LITERATURE REVIEW OF PARASITOIDS OF FILTH FLIES IN THAILAND: A LIST OF SPECIES WITH BRIEF NOTES ON BIONOMICS OF COMMON SPECIES

Chamnarn Apiwathnasorn

Department of Medical Entomology, Faculty of Tropical Medicine, Mahidol University, Bangkok, Thailand

Abstract. We reviewed the literature for surveys of parasitoid of filth flies in Thailand. We found 5 families, with 9 genera and 14 species identified in Thailand. We describe the ecological niches and biology of common species, including *Spalangia cameroni*, *S. endius*, *S. nigroaenea* and *Pachycrepoideus vindemmiae*.

Keywords: pupal parasitoids, synanthropic flies, garbage dump, Thailand

INTRODUCTION

Human activities produce large quantities of organic waste suitable as breeding sites for calyptrate fly species. Synanthropic flies and their association with unsanitary conditions are important for public health reasons since they may be carriers of enteric pathogens (Greenberg, 1971; Olsen, 1998; Graczyk *et al,* 2001; Bernard, 2003, Banjo *et al,* 2005). During their lifecycle, flies are exposed to a wide range of natural enemies (Legner and Brydon, 1966; Morgan *et al*, 1981; Axtell, 1986). There are 23 hymenopterous parasitoids, insects that are parasitic only during immature stages and eventually kills their hosts (Jenkins, 1960). Pupal stages often represent less than 1% of the total eggs deposited by the previous generation of flies (Jenkins, 1960). Pupal parasitoids are among the most important and common natural enemies of filth flies associated with animals and humans (Rutz and Patterson, 1990). Parasitoids are of interest due to the emergence of pesticide resistance among fly populations and a growing demand by the public for more environmentally safe methods of control (Meyer *et al,* 1987; Scott *et al,* 1989; Cilek and Greene, 1994; Legner, 1995). Biological control includes release of natural enemies into the ecosystem to reduce fly populations to below annoyance levels. Thai hymenopterous parasitoids of filth flies have received little attention. They have been the subject of investigations since 1978. Information about their diversity, distribution, host ranges and extent in different habitats which fly populations are suppressed has yet to be determined for these natural parasitoids to be integrated into fly control programs. No attempt has yet been made to use them for fly control. Therefore, we reviewed the litterature surveyed filth fly parasitoids in Thailand and neighboring areas to better understand their niche characteristics in

Correspondence: Chamnarn Apiwathnasorn, Department of Medical Entomology, Faculty of Tropical Medicine, Mahidol University, 420/6 Ratchawithi Road, Bangkok 10400, Thailand.
Tel: 66 (0) 2306 9177; Fax: 66 (0) 2643 5582
E-mail: tmcaw@mahidol.ac.th

order to assist in identification, selection and the process of matching candidate parasitoid species with filth fly habitats.

MATERIALS AND METHODS

The information presented here was derived from four postgraduate dissertations at Mahidol University (Pichayakul, 1978; Apiwathnasorn, 1979; Pratchyanusorn, 1981; Samung, 2000) of parasitoid biology and diversity. The list of parasitoids was obtained from a 1-year survey of native parasitoids of filth flies breeding in municipal garbage dumping areas of 31 provinces of Thailand: Ang Thong, Bangkok, Chachoengsao, Chanthaburi, Chiang Mai, Chon Buri, Chumphon, Kalasin, Kanchanaburi, Khon Kaen, Lampang, Maha Sarakham, Nakhon Pathom, Nakhon Ratchasima, Nakhon Si Thammarat, Narathiwat, Nong Khai, Pattani, Phayao, Ratchaburi, Rayong, Roi Et, Sakon Nakhon, Samut Prakan, Saraburi, Si Sa Ket, Suphan Buri, Surin, Trat, Ubon Ratchathani and Udon Thani (Apiwathnasorn, 1979). The dumping areas each occupied an area of 1.0 hectare and were located at least 10 km from their respective city centers in scrublands, forests, fruit orchards along rivers or roadsides. Most garbage dumps consisted of refuse from households, and included fecal matters, organic residue and decomposed carcasses. Viable fly puparia were hand collected with forceps in 4 to 7 day old garbage heaps. Parasitism was observed in the laboratory at room temperature after the collected pupae were sorted and allowed to complete development of the parasitoids and identification of the fly species. The percent parasitism was calculated by dividing the total number of pupae that produced either a fly or a parasitoid by the total number of parasitoids that emerged from or died in the puparia. The emerged parasitoids were preserved in 70% ethyl alcohol for species determination based on the key of Boucek (1963) with subsequent species confirmation made by Dr Zdenek Boucek [Department of Entomology, the British Museum (Natural History), United Kingdom].

RESULTS

A total of approximately 16,000 pupal specimens of flies were obtained from municipal garbage dumps comprising representatives of only 2 fly species, *Musca domestica* (Linnaeus) and *Chrysomya megacephala* (Fabricius).

Fourteen parasitoid species of filth flies have been reported in Thailand. They occur in two orders: Coleoptera (1 species) and Hymenoptera (13 species) comprising 5 families: Chalcididae, Diapriidae, Encyrtidae, Pteromalidae and Scelionidae. *Spalangia endius* was the most widely distributed, found in 85.3% of collection sites, followed by *S. nigroaenea* (44.1%), *Pachyerepoideus vindemmiae* (23.5%), *Dirhinus crythocerus* (8.8%), *S. cameroni, S. gemina* and *Trichopria* sp (5.9%) and less than 3.0% for the rest. Several species were distinguished easily but some were rare and presented identification difficulties; for instance, specimens in the Family Diapriidae and Scelionidae could not be identified to the species level. A checklist of pupal parasitoids of filth-breeding flies in Thailand with their classification is compiled in Table 1.

It was remarkable that *S. endius* alone or a combination of *S. endius* and *S. nigroaenea* accounted for the majority of the observed parasitization at most localities. The only beetle, *Aleochara trivialis* was collected from *M. domestica* pupae at 3.0% of sites.

Table 1
List of pupal parasitoids of filth flies in Thailand.

Order Hymenoptera		
Family Chalcididae		
	Species	*Brachymeria minuta* (Linnaeus)
		Dirhinus crythrocerus Cameron
		Dirhinus excavatus Dalman
Family Diapriidae		
	Species	*Psilus* Panzer sp
		Trichopria Ashmead sp
Family Encyrtidae		
	Species	*Exoristobia philippinensis* Ashmead
Family Pteromalidae		
	Species	*Pachycrepoideus vindemmiae* (Rondani)
		Spalangia cameroni Perkins
		Spalangia endius Walker
		Spalangia gemina Boucek
		Spalangia nigroaenea Curtis
		Spalangia sp A (unidentifiable species)
Family Scelionidae		
	Species	*Teleas* Latreille sp
Order Coleoptera		
Family Staphylinidae		
	Species	*Aleochara trivialis* Kraatz

Table 2
Biological summary on common species of hymenopterous fly parasitoids.

Species	Life cycle (day)	Male: female	Percentage parasitization	Host	Reference
D. crythrocerus	22	1:2.0	80.0	*M. domestica*	Pratchyanusorn, 1981
P. vindemmiae	21	1:1.5	40.1	*M. domestica*	Samung, 2000
S. endius	20	1:4.3	42.5	*M. domestica*	Pichayakul, 1978

Table 2 summarizes the laboratory biology of some common hymenopterous parasitoids of Thailand. *S. endius* has the potential of being a biological control agent against field populations of *M. domestica*.The results demonstrate developmental period, parasitization rate and sex ratio are fundamental factors determining parasitoid potential as a control agent for synanthropic flies.

DISCUSSION

Rueda *et al* (1997) and Sulaiman *et al*

(1998) found the predominant species of flies at garbage dumps were *C. megacephala* and *M. domestica*. The parasitization rates varied widely from 0 to 55%. The extent to which fly populations are suppressed by indigenous parasitoids is difficult to determine (Simmonds, 1948), but the results from several studies indicate parasitoids play a significant role in suppression of house fly populations (Legner and Brydon, 1966; Legner and Greathead, 1969). Various field investigations have also shown parasitism rates vary in different fly breeding habitats (Petersen and Meyer, 1983; Rueda and Axtell, 1985a; Smith and Rutz, 1991a). Moisture and light levels can affect microhabitat choices made by species of parasitoids (Smith and Rutz, 1991b; Geden, 1999).

Although 14 species of pupal parastioids are reported in this paper, it can be expected that single-sample surveys may find undiscovered parasitoid species. *S. endius* and *S. nigroaenea* accounted for the majority of observed parasitization at most localities, possibly owing to the distribution of the parasitoids. *Muscidifurax* species has been reported to disperse and parasitize to distances of 8-100 m from the release point (Tobin and Pitts, 1999; Floate *et al*, 2000), but female *S. cameroni* rarely disperse more than 3 m (Skovgard, 2002).

Many species of *Aleochara* are natural enemies of dung-breeding flies, with adults that prey on fly eggs and maggots and larvae that parasitize the puparium (Fraenkel and Bhaskaran, 1973). They prefer fresh dung and generally parasitize more than one host species (Klimaszewski, 1984).

Based on field observations, most maggots pupated in clusters on the upper layer of garbage, which could be because the fermentation heat in the inner part of the garbage inhibited development of maggots (West, 1951). However, garbage dumps in Lampang and Phayao Provinces were treated by burning and the pupation sites were found at a depth of 6 cm below the ash soil surface. The parasitization rates were approximately 33% with 3 parasitoid species (*S. cameroni*, *S. endius*, *S. nigroaenea*) involved. This aggress with the observations by Legner (1977) and Rueda and Axtell (1985b) that these 3 species and *P. vindemiae* are more effective at locating buried pupal hosts at various depths of up to 10 cm.

Although *S. endius* and *S. nigroaenea* were found to co-exist on *M. domestica* throughout the collection sites, *S. endius* is usually most abundant in xerophilic habitats and *S. nigroaenea* is found principally in temperate humid habitats (Legner and Brydon, 1966). *B. minuta*, *D. crythrocerus*, *E. philippinensis*, *P. vindemmiae*, *S. endius* and *S. nigroaenea* were recovered from laboratory colonies of *C. megacephala*, *M. domestica* and *Parasarcophaga orchidae* maintained at the Department of Medical Entomology; *P. vindemmiae* was also found parasitizing the oothecae of cockroaches. *E. philippinensis* was found to infect the pupae of flesh flies, *Boettcherisca nathani* and *B. peregrina.* This observation needs further investigation to determine its potential as a biological agent for controlling synanthropic flies.

Gek-Huang and Kailok (1972) demonstrated under laboratory conditions *E. philippinensis* has several good qualities as a biological control agent for synanthropic flies, including short life cycle of two weeks, high fecundity, high female sex ratio (1:6.6) and non-host specificity. However, under field observations *E. philippinensis* had a relatively poor ability to reach the buried pupae in contrast to other *Spalangia* species.

Regarding the field application of a

pupal parasitoid to control filth fly populations, *Spalangia* is the most important genera for biological control of house and stable flies (Geden, 2006). *S. endius* was used in mass releases to suppress fly populations by Legner and Brydon (1966) and Morgan *et al* (1981). Sangeetha and Jebanesan (2010) demonstrated *S. cameroni* and *S. endius* were the most efficient parasitoids against *M. domestica* for biological control. More emphasis should be placed on biological study and use of the hymenopterous parasitoids for filth fly integrated control.

In conclusion, the present paper provides information about diversity and prevalence of naturally occurring parasitoids found parasitizing pupae of filth flies inhabiting garbage dumps. Three species were common in the collection sites; some species always parasitize laboratory colonies of flies. More species may be added to this list in the future if more extensive surveys are carried out. *S. endius* and *S. nigroaenea* are promising candidates for inundative biological control of filth flies in Thailand.

ACKNOWLEDGEMENTS

I wish to extend my sincere thanks to Dr Zdenek Boucek, Department of Entomology, The Natural History Museum, England, for his kind assistance in confirming the identification of hymenopterous parasitoids.

REFERENCES

Apiwathanasorn C. Surveys of hymenopterous parasitoids of medically important flies found breeding in garbage heaps in Thailand. Bangkok: Mahidol University, 1979. 100 pp. MS thesis.

Axtell RC. Fly management in poultry production: cultural, biological and chemical. *Poultry Sci* 1986; 65: 657-67.

Banjo AD, Lawal OA, Adeduji OO. Bacteria and fungi isolated from house fly (*Musca domestica* L.) larvae. *Afr J Biotechnol* 2005; 4: 780-4.

Bernard DR. Control of fly-borne diseases. *Pesticide Outlook* 2003; 14: 222-8.

Boucek Z. A study of *Spalangia* Latr. (Hymenoptera, Chalcidoidea). *Acta Entomol Mus Nat Pragae* 1963; 35: 429-512.

Cilek JE, Greene GL. Stable fly (Diptera: Muscidae) insecticide resistance in Kansas cattle feedlots. *J Econ Entomol* 1994; 87: 275-79.

Fraenkel G, Bhaskaran G. Pupariation and pupation in cyclorrhaphous flies (Diptera): terminology and interpretation. *Ann Entomol Soc Am* 1973; 66: 418-22.

Floate KD, Coghlin P, Gibson GAP. Dispersal of the filth fly parasitoid *Muscidifurax raptorellus* (Hymenoptera: Pteromalidae) following mass releases in cattle confinements. *Biol Control* 2000; 18:172-8.

Geden CJ. Host location by house fly parasitoids (Hymenoptera: Pteromalidae and Chalcididae) in poultry manure at different moisture levels and host densities. *Environ Entomol* 1999; 18: 755-60.

Geden CJ. Biological control of pests in livestock production. In: Hansen LS, Enkegaard A, Steenberg T, Ravnskov S, Larsen J, eds. Implementation of biocontrol in practice in temperate regions–present and near future. Flakkebjerg, Denmark: Proceedings of the International Workshop at Research Centre, 2006: 45-60.

Gek-Huang AS, Kailok C. *Exoristobia philippinensis* Ashmead (Hymenoptera: Encyrtidae) as a biological agent for the control of synanthropic flies. Singapore: The Southeast Asian Ministers of Education Organization, Tropical Medicine and Public Health (SEAMEO TROPMED), Vector Control Workshop, 1972: 8 pp.

Greenberg B. Flies and disease. Vol 1. Ecology, classification and biotic associations. New Jersey: Princeton University Press, 1971: 896 pp.

Graczyk TK, Knight R, Gilman RH, Cranfield MR. The role of non-biting flies in the epidemiology of human infection diseases. *Microbes Infect* 2001; 3: 231-35.

Jenkins DW. Pathogens, parasites and predators of medically important insects. In: Jenkins DW, ed. Conference on Biological Control of Insects of Medical Importance. Reston, VA: American Institute of Biological Sciences Publication. *Am Inst Biol Sci Techn Ser* 1960: 6-20.

Klimaszewski J. A revision of the genus Aleochara Gravenhorst of America north of Mexico (Coleoptera: Staphylinidae, Aleocharinae). *Mem Entomol Soc Can* 1984; 129: 1-211.

Legner EF. Temperature, humidity and depth of habitat influencing host destruction and fecundity of muscoid fly parasites. *Entomophaga* 1977; 22: 199-206.

Legner EF. Biological control of Diptera of medical and veterinary importance. *Vector Ecol* 1995; 20: 59-120.

Legner EF, Brydon HW. Suppression of dung inhabiting fly populations by pupal parasites. *Ann Entomol Soc Am* 1966; 59: 638-51.

Legner EF, Greathead DJ. Parasitism of pupae in East African populations of *Musca domestica* and *Stomoxys calcitrans. Ann Entomol Soc Am* 1969; 62: 128-33.

Meyer JA, Georghiou GP, Hawley MK. House fly (Diptera: Muscidae) resistance to permethrin on southern California dairies. *J Econ Entomol* 1987; 80: 636-40.

Morgan PB, Weidhaas DE, Patterson RS. Programmed releases of *Spalangia endius* and *Muscidifurax raptor* (Hymenoptera: Pteromalidae) against estimated populations of *Musca domestica* (Diptera: Muscidae). *J Med Entomol* 1981; 18: 158-66.

Olsen AR. Regulatory action criteria for filth and other extraneous materials. III. Review of flies and food-borne enteric disease. *Reg Toxicol Pharmacol* 1998; 28: 199-211.

Petersen JJ, Meyer JA. Host preference and seasonal distribution of pteromlalid parasites (Hymenoptera: Pteromalidae) of stable flies and house flies (Diptera: Muscidae) associated with confined livestock in eastern Nebraska. *Environ Entomol* 1983; 12: 567-71.

Pichayakul V. *Spalangia endius* Walker, a hymenopterous parasite, as a biological agent for the control of medical important flies. Bangkok: Mahidol University, 1978. 98 pp. MS thesis.

Pratchyanusorn N. Insecticide susceptibility of the Hymenopteran parasitoid and its significance in fly control. Bangkok: Mahidol University, 1981. 93 pp. MS thesis.

Rueda LM, Axtell RC. Comparison of hymenopterous parasites of house fly, *Musca domestica* (Diptera: Muscidae), pupae in different livestock and poultry production systems. *Environ Entomol* 1985a; 14: 217-22.

Rueda LM, Axtell RC. Effect of depth of house fly pupae in poultry manure on parasitism by six species of Pteromalidae (Hymenoptera). *J Entomol Sci* 1985b; 20: 444-9.

Rueda LM, Roh PU, Ryu JL. Pupal parasitoids (Hymenoptera: Pteromalidae) of filth flies (Diptera: Muscidae, Calliphoridae) breeding in refuse and poultry and livestock manure in South Korea. *J Med Entomol* 1997; 34: 82-5.

Rutz DA, Patterson RS. Biocontrol of arthropods affecting livestock and poultry. Boulder, CO: Westview Press, 1990: 316 pp.

Sangeetha P, Jebanesan A. Life table and host-destruction parameters of *Spalangia cameroni* Perkins and *Spalangia endi*us Walker at different temperatures. *Int J Rec Sci Res* 2010; 6: 146-8.

Samung Y. A biological study of *Pachycrepoideus vindemmiae* (Rondani). A hymenopterous parasitoid of medical importance. Bangkok: Mahidol University, 2000. 127 pp. MS thesis.

Scott JC, Roush RT, Rutz DA. Insecticide resistance of house flies from New York dairies (Diptera: Muscidae). *J Agric Entomol* 1989; 6: 53-64.

Simmonds FJ. Some difficulties in determining by means of field samples the true value of parasite control. *Bull Entomol Res* 1948; 39: 435-40.

Skovgard H. Dispersal of the filth fly parasitoid *Spalangia cameroni* (Hymenoptera: Pteromalidae) in a swine facility using fluorescent dust marking and sentinel pupal bags. *Environ Entomol* 2002; 31: 425-31.

Smith L, Rutz DA. Microhabitat associations of hymenopterous parasitoids that attack house fly pupae at dairy farms in Central New York. *Environ Entomol* 1991a; 20: 675-84.

Smith L, Rutz DA. The influence of light and moisture gradients on the attack rate of parasitoids foraging for hosts in a laboratory arena. *J Insect Behav* 1991b; 4: 195-208.

Sulaiman S, Pawanchee ZA, Jusoh AM, Lim YH, Jeffery J. Trapping synanthropic flies with Neopeace® adhesive at a garbage dumping ground in Malaysia. *Med Entomol Zool* 1998; 49: 223-5.

Tobin PC, Pitts CW. Dispersal of *Muscidifurax raptorellus* Kogan and Legner (Hymenoptera: Pteromalidae) in a high-rise poultry facility. *Biol Control* 1999; 16: 68-72.

West LS. The housefly. Its natural history, medical importance, and control. Ithaca, NY: Comstock Publishing Company, 1951: 584 pp.