PARASITOIDS OF *ASPHONDYLIA PONGAMIAE* (DIPTERA: CECIDOMYIIDAE), THE FLOWER GALL INDUCER OF *PONGAMIA PINNATA* AND THEIR ROLES IN BIOLOGICAL CONTROL

R Devaraj[1] & R Sundararaj[2]

[1]*Biosystematics Division, National Bureau of Agriculturally Important Insects, HA Farm Post, Bellary Road, Bangalore, India 560 024*
[2]*Wood Biodegradation Division, Institute of Wood Science and Technology, 18th Cross, Malleswaram, Bangalore, India 560 003; rsundariwst@gmail.com*

Received July 2012

DEVARAJ R & SUNDARARAJ R. 2014. Parasitoids of *Asphondylia pongamiae* (Diptera: Cecidomyiidae), the flower gall inducer of *Pongamia pinnata* and their roles in biological control. *Pongamia pinnata* is an important indigenous nitrogen fixing evergreen tree and is recognised as a viable source of oil for the growing biofuel industry. The source of its oil is mainly dependent on naturally growing trees and young plantations. Most of the naturally growing or planted *P. pinnata* trees suffer damage due to the flower gall inducer, *Asphondylia pongamiae*, as infestation directly affects the production of seeds. Detailed studies were conducted from 2007 till 2009 to identify the natural parasitoids of *A. pongamiae*. The study revealed the occurrence of four species of hymenopteran parasitoids, namely, *Eurytoma dentata*, *Megastigmus albizziae*, *Neanastatus proximus* and *Ormyrus kama*. The presence of all these parasitoids on *A. pongamiae* formed first records. Among these parasitoids maximum parasitisation was by *E. dendata* followed by *M. albizziae, N. proximus* and *O. kama*. Combined parasitisation, amounting to 37.56% in 2008–2009 and 44.54% in 2007–2008 was observed indicating that these parasitoids played significant role in keeping the population of *A. pongamiae* under control.

Keywords: *Eurytoma dentata, Megastigmus albizziae, Neanastatus proximus, Ormyrus kama*

INTRODUCTION

Natural enemies are important in the ecology and evolution of all organisms. Population dynamic studies of herbivore insects indicate natural enemies as regulating factors and irrespective of the impact on their hosts, whether true predators or parasitoids, they occur in large numbers of species. A lot of work has been done using natural biological forces and integrating them with pest management practices. For biocontrol of insects, there has been a shift in emphasis from the introduction of exotic parasites and predators to the recognition of the importance of naturally occurring biological control agents and this approach is gradually becoming one of the major topics in applied entomology (Weber & Lundgren 2009). *Pongamia pinnata* is an important nitrogen-fixing evergreen tree with multifarious uses. It is indigenous to the Indian subcontinent and South-East Asia and it has recently been recognised as a viable source of oil for the growing biofuel industry (Karmee & Chadha 2005). The source of its oil is mainly dependent on naturally growing trees and young plantations (Divakara & Das 2011). Most of the naturally growing and planted trees suffer damage at all times and usually in an epidemic form by various species of insects. Among the pests, gall inducers are economically important particularly the flower gall inducer *Asphondylia pongamiae*, as its infestation directly affects the production of seeds (Sundararaj et al. 2005) and often leads to no production of seeds (Devaraj & Sundararaj 2012). Many parasitoid species attacking gall midges have been identified, described, and listed (Hawkins 1988, de Graham 1994), and parasitoid communities parasitising on specific gall midges have also been studied (Ehler & Kinsey 1991, Skuhravý et al. 1993). However, so far no information is available on the natural enemy complex of *A. pongamiae*. Hence, detailed studies were undertaken to explore the natural parasitoids of *A. pongamiae* in Bangalore, Karnataka.

MATERIAL AND METHODS

Regular surveys for parasitism of *A. pongamiae* in *P. pinnata* plantations were carried out in 2007–2009 at three sites of 1 km^2 each, in and around Bangalore (12° 58' N, 77° 38' E, 1000 m above sea level), Karnataka. Soil type in the study area is red loam and acidic (pH 6.3 to 6.5). The annual mean maximum and minimum temperatures are 36.8 and 12.2 °C respectively with annual precipitation of 850 mm. Surveys were conducted at 10-day intervals in 2007–2008 and 2008–2009 covering all the three sites. At each sampling time, 10 galls each from 10 trees at each site were collected at random covering all directions (north, south, east, west and top) to obtain 100 flower galls. Sampling was conducted in triplicates. The collected three sets of 100 flower galls each were brought to the Entomology Laboratory of the Institute of Wood Science and Technology, Bangalore. The galls were kept separately in glass jars (10 cm × 15 cm) containing wet blotting paper at the bottom and covered with muslin cloth at room temperature and 65 ± 5% relative humidity. Adults of natural enemies that emerged from the galls in each glass jar were collected using an aspirator. The collected parasitoids were sorted by microscopic observation, counted and the monthly mean of nine observations (three observations at an interval of 10 days in a month with three replications) was computed. The parasitoids were preserved in 70% alcohol and taxonomic experts confirmed their identities. Data analysis including one-way ANOVA on the extent of parasitisation was performed using SigmaStat ® 3.1 statistical software.

RESULTS AND DISCUSSION

In Karnataka, *P. pinnata* comes into new flush of leaves from early February and flowering occurs once a year starting at the end of February to beginning of March and flowers until the middle of April. The life cycle of *A. pongamiae* is univoltine. It completes its larval and pupal period within the galls. Adults emerge from the galls and oviposit on buds coinciding with the budding and flowering of *P. pinnata*. Egg laying on buds induces gall induction and bud changes into flower gall. Our observations confirmed the presence of four species of hymenopteran parasitoids of *A. pongamiae*, namely, *Eurytoma dentata*, *Megastigmus albizziae*, *Neanastatus proximus* and *Ormyrus kama*. The presence of the four parasitoids on *A. pongamiae* is a first world record. The comparative parasitisation by different parasitoids in 2007–2008 and 2008–2009 is shown in Table 1. The highest level of of parasitisation was by *E. dentata* which ranged from 25.54% in 2007–2008 to 24.79% in 2008–2009. *Eurytoma dentata* emerged in two spells—first from June till November reaching peak in July and the second, from February till March (Figure 1). The present observation concurred with the findings of Sertkaya et al. (2006) who reported *E. dentata*, with parasitisation rates ranging from 3.50–65.30%, as the most common parasitoid of *Asphondylia capsici* which induced gall in pepper in Antakya, Turkey. Similarly *E. dentata* was reported to be the most effective parasitoid (extent of parasitisation was 88%) for gall midge *Asphondylia trabuti* which infested the leaves of *Sonchus* spp. in Italy (Rizzo & Massa 1998).

The level of parasitisation by *M. albizziae* in 2007–2008 and 2008–2009 ranged from 7.64 to 6.06% (Table 1). It emerged in one spell starting from June till November peaking in July (Figure 2). *Megastigmus albizziae* has been observed in the pods of *Albizzia odoratissima* (Mukerji 1950) and *M. cupressi,* in the seeds of *Cupress torulosa* (Mathur 1955). *Megastigmus viggianii* has been reported in bud galls of *Calycopterys floribunda* as

Table 1 Comparative parasitisation by different parasitoids during the periods 2007–2008 and 2008–2009

Parasitoid	Family	Parasitisation (%) (Mean ± SD)	
		2007–2008	2008–2009
Eurytoma dentata	Eurytomidae	25.54 ± 5.23	24.79 ± 3.95
Megastigmus albizziae	Torymidae	7.64 ± 4.98	6.06 ± 2.64
Neanastatus proximus	Eupelmidae	7.39 ± 4.05	5.67 ± 2.18
Ormyrus kama	Ormyridae	3.06 ± 1.17	2.57 ± 1.38
CD (p = 0.05%)		3.08	2.76

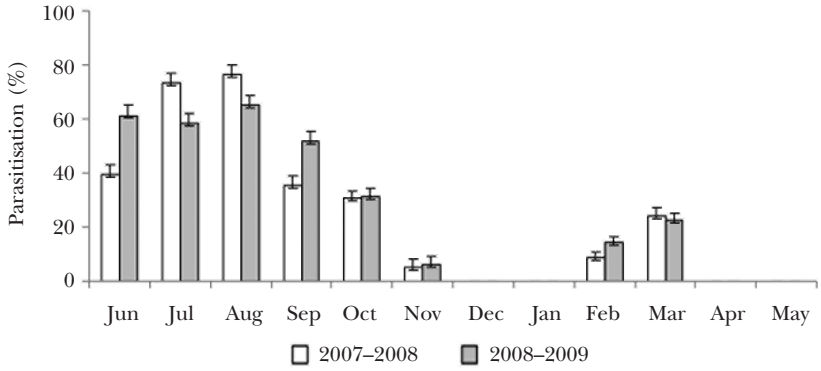

Figure 1 Parasitisation by *Eurytoma dendata* during the periods 2007–2008 and 2008–2009

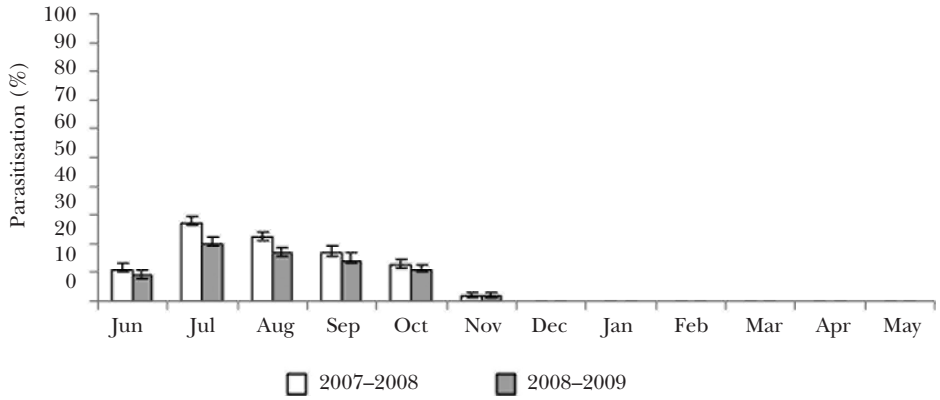

Figure 2 Parasitisation by *Megastigmus albizziae* during the periods 2007–2008 and 2008–2009

inquiline or parasites inside the galls (Narendran & Sureshan 1988). Hence, emergence of *M. albizziae* as inquiline or parasite needs further verification.

The level of parasitisation by *N. proximus* in 2007–2008 and 2008–2009 ranged from 7.39 to 5.67% (Table 1). Parasitasation occurred in two spells with the first from July till November reaching peak in August with no emergence from November to January (Figure 3). Parasitisation by *N. proximus* has been reported in Rajasthan and Delhi in India but its host is unknown (Narendran et al. 2006). The emergence of *N. proximus* on *A. pongamiae* confirmed the findings of Herting (1978) who reported Cecidomyiidae as primary hosts of *N. proximus*.

The extent of parasitisation by *O. kama* was the lowest ranging from 3.06% in 2007–2008 to 2.57% in 2008–2009 (Table 1). It occurred in one spell starting from July till October with peak emergence in August (Figure 4). Our findings concurred with reports by Boucek (1988) whereby ormyrids parasitised gall-forming Diptera and by Askew (1994) who reported Cecidomyiidae as hosts of *Ormyrus* species.

High levels of combined parasitisation, i.e. 37.56% in 2008–2009 and 44.54% in 2007–2008 was observed. Mortality due to parasitoids (and inquilines) in gall-making Cecidomyiidae is commonly high, about 50% or higher (Hawkins 1988). This might be attributed to the high level of infestation of flower gall on *P. pinnata* in Karnataka (Devaraj & Sundararaj 2012) as well as the trees were maintained without any agricultural inputs and free from any pesticidal applications (Mangala et al. 2012). When rearing galls, large numbers of parasites are obtained rather than the gall-makers themselves (Mani 1964). These natural enemies may exert important evolutionary pressure on gall-makers (Brown et al. 1995) and keep the infestation of *A. pongamiae* under control. In the present study, the periods of parasitoid emergence was from June till November and February till March with no emergence in December and January, the winter months. This confirms the fact that late

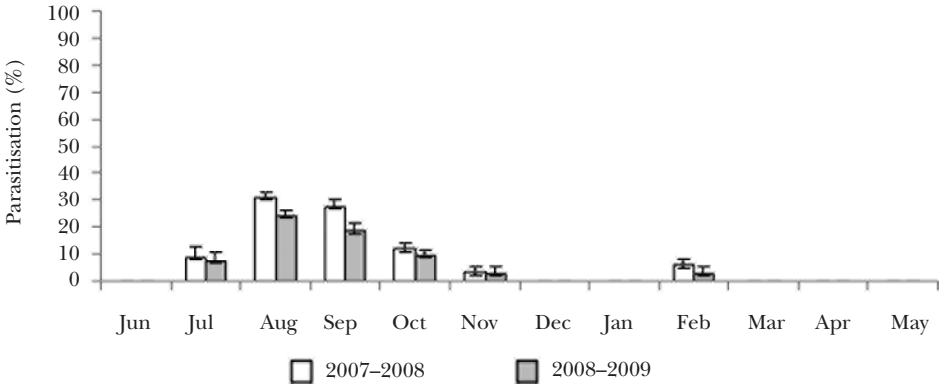

Figure 3 Parasitiaation by *Neanastatus proximus* during the periods 2007–2008 and 2008–2009

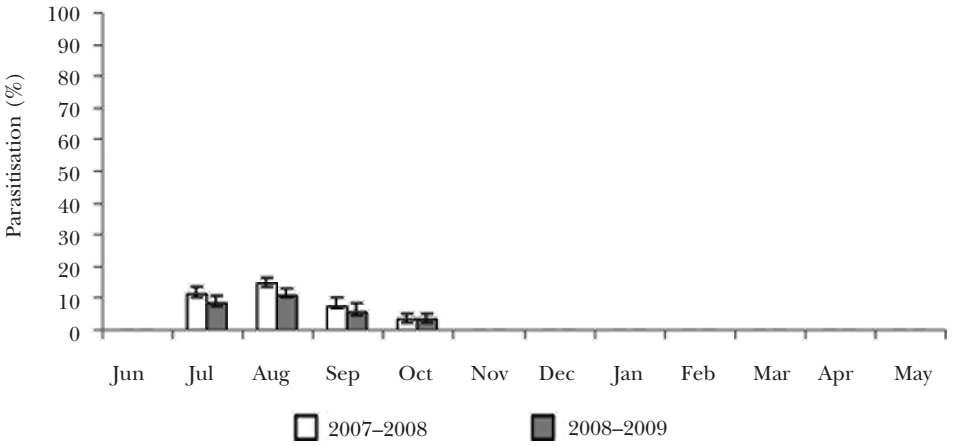

Figure 4 Parasitisation by *Ormyru kama* during the periods 2007–2008 and 2008–2009

parasitoids become less active during winter and this type of life history is common among many species inhabiting galls on evergreen trees (Ohno & Yukawa 1984, Yukawa & Ohsaki 1988).

The annual cycle of trees consists of dormant, quiescent and active periods (Fuchigami et al. 1982) and the quiescent period starts in winter (Hakkinen et al. 1998). Food resources determine herbivore development directly and indirectly by affecting the development of natural enemies (Havill & Raffa 2000). Nutritional status of the host tree *Rollinia laurifolia* induces dormancy in its gall inducers (Goncalves & Moreira 2009). High level of cumulative parasitisation of the natural parasitoids of *A. pongamiae* emphasised the need to have more truly integrated management approaches against *A. pongamiae* on *P. pinnata*. This will create opportunities for increased inclusion of biologically-based pest management strategies using the four parasitoids.

ACKNOWLEDGEMENTS

The authors are grateful to SC Joshi and OK Remadevi from the Institute of Wood Science and Technology, Bangalore for the facilities provided. Thanks are due to TC Narendran from the University of Calicut, Kerala and S Singh from the Forest Research Institute, Dehra Dun for identification of parasitoids. Funds provided by the Department of Science and Technology, Government of India for conducting this research work is also acknowledged.

REFERENCES

Askew RR. 1994. Two new European species of *Ormyrus* (Hymenoptera, Ormyridae). *Entomologist's Monthly Magazine* 130: 87–93.

Boucek Z. 1988. *Australasian Chalcidoidea, a Biosystematic Revision of Genera of Fourteen Families, With a Reclassification of Species*. CAB International, Wallingford.

Brown JM, Abrahamson WG, Packer RA & Way PA. 1995. The role of natural-enemy escape in a gallmaker host-plant shift. *Oecologia* 104: 52–60.

Devaraj R & Sundararaj R. 2012. Incidence of flower gall inducer *Asphondylia pongamiae* Mani (Diptera: Cecidomyiidae) on *Pongamia pinnata* (L.) Pierre. Pp 57–58 in Balu A et al. (eds) *Abstracts of the National Seminar on Forest Health Management (FHM-2012)*. 21–22 March 2012, Coimbatore.

Divakara BN & Das R. 2011. Variability and divergence in *Pongamia pinnata* for further use in tree improvement. *Journal of Forestry Research* 22: 193–200.

Ehler LE & Kinsey MG. 1991. Ecological recovery of a gall midge and its parasite guild following disturbance. *Environmental Entomology* 20: 1295–1300.

Fuchigami LH, Weiser CJ, Kobayashi K, Timmis R & Gusta LV. 1982. A degree growth stage (°GS) model and cold acclimation in temperate woody plants. Pp 93–116 in Li PH & Sakai A (eds) *Plant Cold Hardiness and Freezing Stress. Mechanisms and Crop Implications*. Volume 2. Academic Press, New York.

Goncalves SJM & Moreira GRP. 2009. A unique seasonal cycle in a leaf gall inducing insect, the formation of stem galls for dormancy. *Journal of Natural History* 43: 843–854.

de Graham MWR. 1994. New European species of *Torymus dalman* (Hym., Chalcidoidea). *Entomologist's Monthly Magazine* 130: 1556–1559.

Hakkinen R, Linkosalo T & Hari P. 1998. Effects of dormancy and environmental factors on timing of bud burst in *Betula pendula*. *Tree Physiology* 18: 707–712.

Havill NP & Raffa KF. 2000. Compound effect of induced plant responses on plant herbivores and parasitoids: implications for tritrophic interactions. *Ecological Entomology* 25: 171–179.

Hawkins BA. 1988. Do galls protect endophytic herbivores from parasitoids? A comparison of galling and non-galling Diptera. *Ecological Entomology* 13: 473–477.

Herting B. 1978. *Neuroptera, Diptera, Siphonaptera. A Catalogue of Parasites and Predators of Terrestrial Arthropods. Section A. Host or Prey/Enemy*. Commonwealth Institute of Biological Control, London.

Karmee SJ & Chadha A. 2005. Preparation of bio-diesel from crude oil of *Pongamia pinnata*. *Bioresource Technology* 96: 1425–1429.

Mangala N, Sundararaj R & Nagaveni HC. 2012. Scales and mealybugs (Coccoidea: Hemiptera) infesting *Pongamia pinnata* (L.) Pierre and their population dynamics in Karnataka, India. *Annals of Forestry* 20: 110–115.

Mani MS. 1964. *Ecology of Plant Galls*. Dr. W. Junk Publisher, The Hague.

Mathur RN. 1955. A new species of *Megastigmus dalman* (Hymenoptera: Chacidoidea) from seeds of *Cupressus torulosa* Don. *Proceedings of the Royal Entomological Society London* (B) 24: 91–93.

Mukerji S. 1950. On a new species of phytophagous Chalcidoidea *Megastigmus albizziae* sp. n. feeding on *Albizziae oratissima* pods in environs of Delhi. *Proceedings of the Royal Entomological Society London* (B) 19: 129–132.

Narendran TC & Sureshan PM. 1988. A contribution to knowledge of Torymidae of India (Hymenoptera: Chalcidoidea). *Bollettino del Laboratorio di Entomologia Agraria Filippo Silvestri* 45: 37–47.

Narendran TC, Santhosh S, Peter A, Sheeba M & Jilcy MC. 2006. A revision of *Neanastatus* Girault (Hymenoptera: Eupelmidae) of India with a key to Oriental species. *Hexapoda* 13: 1–15.

Ohno K & Yukawa J. 1984. Description of a new gall midge (Diptera: Cecidomyiidae) causing leaf galls on *Camellia japonica* L., with notes on its bionomics. *Kontyû* 53: 427–434.

Rizzo MC & Massa B. 1998. On two Italian gall midges (Diptera Cecidomyiidae) and their parasitoids. *Entomologica* 32: 121–131.

Sertkaya E, Telli S & Yigit A. 2006. Pest status and parasitoids of Gall midge, *Asphondylia capsici* Barnes (Diptera: Cecidomyiidae) in Antakya province. *Turkiye Entomoloji Dergisi* 30: 223–234. (In Turkish)

Skuhravý V, Skuhravá M & Brewer JW. 1993. The saddle gall midge *Haplodiplosis marginata* (Diptera: Cecidomyiidae) in Czech Republic and Slovak Republic from 1971–1989. *Acta Societatis Zoologica Bohemoslovaca* 57: 117–137.

Sundararaj R, Rajamuthukrishnan & Remadevi OK. 2005. Annotated list of insect pests of *Pongamia pinnata* (L.) Pierre in India. *Annals of Forestry* 13: 337–341.

Weber DC & Lundgren JG. 2009. Assessing the tropic ecology of the Coccinellidae: their role as predators and as prey. *Biological Control* 51: 199–214.

Yukawa J & Ohsaki N. 1988. Separation of the aucuba fruit midge, *Asphondylia aucubae* sp. *nov*. from the ampelopsis fruit midge, *Asphondylia baca* Monzen (Diptera: Cecidomyiidae). *Kontyû* 56: 365–376.