

SURVEY OF FORENSICALLY IMPORTANT FLY SPECIES IN NORTHERN THAILAND

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Abstract. There are few studies of forensically important fly species in multiple habitats from northern Thailand. We report here a survey of fly species from three provinces of northern Thailand: Nan, Phitsanulok and Chiang Mai. We conducted sweep net collections at 9 locations in the studied provinces. We collected a total of 862 specimens, comprised of 52 species and 3 families (Calliphoridae, Sarcophagidae and Muscidae). Of the specimens collected, 82.6% were blow flies, 16.1% were flesh flies and 1.3% were muscids. The collected blow flies were comprised of 11 genera: *Bengalia*, *Catapicephala*, *Borbororhinia*, *Chrysomya*, *Cosmina*, *Hemipyrellia*, *Hypopygiopsis*, *Idiella*, *Isomyia*, *Lucilia* and *Stomorhina*. The flesh flies were comprised of 9 genera: *Boettcherisca*, *Fengia*, *Lioproctia*, *Miltogramma*, *Myorhina*, *Parasarcophaga*, *Seniorwhitea*, *Sarcorohdendorfia* and *Sarcosolomonina*. The muscid flies were comprised of 3 genera: *Hydrotaea*, *Musca* and *Neomyia*. The survey provides data regarding fly species of potential forensic importance in northern Thailand.

Keywords: survey, fly, forensic entomology, Thailand

INTRODUCTION

Blow flies (Diptera: Calliphoridae), flesh flies (Diptera: Sarcophagidae), and muscids (Diptera: Muscidae) are commonly collected as evidence in forensic entomology investigations worldwide.

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Some of these are found associated with human corpses and/or death scenes. They can be valuable for estimating time of colonization (Tomberlin *et al*, 2011) to calculate the minimum postmortem interval (PMI_{min}) (Anderson, 1997), cause of death (Magni *et al*, 2016) and possible corpse relocation (Picard and Wells, 2012). Blow flies, *Chrysomya megacephala* (Fabricius) and *Chrysomya rufifacies* (Macquart) are the most common flies associated with human remains in Thailand (Sukontason *et al*, 2007). Previous studies reported

the flies associated with human remains include blow flies (*Chrysomya villeneuvei* Patton, *Chrysomya pinguis* (Walker), *Chrysomya bezziana* (Villeneuve), *Chrysomya nigripes* Aubertin, *Lucilia cuprina* (Wiedemann), *Lucilia porphyrina* (Walker), flesh flies (*Liopygia ruficornis*) (Fabricius) and muscids (*Hydrotaea spinigera*) (Stein) (Sukontason *et al*, 2007; Monum *et al*, 2017). A study of carrion flies associated with broiler carcasses in Nakhon Sawan Province, central Thailand, found these flies within these three families comprised 93.4% of insects collected (Moophayak *et al*, 2017). However, it is important to know the distribution of fly species.

Thailand has a variety of ecosystems that include flies. A survey of fly species of forensic importance from Chiang Mai Province, northern Thailand during 2000 found *C. megacephala* was the most common species, followed by *C. rufifacies* (Sukontason *et al*, 2003). A survey of fly species from Chiang Mai and Lampang Provinces during 2007-2008 found 6 genera and 14 species of blow flies; *C. megacephala* was the most common species, followed by *C. pinguis*, *L. porphyrina*, *C. rufifacies* and *Chrysomya chani* Kurahashi. Fly species found more commonly in highland areas were *C. pinguis*, *Chrysomya thanomthini* Kurahashi & Tumrasvin, *Hypopygiopsis tumrasvini* Kurahashi, *Lucilia papuensis* (Macquart) and *L. porphyrina* (Moophayak *et al*, 2014).

Forested areas are important sources of forensically important flies (Moophayak *et al*, 2014). Most forensic cases involving decomposing human remains in this region occur in forested areas (Sukontason *et al*, 2007). Without knowledge of what species occur in these areas it is difficult to make accurate forensic entomology determinations; therefore, we aimed to conduct this study to determine what fly

species are in these areas.

MATERIALS AND METHODS

Sampling site

This study was conducted in three provinces in northern Thailand: Nan, Phitsanulok and Chiang Mai (Fig 1). In these provinces, various environments were chosen to sample: urban, suburban, forested areas, paddy fields, farms, waterfalls and highland areas (Table 1). Four sites were sampled in Nan Province (Jao Dam, Ban Nalare, Ban Don Sathan and Mushroom Farm), four in Phitsanulok Province (Kaokrayang Forest, rest area, Huay Nam Fong and Suanpa Waterfall) and one site in Chiang Mai Province (Mueang District).

Collection and identification of flies

Adult flies were sampled at each site using a sweep net at different times of the day between 0900 and 1500 hr to collect flies attracted to one-day-old tainted beef offal (300 g placed on a plastic plate), which was placed on the ground. After collection, the flies were killed in a plastic test tube containing ethyl acetate and then transferred to plastic test tubes labelled to include collection site and date. The specimens were then identified and sexed at the Department of Parasitology, Faculty of Medicine, Chiang Mai University, using a dissecting microscope (Olympus, Tokyo, Japan) and the key of Kurahashi and Bunchu (2011) for blow flies, Kurahashi and Chaiwong (2013) for flesh flies and Tumrasvin and Shinonaga (1977, 1978, 1982) for muscids.

RESULTS

A total of 826 flies (328 males and 498 females) were collected from the 9 collection locations (Table 1). Fifty-two

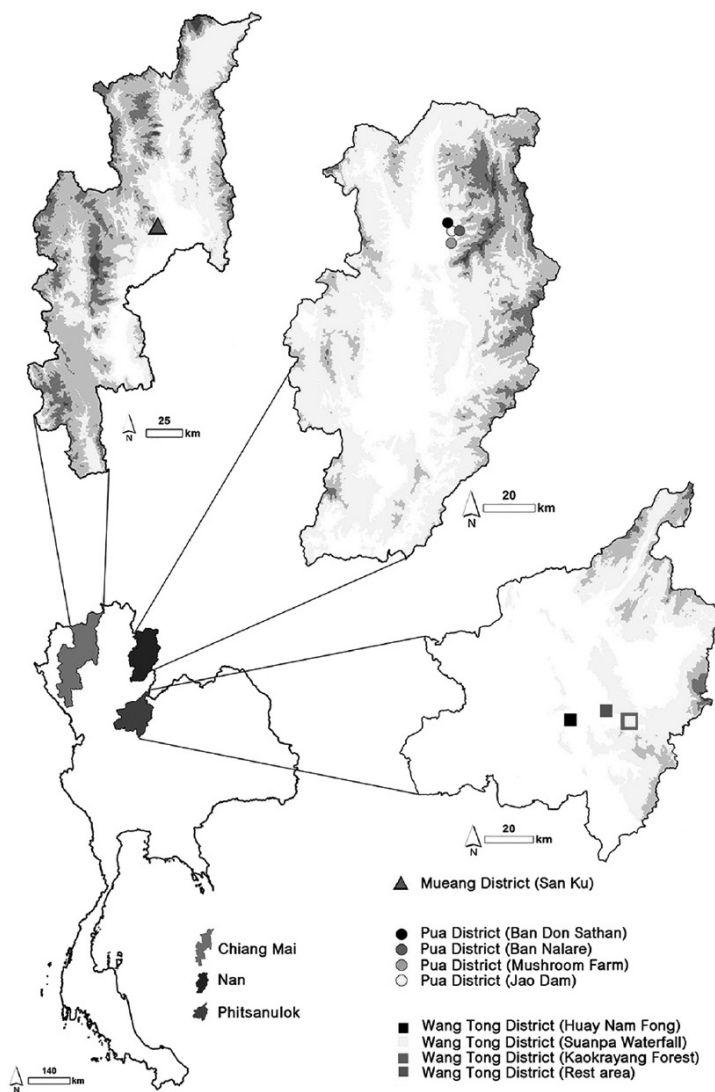


Fig 1–Map of study sites in northern Thailand.

species from three families (Calliphoridae, Sarcophagidae and Muscidae) were identified. Blow flies comprised 82.6% of collected specimens, followed by flesh flies (16.1%) and muscids (1.3%) (Fig 2). The collected blow flies consisted of 27 species from 11 genera: *Bengalia*, *Catopicephala*, *Borbororhinia*, *Chrysomya*, *Cosmina*, *Hemipyrellia*, *Hypopygiopsis*, *Idiella*,

Isomyia, *Lucilia* and *Stomorhina* (Table 2). The 3 genera of muscid flies identified were: *Hydrotaea*, *Musca* and *Neomyia*. The 9 genera of flesh flies identified were: *Boettcherisca*, *Fengia*, *Lioproctia*, *Miltogramma*, *Myorhina*, *Parasarcophaga*, *Seniorwhitea*, *Sarcorhdendorfia* and *Sarcosolomonina* (Table 3). *Bengalia pseudovaricolor* Kurahashi & Tumrasvin was collected only at a high

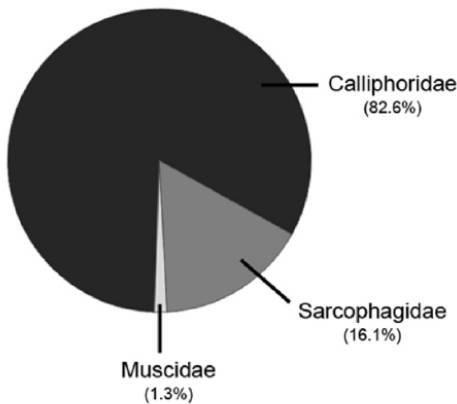


Fig 2–Proportions of three studied fly families.

altitude on Doi Suthep–Pui Mountain with an elevation of 1,595 m.

DISCUSSION

It is important to have an accurate database of fly species to use for forensic entomology. Our findings show a variety species of flies in the study areas. Blow flies were the most commonly observed species, followed by flesh flies and muscids. The most common species in our study, *C. megacephala*, was found in most habitats sampled. These results are consistent with previous studies from Chiang Mai (Ngoen-klan *et al*, 2011; Moophayak *et al*, 2014, Klong-klaew *et al*, 2017). Klong-klaew *et al* (2017) found *C. megacephala* and *C. rufifacies* were the two most common species found throughout the year, collected using a semi-automatic funnel trap. Both these species were found in large numbers across a variety ecological habitats in our study.

C. megacephala, while found in all habitats, occurred more commonly at lower elevations. *C. rufifacies* was not found at higher elevations. However, *C. pinguis*, *L. porphyrina*, and *L. papuensis* were more

Table 1
Description of study sites in northern Thailand.

Province	Study sites	Altitude ^a	Latitude	Longitude	Habitat description
Nan	Jao Dam	309	19°10'45.78" N	100°57'32.64" E	Rural area, small river, small bushes
	Ban Nalare	417	19°10'47.16" N	100°59'13.68" E	Mountainous
	Ban Don Sathan	260	19°12'29.28" N	100°56'39.54" E	Rice fields, river banks
	Mushroom Farm	369	19°8'12.54" N	100°57'23.34" E	Mountainous, hilly, rice field, mushroom farm, few houses
Phitsanulok	Kaokrayang Forest	179	16°50'46.74" N	100°44'52.08" E	Forest fringes
	Rest area	150	16°53'10.32" N	100°39'26.34" E	Roadside, semi-urban, bush and forest
	Huay Nam Fong	122	16°51'8.4" N	100°31'4.92" E	Mixed deciduous forest
Chiang Mai	Suanpa Waterfall	195	16°50'42.84" N	100°44'59.28" E	Forest, nearby waterfall
	Suthep-Pui Mountain	1,595	18°48'56" N	98°53'40" E	Mountainous, highland, intensive mixed deciduous forest

^aMeters above sea level.

Table 2
Blow fly species collected by study site in northern Thailand.

	Jao Dam				Nan				Phitsanulok				Chiang Mai			
	Ban Nalare		Ban Don Sathan		Mushroom Farm		Kaokrayang Forest		Rest area		Huay Nam Fong		Suanpa Waterfall		Mueang District	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
<i>Bengalia pseudovaricolor</i>															1	3
<i>Catantopcephala sinica</i>	2	1	1	1			1									
<i>Borbororhinia laojanae</i>																1
<i>Chrysomya chani</i>																
<i>Chrysomya megacephala</i>	4	49	6	14	2	12	6	22	6	18	3	15			1	2
<i>Chrysomya pinguis</i>			2	2			1								1	32
<i>Chrysomya ruffifacies</i>		5		3	5	3	7	49	5	5	1	8				
<i>Chrysomya villeneuvi</i>	2	5	6				2	4							1	3
<i>Chrysomya nigripes</i>			1	2		2		1								
<i>Cosminia bicolor</i>								1		1						
<i>Cosmina limbipennis</i>								1								
<i>Cosmina vanidae</i>								1								
<i>Hemipyrellia ligurriens</i>	22	10	11	2	7	5	10	7	7	5						
<i>Hemipyrellia pulchra</i>								5			2					
<i>Hypopygiopsis infumata</i>	3	2	12	12			3	1								
<i>Hypopygiopsis tumrasoini</i>			1	1												1
<i>Idiella ditosa</i>																1
<i>Idiella euidetioides</i>																2
<i>Isonomyia hetauda</i>																1
<i>Isonomyia viridaurea</i>																1
<i>Lucilia cuprina</i>																1
<i>Lucilia papuensis</i>	1	2		1	5		1	1	7	2	1				1	11
<i>Lucilia porphyrina</i>				4												25
<i>Lucilia sinensis</i>			8													
<i>Stomorphina discolor</i>				1				1	2	1	1					
<i>Stomorphina proclular</i>								4								
<i>Stomorphina siamensis</i>								1								2

M, male; F, female.

Table 3
Flesh fly and muscid species collected by study site in northern Thailand.

	Jao Dam				Nan				Phitsanulok				Chiang Mai			
	Ban Nalare		Ban Don Sathan		Mushroom Farm		Kaokrayang Forest		Rest area		Huay Nam Fong		Suanpa Waterfall		Mueang District	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
<i>Sarcophagidae</i>																
<i>Boettcherisca nathani</i>	1		1		6		1									1
<i>Boettcherisca peregrina</i>	2	3														
<i>Fengia ostindicae</i>			5													
<i>Lioproctia pattoni</i>	1	1	1		6		1	2		2						
<i>Miltogramma angustifrons</i>							1									
<i>Myorhina caudagali</i>						1										
<i>Parasarcophaga albiceps</i>	4		5		4											
<i>Parasarcophaga brevicornis</i>	6				1				1	1				1		
<i>Parasarcophaga dix</i>									2							
<i>Parasarcophaga taenionota</i>									2							
<i>Parasarcophaga idmais</i>									2					1		
<i>Parasarcophaga albiceps</i>																1
<i>Parasarcophaga scopariiformis</i>																
<i>Seniorulitea princeps</i>	2				1				4	1						
<i>Sarcrohendendorfia antilope</i>	1	4			3											1
<i>Sarcrohendendorfia inextricata</i>	1	1			2				3	3						
<i>Sarcrohendendorfia montana</i>									1							
<i>Sarcosolomonita rohdendorfi</i>	2	1							5	8						
<i>Sarcosolomonita seniorulitei</i>	1	4	4	1	1											
<i>Sarcosolomonita crinita</i>																
<i>Muscidae</i>																
<i>Hydrotaea chalcogaster</i>																
<i>Hydrotaea spinigera</i>									1							
<i>Musca domestica</i>									1	1						
<i>Neomyia claripennis</i>	3	1														1
<i>Neomyia gravis</i>																1

M, male; F, female.

abundant at higher elevations, as reported previously (Moophayak *et al*, 2014).

Several blow fly species found in this study have been found to be forensically important in other locations. *Chrysomya megacephala* and *C. rufifacies* were reported to be found from human remains in Thailand (Sukontason *et al*, 2007) and Malaysia (Syamsa *et al*, 2010; Kavitha *et al*, 2012; Kumara *et al*, 2012; Kavitha *et al*, 2013a; *ibid*, 2013b; Syamsa *et al*, 2017). In Brazil, *C. megacephala* has been found on cadavers (Oliveira and Vasconcelos, 2010). *C. megacephala*, *C. rufifacies* and other *Chrysomya* species have been found on human remains, including *C. villeneuvei*, *C. pinguis* (Kumara *et al*, 2012; Kavitha *et al*, 2013a; Monum *et al*, 2017), *C. chani* (Wang *et al*, 2017; Sukontason *et al*, 2018) and *C. nigripes* (Sukontason *et al*, 2006; Kavitha *et al*, 2013a; Syamsa *et al*, 2017; Wang *et al*, 2017). Further studies are needed to determine the developmental rate of these forensically important species, since blow flies are the most common flies found on human cadavers (Wang *et al*, 2017).

Blow fly species, tribe Luciliini, are forensically important, such as *L. cuprina* (Sukontason *et al*, 2007; Syamsa *et al*, 2010; *ibid*, 2017), *L. porphyrina* (Monum *et al*, 2017), *Hemipyrellia ligurriens* (Wiedemann) (Sukontason *et al*, 2007; Kumara *et al*, 2012; Wang *et al*, 2017) and *Hemipyrellia tagaliana* (Bigot) (Kumara *et al*, 2012). In Shenzhen China, *Lucilia bazini* (Seguy) and *Lucilia sericata* (Meigen) (Wang *et al*, 2017) have also been found on human remains.

Waterfalls are also preferred by some flies. In our study, rare blow fly species [*Borbororhinia laojanae* Kurahashi & Tumorasvin and *Idiella divisa* (Walker)], and flesh flies (*Parasarcophaga brevicornis* (Ho) and *Seniorwhitea princeps* (Wiedemann)) were collected from Suanpa Waterfalls, of

Phitsanulok Province. It is possible these species require a specific environment.

Some flesh fly species have forensic importance, such as *Microcerella halli* (Engel), which has been used to estimate the PMI_{min} in a human corpse in southern Brazil (Vairo *et al*, 2017). Other species confirmed to be forensically important found on human cadavers include *L. ruficornis* in Thailand (Sukontason *et al*, 2007) and Malaysia (Kumara *et al*, 2012), *S. princeps* in Malaysia (Kumara *et al*, 2012), *Sarcophaga (Liosarcophaga) dux* Thomson and *Sarcophaga peregrina* (Robineau-Desvoidy) in Malaysia (Raja and Muhammad, 2016), *S. peregrina* in China (Wang *et al*, 2017), *Parasarcophaga crassipalpis* Macquart in China (Wang *et al*, 2017), *Sarcophaga argyrostoma* (Robineau-Desvoidy) in Iran (Talebzadeh *et al*, 2017), *Lipoptilocnema delfinado* Mulieri & Mello-Patiu in Argentina (Mulieri *et al*, 2017), *Sarcophaga africa* Wiedemann, *S. argyrostoma*, *Sarcophaga caerulescens* Zetterstedt, *Sarcophaga similis* Meade and *S. dux* in Switzerland (Cherix *et al*, 2012), *Peckia (Peckia) chrysostoma* (Wiedemann) in Brazil (Vasconcelos *et al*, 2014) and *Sarcophaga haemorrhoidalis* (Fallen) in Mexico (Solís-Esquível *et al*, 2016). Several flesh fly species have been collected from domestic pig carcasses, such as *Helicobia pilifera* Lopes, *Microcerella erythropyyga* (Lopes), *Oxysarcodexia fringidea* Curran & Walley and *Peckia (Peckia) pexata* (Wulp) in Brazil (Dias *et al*, 2015), *Peckia (Patonella) intermutans* (Walker) in Brazil (Faria *et al*, 2013), *S. caerulescens* and *S. similis* in central Europe (Szpila *et al*, 2015). Further, developmental studies of flesh flies need to be conducted, similar to those reported from Brazil (Vairo *et al*, 2017).

Compared to blow flies and flesh flies, muscids are used less often for forensic entomology. Muscids have been occasionally

reported associated with human remains (Bonacci *et al*, 2017; Wang *et al*, 2018). Previous studies of muscids associated with death scenes reveal *H. spinigera* has been found to be associated with human corpses in Thailand (Sukontason *et al*, 2007), Malaysia (Syamsa *et al*, 2017) and China (Wang *et al*, 2017); *Synthesiomya nudiseta* (Wulp) has been found to be associated with human corpses in Malaysia (Syamsa *et al*, 2017) and *Fannia canicularis* (Linnaeus) in an elderly neglect case in Italy (Bonacci *et al*, 2017). *Musca domestica* Linnaeus was found in low numbers in our survey. However, this may still play an important role in forensic investigation since females can oviposit their eggs on freshly dead pigs, thus have the potential to be used to determine the PMI_{min} (Chin *et al*, 2008). In Malaysia, Chin *et al* (2008) found *M. domestica* oviposited on a pig carcass 2 hours after death. Chen *et al* (2010) found third instar *M. domestica* and *H. spinigera* on a monkey carcass (*Macaca fascicularis*) in the dry stage of decomposition. Immature and adult *M. domestica* was found on a raccoon carcass (*Procyon lotor* L.) placed in a salt marsh habitat in southeastern Florida, USA (Richards *et al*, 2015). In urban Riyadh, Saudi Arabia, *M. domestica* was the most abundant species found on rabbit carcasses (Mashaly and Al-Mekhlafi, 2016). In Xinxiang, China, *M. domestica* was one of the main species found on rat and rabbit carcasses (Hongyan *et al*, 2017). Human cases involving *M. domestica* are being reported with increasing frequency in the literature. The larvae of *M. domestica* were collected from human corpses in Mexico (Solís-Esquivel *et al*, 2016) and China (Wang *et al*, 2017). Wang *et al* (2018) reported a case of *M. domestica* used to estimate the PMI_{min} in China. *Musca domestica* may be an indicator of an anthropic environment (Faria *et al*, 2013).

Such information supports the increasing forensic importance of muscids.

In our study we found many fly species of forensic importance. However, we only investigated flies with potential forensic importance in a variety of habitats. Further studies are needed to clarify exact habitats of the various fly species of forensic importance.

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