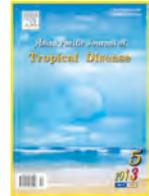




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## Stomoxyni fly fauna of the Khao Yai National Park, Thailand

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## PEER REVIEW

## Peer reviewer

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## Comments

To my point of view, this manuscript deserves to be published. It will be important for all scientists working on Diptera, but also to epidemiologists working on vector transmitted diseases.

Details on Page 351

## ABSTRACT

**Objective:** To determine species diversity, relative population abundance and diurnal activity of the Stomoxyni flies at the Khao Yai National Park.

**Methods:** Stomoxyni flies were collected bimonthly from February to June, 2012, using Vavoua traps. Species were identified based on morphological characteristics.

**Results:** A total of 712 individuals of 3 genera and 6 species were captured including *Stomoxys calcitrans* (13.3%), *Stomoxys indicus* (0.7%), *Stomoxys pullus* (44.4%), *Stomoxys uruma* (19.7%), *Haematobosca sanguinolenta* (19.2%) and *Haematostoma austeni* (2.7%).

**Conclusions:** This study provides information about Stomoxyni flies fauna at the Khao Yai National Park. These results may be useful for Stomoxyni fly control programs.

## KEYWORDS

Stomoxyni flies, *Stomoxys*, *Haematobosca*, *Haematostoma*, Ecology, Morphology, Daily activity

## 1. Introduction

Stomoxyni flies (Diptera: Muscidae) are hematophagous flies which have medical and veterinary importance. They consist of 10 genera and about 50 species[1]. Adult flies are major irritant pests of livestock and wildlife as they feed on the blood of mammals, including humans, and may transmit many parasites and pathogens[2–4]. Among these flies, *Stomoxys calcitrans* (*S. calcitrans*), the cosmopolitan species, can attack most large mammals including domestic cattle, horses, donkeys, dogs, swine, sheep, goats, camels and wild hosts of the families Bovidae, Cervidae, Equidae, Canidae and Felidae[5]. These species are an important

vector for *Habronema microstoma*, which can infect horses[1], and has been implicated as a mechanical vector for several pathogens, such as *Trypanosoma evansi* (agent of surra), *Trypanosoma equinum* (agent of mal de caderas), *Trypanosoma brucei* and *Trypanosoma vivax* (agent of nagana) and retroviruses (equine infectious anemia virus and bovine leukosis virus)[6–8]. It also attacks human when their animal hosts are absent[2].

The present study was carried out to determine the diversity, relative population abundance and diurnal activity of Stomoxyni flies in Khao Yai National Park, Thailand. The information obtained from this study will provide basic biological data for Stomoxyni fly control programs.

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## 2. Materials and methods

### 2.1. Study area

Khao Yai National Park is the first National park in Thailand covering an area of 2168 square kilometers (Figure 1). This park lies largely in Nakhon Ratchasima Province and includes parts of Saraburi, Prachinburi and Nakhon Nayok Provinces. The area contains evergreen forests and grasslands. More than 2000 species of plants, 320 species of birds and 70 species of mammals are found in the area[9]. Therefore, the site is potentially an important source of arthropod vectors.

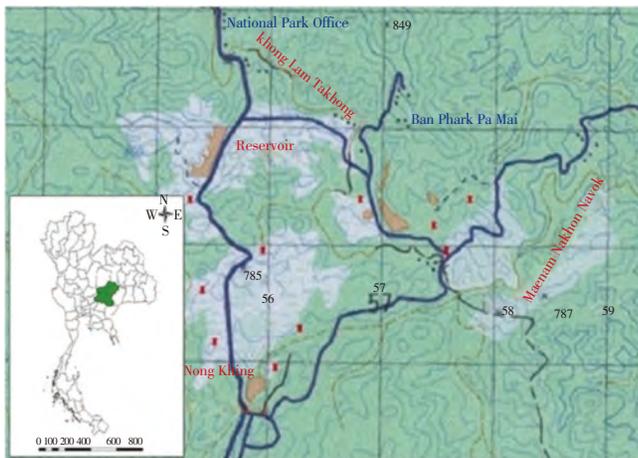


Figure 1. Map of Stomoxyni fly collection sites at Khao Yai National Park.

### 2.2. Fly collection

Adult flies were collected bimonthly from February to June of 2012 using ten Vavoua traps made from blue and black cotton cloth with white polyester mosquito netting[10] (Figure 2). The traps were randomly placed at the grassland areas of the park, from 6:00 am to 18:00 pm for 3 consecutive days per month. The captive flies were collected at 2 h interval to study the diurnal activity. The temperature and relative humidity were also recorded (Table 1). The flies were then transported to the laboratory of the Vector–Borne Diseases Research Unit (VBRU), Faculty of Veterinary Science, Mahidol University, Thailand, for species identification.

Table 1

Information about climatic data at Khao Yai National Park.

Date	Temperature (°C)		Humidity (%)	
	Max	Min	Max	Min
February 2012	31.7	20.5	82.2	35.3
April 2012	33.3	20.6	84.9	46.8
June 2012	32.0	24.3	84.3	52.3

### 2.3. Morphology identification

The specimens were identified to the species level using the taxonomic keys of Zumpt and Tumrasvin and Shinonaga with a stereomicroscope[2,11].

## 3. Results

A total of 712 Stomoxyni flies were collected, comprising 3 genera: *Stomoxys*, *Haematobosca*, *Haematostoma*. The most abundant genera were *Stomoxys* (78.1%) followed by *Haematobosca* (19.2%) and *Haematostoma* (2.7%). Six species were identified: *S. calcitrans* (13.3%), *Stomoxys indicus* (0.7%), *Stomoxys pullus* (44.4%) (*S. pullus*), *Stomoxys uruma* (19.7%) (*S. uruma*), *Haematobosca sanguinolenta* (19.2%) (*H. sanguinolenta*) and *Haematostoma austeni* (2.7%) (*H. austeni*) (Table 2, Figure 3). Morphological characters (body length and frontal index) measured on both sexes of the different species are given in Table 3. They are in accordance with what is known from the bibliography[2]. The diurnal activity of each species is shown in Figure 4. *S. calcitrans* and *S. uruma* showed a peak of diurnal activity from 14:00 to 16:00, while the remaining species showed it from 16:00 to 18:00.

Table 2

Total number of Stomoxyni flies collected at Khao Yai National Park.

Species	Number of flies		
	Male	Female	Total
<i>S. calcitrans</i>	48	47	95 (13.3%)
<i>Stomoxys indicus</i>	2	3	5 (0.7%)
<i>S. pullus</i>	221	95	316 (44.4%)
<i>S. uruma</i>	114	26	140 (19.7%)
<i>H. sanguinolenta</i>	94	43	137 (19.2%)
<i>H. austeni</i>	10	9	19 (2.7%)
Total	389	323	712 (100%)



Figure 2. The Vavoua trap used for collecting the Stomoxyni flies.

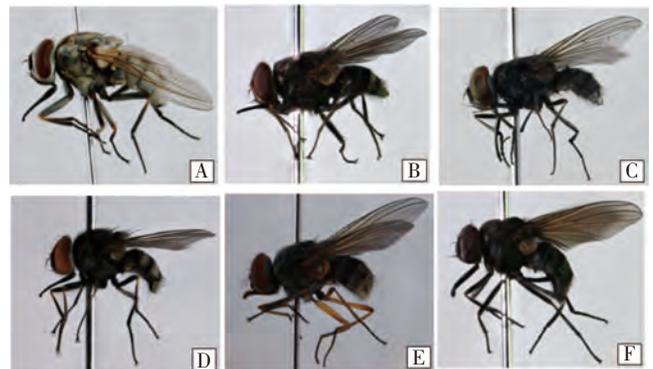


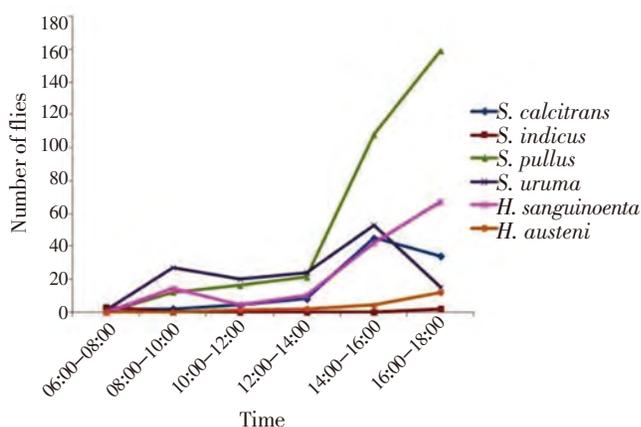
Figure 3. Morphology of the Stomoxyni flies collected at Khao Yai National Park. A. *S. calcitrans*; B. *Stomoxys indicus*; C. *S. pullus*; D. *S. uruma*; E. *H. sanguinolenta*; F. *H. austeni*.

**Table 3**

Some morphological characters of Stomoxyini flies of Khao Yai National Park.

Species	Body length (mm)		Frontal index* (mm)	
	Male	Female	Male	Female
<i>S. calcitrans</i>	5.0–6.0	5.0–6.0	0.33–0.36	0.52–0.57
<i>Stomoxys indicus</i>	4.0–6.0	4.0–6.0	0.15–0.17	0.40–0.46
<i>S. pullus</i>	4.0–5.5	3.5–5.0	0.10–0.14	0.40–0.47
<i>S. uruma</i>	3.5–4.5	3.5–4.5	0.15–0.19	0.44–0.50
<i>H. sanguinolenta</i>	4.5–6.0	4.5–5.5	0.14–0.16	0.45–0.55
<i>H. austeni</i>	4.0–5.0	4.0–5.0	0.10–0.12	0.50–0.55

\*Frontal index—the smallest width of the frons/ the greatest length of the eye.



**Figure 4** Number of Stomoxyini flies collected at Khao Yai National Park, from 6 am to 18 pm.

#### 4. Discussion

This study confirms the presence of Stomoxyini flies species at Khao Yai National Park, Thailand<sup>[12]</sup>. The 6 species found in our study are known to be present in the Southeast Asia<sup>[2]</sup>. *S. pullus* was the most abundant species collected in this study. This species was first recorded in Thailand in 1975 and has been reported again recently by Changbunjong *et al.* at the study site park and in a livestock farm in Kanchanaburi Province<sup>[11,12]</sup>. *S. uruma*, the 2nd most abundant species, has been reported for Thailand by Zumpt and Changbunjong *et al.*<sup>[2,12]</sup>. This species has also been found in Hong Kong, India, Vietnam and Taiwan<sup>[2]</sup>. Other species collected in this study, *i.e.* *S. calcitrans*, *Stomoxys indicus* and *H. sanguinolenta* are commonly found in Thailand, especially in livestock farms, zoos, and national parks<sup>[12–15]</sup>. *H. austeni* has been reported as a jungle fly, but it has rarely been collected despite its wide distribution in the Southeast Asia including Borneo, Malaysia, Laos and Burma. In Thailand, this species has been found only at Khao Yai National Park<sup>[11,12]</sup>. The large diversity of Stomoxyini flies at Khao Yai National Park is similar to a study conducted by Mihok *et al.*<sup>[16]</sup> at the Nairobi National Park in Kenya using Vavoua traps; they found 11 species of *Stomoxys* and other genera of Stomoxyini flies including *Prostomoxys*, *Haematobosca*, *Stygeromyia* and *Rhinomusca*.

The previous studies showed that the abundance of fly populations related to the environmental factors such as temperature, relative humidity, rainfall and light intensity to maintain suitable breeding habitats, and biotic factors such as distribution and abundance of animal hosts at the park<sup>[12,13,15]</sup>. Additionally, physical factors such as habitat types were also reported to be related with the abundance of fly populations<sup>[17]</sup>. In the present study the number of Stomoxyini flies was lesser than the previous survey<sup>[12]</sup>. Our observations during the study indicated that main climatic factors as rainfall, temperature may be the most important factor effecting the abundance of these flies.

The diurnal activity of Stomoxyini flies was observed among different periods of time (6:00–18:00). Our result confirmed the crepuscular behavior of *Stomoxys indicus*<sup>[2]</sup>. This species is more active in the early morning (6:00) and the late afternoon (18:00). For *S. calcitrans*, we observed a peak of flight activity from 14:00 to 16:00, similar to the results conducted by Muenworn *et al.*<sup>[14]</sup>. They found the highest peak for males of *S. calcitrans* in the afternoon (14:00–16:00) whereas females showed an increase of activity all along the day until 16:00. For the other species, *S. uruma*, *S. pullus*, *H. sanguinolenta* and *H. austeni*, we provide the first report on daily activities in Thailand. The activity of these flies may be affected by temperature and relative humidity. Moreover, the feeding behavior of wild animals at the park may also be related to the daily activity of these flies. Most wild animals move from bedding areas to feeding areas in the late afternoon or at night.

In conclusion, this study provides information about the Stomoxyini fly fauna at the Khao Yai National Park, Thailand. A total of 712 individuals of 3 genera and 6 species were captured. *S. pullus* was the predominant species. The fly fauna was characteristic depending on the environment of the park. Further investigation is required to comprehend the Stomoxyini flies and their role associated with wildlife hosts in Khao Yai National Park. Our results are useful for fly control programs.

#### Conflict of interest statement

We declare that we have no conflict of interest.

#### Acknowledgements

This work was supported by Faculty of Veterinary Science, Mahidol University (Grant No. 0517.131/00195). The authors would like to thank the Department of Natural Parks, Wildlife and Plant Conservation for permission to conduct the study in the area. Special thanks go to Dr. Norberto Asensio, Faculty of Environment and Resource studies, Mahidol University for a critical review of this manuscript.

## Comments

### Background

The Stomoxyini tribe of flies has been little studied in the world. Only *S. calcitrans*, the only cosmopolitan species has been studied because of its presence in USA and Europe. Nevertheless there are many other species, and it is important that teams develop studies on this tribe in many parts of the world. As we know now that the genus *Stomoxys* originated probably in Asia and not in Africa, it is important that studies are being conducted in Thailand.

### Research frontiers

This manuscript reports about a survey of biodiversity of Stomoxyini tribe in the Khao Yai National Park of Thailand. The authors show a very important biodiversity, with captures of species considered as very rare. They show that most of these species are related to the wild fauna. This is the most comprehensive survey since the work of Tumrasvin and Shinonaga in 1978.

### Related reports

The protocol is very clear. The authors used Vavoua traps during the period February to June 2012. It would be interesting to pursue the work for a complete year to get the seasonal variation of abundance. But their results are already very useful, because they studied the daily activity of the different flies. And they show that some of them do have a crepuscular activity.

### Innovations & breakthroughs

We already knew that, in Thailand, anthropophilic species such as *S. calcitrans*, *S. indicus* and *S. sitiens* were present in farms, but the authors show that many other genera and species are present in contact with wild fauna.

### Applications

All these species are hematophagous and potential vectors of different pathogens. Some of these species could be an important link between wild fauna and domestic animals for the transmission of pathogens. That's why it is so important to study all these species to understand the emergence of new epidemics.

### Peer review

To my point of view, this manuscript deserves to be published. It will be important for all scientists working on Diptera, but also to epidemiologists working on vector transmitted diseases.

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