Spatial Distribution of Forensically Significant Blow Flies in Subfamily Luciliinae (Diptera: Calliphoridae), Chiang Mai Province, Northern Thailand: Observations and Modeling Using GIS

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Abstract: Blow flies of the subfamily Luciliinae (Diptera: Calliphoridae) are one of the main forensically important subfamilies globally. In addition to being used to estimate the minimum post-mortem interval (PMI_{min}), assuming colonization occurred after death, blow fly specimens found infesting a human corpse are used to determine if the corpse was relocated or if the individual ingested narcotics prior to death. The presence of these blow flies in a given area is strongly influenced by abiotic and biotic factors, such as temperature, elevation, and habitat. Having this information, along with geographical distributions and the characteristics of preferred habitats, is necessary to better understand the biology of this group. This study aimed to characterize the spatial distribution of Luciliinae throughout 18 sampling sites within six ecozones (disturbed mixed deciduous forest, mixed deciduous forest, mixed orchard, paddy field, lowland village, and city/town) in central Chiang Mai Province, northern Thailand over one year (May 2009–May 2010). The purpose of the study was to elucidate the relationship of blow fly species composition with environmental abiotic factors (e.g., temperature, relative humidity, light intensity), and to predict the distribution of the common species within this subfamily using GIS. Adult collections were performed biweekly, baited with one-day-old beef offal. A total of 2331 Luciliinae flies trapped, comprising eight species, of which the four predominant species were *Hemipyrellia ligurriens* (Wiedemann) ($n = 1428$; 61.3%), *Lucilia porphyrina* (Walker) ($n = 381$; 16.3%), *Hemipyrellia pulchra* (Wiedemann) ($n = 293$; 12.6%), and *Lucilia papuensis* Macquart ($n = 129$; 5.5%). Population density across species varied seasonally, peaking in August 2009 coinciding with the rainy season. Predicting population composition was based on a model developed with ArcGIS 9.2, which utilized environmental variables (temperature, relative humidity, and light intensity) in conjunction with abundance data. Models indicated *H. ligurriens* had the most widespread geographic distribution, while *H. pulchra* was predicted to occur largely in mixed orchards and lowland villages. *Lucilia porphyrina* and *L. papuensis* were less widespread, restricted mainly to mixed deciduous forest. This model, along with knowledge of forensic information, may be useful under certain investigations where the corpse may have been relocated.

1. Introduction

Blow flies (Diptera: Calliphoridae) draw much attention from the forensic community due to their close association with decomposing remains and subsequent value as evidence [1–4]. They are the first group of insects to arrive at a corpse, often within minutes of death, thus being used in the crime scene investigation especially in estimating a minimum postmortem interval (PMI_{min}) [3,5,6]. In many countries, blow flies of the subfamily Chrysomyinae (e.g., genus *Chrysomya*) account for the predominant taxa found infesting human corpses; however, those of the subfamily Luciliinae (e.g., genus *Lucilia*, *Hemipyrellia*, *Hypopygiopsis*) are still of consequence because of their distribution and close association with such resources [7–10]. Examples of cases where remains were infested with Luciliinae flies included *L. papuensis* in Australia [11], *H. ligurriens* in Malaysia [12], China [8], and Australia [11], *Hemipyrellia tagaliana* (Bigot) in Malaysia [13], and *Hypopygiopsis violacea* Macquart in Malaysia [14]. In Thailand, 10 species of Luciliinae flies have been recorded, including the genera *Lucilia*, *Hemipyrellia*, and *Hypopygiopsis* [15]. Among these, *H. ligurriens*, *Lucilia cuprina* (Wiedemann), and *L. porphyrina*, were found in association with human corpses [4,16]. Although the Luciliinae flies found in Thailand occur mainly in Asia, Australia, and Oceania [17–21], very little information about their spatial and temporal distributions and forensic cases have been reported. This limitation may be due to Luciliinae flies accounting for a small proportion of the populations that infest dead bodies. A recent study in Thailand reported that Luciliinae flies accounted for only 0.63% of a total of 147,248 calliphorids collected throughout a year [22]. Furthermore, Luciliinae accounted for 5.9% of blow flies collected from human corpses in Malaysia [12] and 6.5% of blow flies from cases in Thailand [4].

Knowledge of the distribution, biology, and behavior of forensically important flies is helpful in forensic investigations by providing information about time, location, and condition of the death [2,3,23,24]. In Thailand, the majority of studies on Luciliinae have focused on species identification [25–27] and developmental rate of the immature stages [28,29]. Although surveys of forensically important flies have been conducted on a local scale in Thailand, a comprehensive landscape assessment of the distribution of Luciliinae that are forensically important is limited [30–32]. Previous work on spatial analysis of forensically important blow flies has focused on *Chrysomya megacephala* (Fabricius) [33], *Chrysomya rufifacies* (Macquart) [34], *Chrysomya pinguis* (Walker), *Chrysomya chani* Kurahashi, *Chrysomya villeneuvi* Patton and *Ceylonomyia nigripes* (Aubertin) [35]. However, studies on Luciliinae flies are lacking. Thus, this study aimed to investigate the occurrence of Luciliinae blow flies across six diverse land use categories in central Chiang Mai Province, northern Thailand. The influence of climatic factors (temperature, relative humidity, and light intensity) on their geographic distributions was investigated. Furthermore, the predicted distributions of the predominant species sampled were modeled using ArcGIS 9.2 (ESRI, Redlands, CA, USA). To our knowledge, this is the first study to spatially and temporally characterize the Luciliinae fly population over a variety of land use types in Thailand.

2. Materials and Methods

2.1. Study Areas

In order to develop a prediction model, flies of forensic importance were sampled in May 2009 to May 2010 by selecting 18 study sites located within three districts of Chiang Mai Province, northern Thailand. These calibrated study sites were distributed across the following districts: one urban (Mueang Chiang Mai (MU)) and two suburban sites (Hang Dong (HD) and Mae Rim (MR)) (Figure 1). Following a systematic random sampling method [36], the study area within the three districts was partitioned into a sampling frame of 5 × 5 km for suburban areas (Mae Rim and Hang Dong districts)