerate their presence.[9]

Leguminous plants serve as larval hosts for many lycaenid species and often more than one species uses the same host plant.[9, 13] Because competition for limited larval food resources can be intense, larvae may benefit by association with ants which eliminate not only predators but also other competitors for the same food resources.[9]

Pueraria phaseoloides (Roxb.) Bth. (Fabaceae: Papilionoideae), known vernacularly in Thailand as

Fig 1. *Pueraria phaseoloides* growing along road on Khao Khaw Hong.

"Thua Sian Pee", is a leguminous vine which is widely distributed in Southeast Asia. This plant commonly occurs along the margins of roads through secondary forest and rubber plantations which cover the slopes of Khao Khaw Hong, a hill near Hat Yai in Songkhla Province, South Thailand, where it blooms in late December to February.[14] There, *P. phaseoloides* occurs in patches of varying size up to several square meters (Fig 1) from the base to the summit (elevation range 180-400 m), in situations ranging from full to partial sun exposure, and often near or intermingled with other herbaceous forbs and woody shrubs. On Khao Khaw Hong, *P. phaseoloides* is host to at least six lycaenid species, which feed on developing flowers and fruit. Several species of ants also forage on *P. phaseoloides* inflorescences, where they imbibe fluid secreted from dehiscent flower pedicel scars (nodosities) (apparent in Fig 5 beneath the larva). During January and February 2001, a survey was conducted on Khao Khaw Hong to ascertain the relative abundances and associations of lycaenid larvae and ants on *P. phaseoloides* inflorescences.

Methods

Inflorescences of *P. phaseoloides* were visually inspected *in situ* for presence of ants and lycaenid larvae and eggs over four days in January and February 2001; surveys were conducted between the hours of 08:00 and 15:00. The survey included all inflorescences encountered along forest roads (approximately 5 km total distance) having at least some mature flowers, as ants were seldom observed on less mature inflorescences. The weather during survey periods was primarily warm and sunny, although rain beginning in late morning on one day caused the termination of observations at that time.

The number of inflorescences inspected, as well as the numbers having associated ants, lycaenid larvae, and eggs, were recorded. Only older larvae (3rd instar and older) were counted, as 1st and 2nd instar larvae are frequently concealed within flowers and could not be adequately surveyed without destructive sampling techniques. Likewise, some lycaenid eggs may have been overlooked because they are often placed in tight spaces within or between flower buds where they are difficult to observe without destructive sampling techniques.

Samples of all ant species and lycaenid larvae were collected for subsequent examination and identification. Ants were identified by Dr. Decha Wiwatwittaya, using available keys and by comparison with voucher specimens in his collection. No complete faunal survey of ants from Thailand has been published and it is likely that several species await formal description. Lycaenid immatures were identified by the author by comparison with preserved larval specimens associated with reared adults in the author's collection. Each species was distinguishable according to unique differences in larval chaetotaxy (to be reported elsewhere). Lycaenid eggs could not be identified to species in the field.

Voucher ant and reared adult lycaenid specimens are deposited in the insect collections at Kasetsart University in Bangkok and/or at the Entomology Research Museum of the University of California at Riverside, CA, USA. Plant voucher specimens are deposited at the herbaria of Chiang Mai University in Chiang Mai and University of California, Riverside, CA, USA.

Statistical significance of associations between ants and lycaenid larvae was tested using Chi Square tests of independence, when appropriate.[15]

Results

A total of 1202 inflorescences were inspected; the results are summarized in Table 1 (category totals exceed 1202 because inflorescences having both eggs and larvae are included in both categories). Ants representing 15 species in 12 genera were found on 837 inflorescences. Ants were not evenly distributed, but rather a single species nearly always occupied multiple adjacent inflorescences. This was especially the case with the two most frequently found species *Oecophylla smaragdina* (Fabricius, 1775) and *Dolichoderus thoracicus* (Smith, 1860), which typically occupied several inflorescences in close proximity. A few ant species occurred as several foragers on a single isolated inflorescence (*e.g. Meranoplus bicolor* (Guérin, 1845)) or as solitary individuals in patches of inflorescences dominated by other species (*e.g. Camponotus rufoglaucus* (Jerdon, 1851) and *Monomorium destructor* (Jerdon, 1851)).

Larvae of three lycaenid species (*Catochrysops panormus* (Felder, 1860), *Jamides celeno* (Cramer, 1775), and *Rapala pheretima* (Hewitson, 1863)) were found on a total of 71 inflorescences, some of which had multiple larvae. Lycaenid eggs were also found on 71 inflorescences, some of which also contained larvae. In unrelated observations of *P. phaseoloides* inflorescences on and near Khao Khaw Hong, the author has found larvae of three additional lycaenid species, which were not found in the present survey: *Euchrysops cnejus* (Fabricius, 1798), *Lampides boeticus* (Linnaeus, 1767), and *Rapala iarbus* (Fabricius, 1787). The lycaenid species found on *P. phaseoloides* are polyphagous and opportunistically use its seasonally available inflorescences as a larval food resource; all except *Rapala* are restricted to fabaceous hosts.[16, 17]

Table 1. Number of inflorescences of *Pueraria phaseoloides* with associated ants and lycaenid immatures.

Ant species present	*C. panormus* larvae	*J. celeno* larvae	*R. pheretima* larvae	lycaenid eggs	no lycaenid immatures
Dolichoderus thoracicus	3			9	195
Iridomyrmex anceps					2
Tapinoma indicum		9		4	17
Technomyrmex sp. 1		7		7	70
Technomyrmex sp. 2					17
Anoplolepis gracilipes		22		25	24
Camponotus (Myrmosericus) rufoglaucus				1	6
Camponotus (Tanaemyrmex) sp. 1		3		1	48
Oecophylla smaragdina			23	3	327
Crematogaster sp. 1				1	17
Crematogaster sp. 2					28
Meranoplus bicolor		1			1
Monomorium destructor					1
Pheidole capellinii		6		10	26
Tetramorium bicarinatum					20
no ants				10	268
totals	3	48	23	71	1067

Fig 2. Inflorescence of *P. phaseoloides* with *O. smaragdina* and larva of *R. pheretima*.

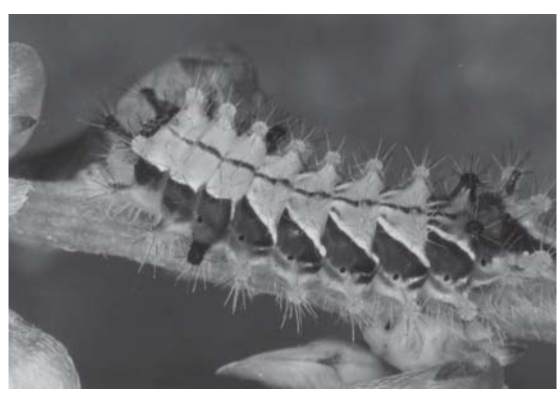

Fig 3. Larva of *R. pheretima*.

Fig 4. Larva of *C. panormus*.

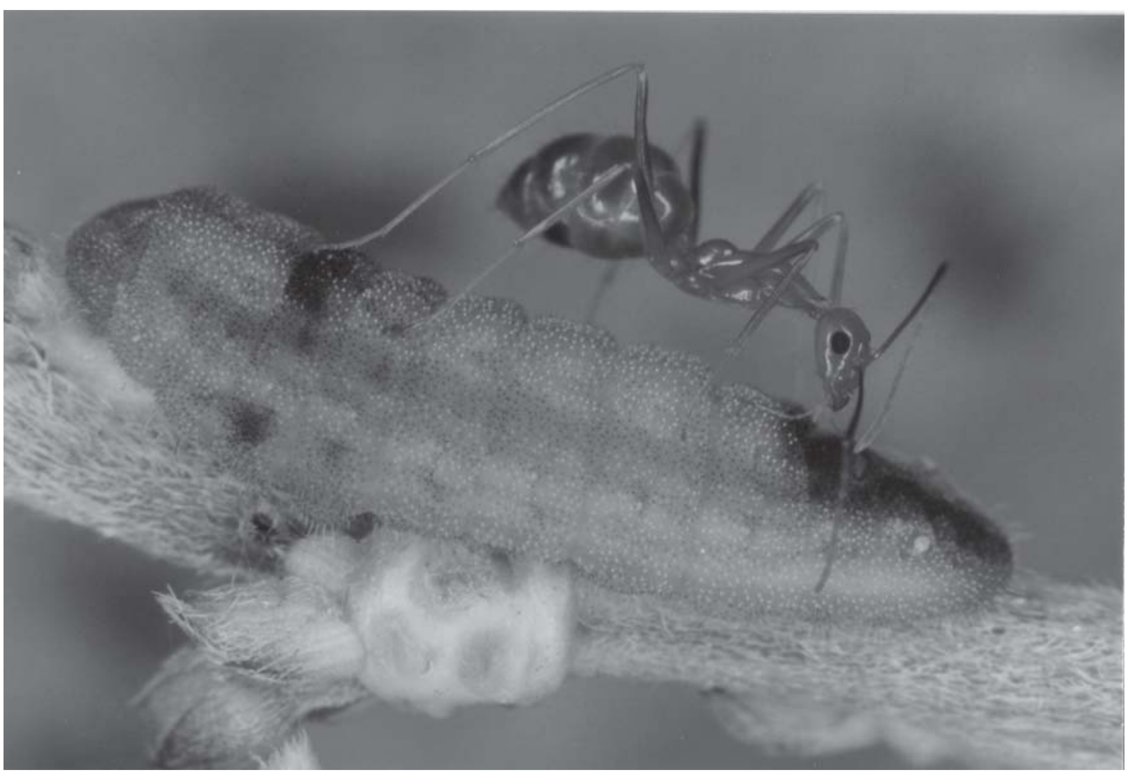

Fig 5. Larva of *J. celeno* with *A. gracilipes* in attendance.

Oecophylla smaragdina is one of the largest (6-7 mm long) and most aggressive ants found associated with *P. phaseoloides* and was present on 29.4 % of all inflorescences. Although workers of most other ant species quickly ran away or dropped to the ground when the inflorescences they occupied were inspected, those of *O. smaragdina* usually remained to attack the inspector. Only *R. pheretima* larvae (Figs 2, 3) were found in association with *O. smaragdina*.

Dolichoderus thoracicus (approximately 3.5 mm long) was the second most abundant ant species in terms of inflorescences occupied (17.2%). Although less aggressive than *O. smaragdina*, *D. thoracicus* also seemed to be more tenacious than most other ants in defending the inflorescences it occupied when they were disturbed. Only *C. panormus* larvae (Fig 4) were found in association with *D. thoracicus*.

Jamides celeno larvae were most abundant (approximately 65% of all larvae) and were found in association with six species of ants, which collectively occupied 23.4 % of all inflorescences. The distribution of *J. celeno* larvae among its associated ant species was not random (X^2=34.5; df=5; P<0.001). The strongest associations were with *Anoplolepis gracilipes* (Smith, 1857) (Fig 5) (X^2=138; df=1; P<0.001) and *Tapinoma indicum* Forel, 1895 (X^2=47.8; df=1; P<0.001), whose body lengths are approximately 5 and 1.5 mm, respectively. Association with *Pheidole capellinii* Emery, 1887 (length approximately 2 mm) was somewhat weaker (X^2=9.4; df=1; P<0.01), while associations with *Camponotus (Tanaemyrmex)* sp. 1, *Technomyrmex* sp. 1, and *M. bicolor* were not statistically significant (X^2=0.09, 3.3, and 0.97, respectively; df=1; P>0.05). Five ant species, *Crematogaster* sp. 2, *Iridomyrmex anceps* (Roger, 1863), *M. destructor*, *Technomyrmex* sp. 2, and *Tetramorium bicarinatum* (Nylander, 1846), which collectively occupied 5.6% of all inflorescences, were not associated with any lycaenid larvae. Single lycaenid eggs (but no larvae) were found on inflorescences occupied by two additional ant species, *C. rufoglaucus* and *Crematogaster* sp. 1. In addition, ten eggs were found on inflorescences not occupied by ants.

Discussion

The diversity of microclimatic situations, including variable insolation and proximity of patches of *P. phaseoloides* to secondary forest and rubber plantations supporting diverse understory vegetation, promoted the presence of a diverse ant fauna. Nevertheless, two species, *O. smaragdina* and *D. thoracicus*, collectively occupied 46.6% of all inflorescences (approximately 60% of all ant-occupied inflorescences). In contrast, 59 ant species in 31 genera were reported for a more comprehensive pit-fall trap survey over two years in rain forest at Ton Nga Chang Wildlife Sanctuary,[18] also in Songkhla Province. Five ant genera found in this survey (*Anoplolepis, Iridomyrmex, Melanoplus, Technomyrmex,* and *Tetramorium*) were not reported in the Ton Nga Chang survey. This difference may be due to the drier and more disturbed environment at Khao Khaw Hong, as well as to different survey methodologies. A more relevant comparison may be the 12 ant genera reported associated with *Saraca thaipingensis* (and various lycaenid larvae) in West Malaysia,[9] eight of which (*Crematogaster, Dolichoderus, Meranoplus, Oecophylla, Pheidole, Tapinoma, Technomyrmex,* and *Tetramorium*) were also found associated with *P. phaseoloides* at Khao Khaw Hong.

The distribution of lycaenid larvae on *P. phaseoloides* was apparently limited by the presence of those ant species with which they were associated and/or by the distribution of other ants with which they may be incompatible. The exclusive presence of *R. pheretima* larvae on inflorescences occupied by *O. smaragdina* may be explained by its reported obligate relationship with that ant species, which often kills larvae with which it does not form stable attendance relationships.[9] The occurrence of *C. panormus* larvae with *D. thoracicus* indicates the compatibility of those species, but not necessarily an obligate relationship. Too few *C. panormus* larvae were found to permit valid statistical analysis of their distribution with respect to the ant species. *Jamides celeno* is a facultative myrmecophile, as its larvae were found in association with six ant species. Nevertheless, its associations with *A. gracilipes* and *T. indicum* were significantly greater than with other species. The absence of *J. celeno* larvae in association with *D. thoracicus* is not likely due to chance (X^2=8.5; df=1; P< 0.01), indicating possible incompatibility of those species.

The observed relative abundances of lycaenid larvae cannot be attributed solely to the proportion of food resources occupied by their respective ant associates. Thus, larvae of *J. celeno* were about twice as numerous as those of *R. pheretima*, although ant associates of the former species occupied fewer inflorescences than did those of the latter. Because *J. celeno* is a facultative myrmecophile, the larval resources available to it may include all that are not occupied by incompatible ant species such as *O. smaragdina* (and perhaps *D. thoracicus*). In that case, the number of inflorescences available to *J. celeno* and *R. pheretima* would be more nearly proportional to the observed abundances of their larvae.

Other factors in the differential abundances of *J. celeno* and *R. pheretima* larvae may include differences in abundance, size, compatibility, and temperament of their respective ant associates. Such characteristics are likely to affect the relative capacities of ants to protect lycaenid eggs and larvae from various predators observed in the study area, which ranged in size from tiny egg parasitoids around ¼ mm long to hunting wasps exceeding 1 cm in length (Hymenoptera: Scelionidae, Trichogrammatidae, Sphecidae, and Vespidae).

The distribution of lycaenid eggs more-or-less mirrors the distribution of larvae with respect to ants, although one discrepancy from that pattern is notable. *Oecophylla smaragdina* occupied the greatest number of inflorescences and was associated with one third of all larvae, but only about 4% of all eggs. This may be attributed to the tendency of this ant to attack and drive off potential ovipositing female butterflies, especially of species whose larvae it does not tend, and of female *R. pheretima* to deposit their eggs at sites near, but not occupied by, *O. smaragdina* workers.[9]

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