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FAUNISTIC ANALYSIS OF HAWK MOTHS (LEPIDOPTERA: SPHINGIDAE) DISTRIBUTED IN UZBEKISTAN

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SUMMARY

This study on hawk moths, belonging to the family Sphingidae found in different regions of Uzbekistan, was successful in its conduct during 1998–2024, as well as research of literature sources. In total, the work recorded 27 species that belong to 16 different genera in the republic. The study sample collection came from the different regions, as follows: 791 from the northwestern regions, 443 from the central and southern regions, and 342 from the eastern regions in the Fergana Valley. Analysis based on varied landscapes revealed the collection of 563 samples (35%) originated from deserts, 441 samples (27%) from mountainous regions, and 628 samples (38%) procured from the lowlands and agro-landscapes. Most samples collected took place during spring, summer, and autumn. Twenty-one out of 27 hawk moth species recorded emerged during the research, while the remaining six species identified were reliant on the literature sources and material obtained from the Zoology Institute, Academy of Sciences, Uzbekistan.

Keywords: Sphingidae, hawk moths, biogeography, ecology, distribution, Northwestern and Central Uzbekistan

Key findings: The promising faunal analysis revealed hawk moth species appeared widely distributed in three regions of Uzbekistan. The species composition also varies across the different regions.

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INTRODUCTION

Hawk moths belong to the family Sphingidae of butterflies, widely distributed worldwide, except in Antarctica (Weyburn, 2002). Additionally, the hawk moth family is a distinct group within the order Lepidoptera, characterized by unique morphological features. Currently, the hawk moth family's classification comprises three (3) subfamilies and over 200 genera (Kawahara *et al.,* 2009). However, varying reports occurred regarding the total number of hawk moth species. According to Van-Nieukerken *et al*. (2011), the global fauna has more than 206 genera and over 1463 species. Furthermore, Kitching (2003) reported that the Sphingidae family of butterflies comprises more than 1700 species globally. Although most sphingids are benign and interesting members of the fauna, some species have economic importance. These utilize apples, pears, cherries, soybeans, camphor, sugarcane, walnuts, pistachios, sesame, peanuts, chilis, tomatoes, potatoes, maize, eggplants, teak, sweet potatoes, peas, coffee, taro, tobacco, sugar beets, buckwheats, olives, and grapes as larval host plants (Rafi *et al.,* 2014). Maize (*Zea mays* L.) is a primary cereal crop, which ranks third after rice and wheat in production (Sobirova *et al.,* 2024).

Based on the faunal, biological, and ecological characteristics of hawk moths in Central Asia, including CIS (Commonwealth of Independent States) countries, notable studies have succeeded in researching the family Sphingidae (Davletshina *et al*., 1979; Efetov and Budashkin, 1990; Trofimova, 2006; Tikhonov, 2007; Susarev and Ruchin, 2011; Shovkun, 2015). Koshkin and Yevdoshenko (2019) studied the fauna of hawk moths (Lepidoptera, Sphingidae) in the Russian Far Eastern regions and recorded 22 species belonging to 14 genera and three subfamilies, with *Theretra japonica* (Boisduval, 1869) as a newly recorded species for this region.

Yakhontov (1960) reported three species of hawk moths existed in the fauna of Uzbekistan: *Deilephila elpenor* (Linnaeus, 1758), *Theretra alecto* (Linnaeus, 1758), and *Hyles livornica* (Esper, 1780). Additionally, he also identified *Theretra alecto* (Linnaeus, 1758) as a pest species. The past research 'Insects of Uzbekistan' provides exploration of 20 species of hawk moths in Uzbekistan (Azimov *et al.,* 1993). Moreover, it includes descriptions of 12 more species found in the country. Furthermore, in Uzbekistan's Red Book, the listed four species of hawk moths were *Laothoe philerema* (Djakonov, 1923), *Acosmeryx naga* (Moore, 1857), *Sphingonaepiopsis kuldjaensis* (Graeser, 1892), and *Dolbino grisea* (Hampson, 1892). However, these species were nonexistent across all the regions of Uzbekistan (Red Book of the Republic of Uzbekistan, 2019). These species primarily inhabit mountainous areas, riparian forests along riverbanks, and orchards, particularly apple groves and vineyards. Although the study of these habitats was insufficient, precise data of these regions is necessary.

About the Uzbekistan fauna, systematics, distribution, and bioecological characteristics of hawk moths, limited studies have progressed. However, recently, the studies on hawk moths have succeeded in the southern part of the Fergana Valley (Shermatov *et al*., 2021). During these investigations, eight different species belonging to three subfamilies were notable in the Southern Fergana Region. Additionally, the species *Agrius convolvuli* (Linnaeus, 1758) was a new recording for the southern regions of Fergana.

Among the studies conducted on Lepidoptera in Uzbekistan, Kh.U. Bekchanov's dissertation, 'Fauna and Ecology of Lepidoptera (Insecta, Lepidoptera) in Northwestern Uzbekistan,' holds particular significance. In this research, he provided a description of the contemporary taxonomic status of hawk moths distributed in northwestern Uzbekistan. The said region was also noteworthy as home for the 10 species belonging to 10 genera, four tribes, and three subfamilies. These species include *Mimas tiliae orientalis* Melichar, Melichar & Rezac, 2021; *Smerinthus ocellata ocellata*, *Laothoe populi populi*, *Sphinx ligustri*, *Hyloicus pinastri*, *Acherontia atropos*, *Hemaris fuciformis fuciformis*, *Theretra alecto*, and *Deilephila elpenor* (all in Linnaeus, 1758); and *Hyles hippophaes bienerti* (Staudinger, 1874).

Insect studies at the regional level are highly valuable in Uzbekistan, as exemplified by the research work of Kh.U. Bekchanov. His research highlighted that the species diversity of hawk moths in the area had considerable differences from the middle reaches of the Zarafshan River. Specifically, five species of hawk moths, i.e., *Laothoe populi populi*, *Sphinx ligustri*, *Theretra alecto*, *Deilephila elpenor* (Linnaeus, 1758), and *Hyles hippophaes bienerti* (Staudinger, 1874), were prevalent in northwestern Uzbekistan, as well as in the middle reaches of the Zarafshan River. However, other species, including *Mimas tiliae orientalis*, *Smerinthus ocellata ocellata*, *Sphinx pinastri*, *Acherontia atropos*, and *Hemaris fuciformis* (Linnaeus, 1758), were not evident in the studied regions. The presented research may be the first study conducted on hawk moths in Uzbekistan over the past 50 years and holds significant scientific and practical value.

MATERIALS AND METHODS

In Uzbekistan, the past research on hawk moths has been the work of Bekchanov (2023) between 1998 and 2019 across 40 locations in northwestern Uzbekistan. Omonov *et al*. (2023) carried out investigations between 2021 and 2024 in 20 locations in Central Uzbekistan. Shermatov *et al*. (2021) conducted between 2019 and 2024 in 10 locations in the Fergana Valley. Additionally, this study analyzed the samples collected from three different regions of Uzbekistan, viz., Northwestern, Central, and Southern (Figure 1), with the specimens preserved in the core collection at the Institute of Zoology, Academy of Sciences, Uzbekistan. The distance between the northernmost and southernmost points of Uzbekistan is 935 km, while the distance between its westernmost and easternmost points is 1400 km (Abdullaev *et al.* 2024). Uzbekistan is strategic due to its geographical location, with almost the same geographical latitude as the countries around the Mediterranean Sea (Medetov *et al.,* 2024). Given its geographical location, Uzbekistan has a unique natural climatic condition. Much of central and northeastern Uzbekistan comprises a surrounding of mountains (Tian Shan east of Tashkent and Samarkand, Hissar Range) and adjacent Tajikistan (Hissar and Zeravshan ranges) (Nabozhenko *et al.,* 2024).

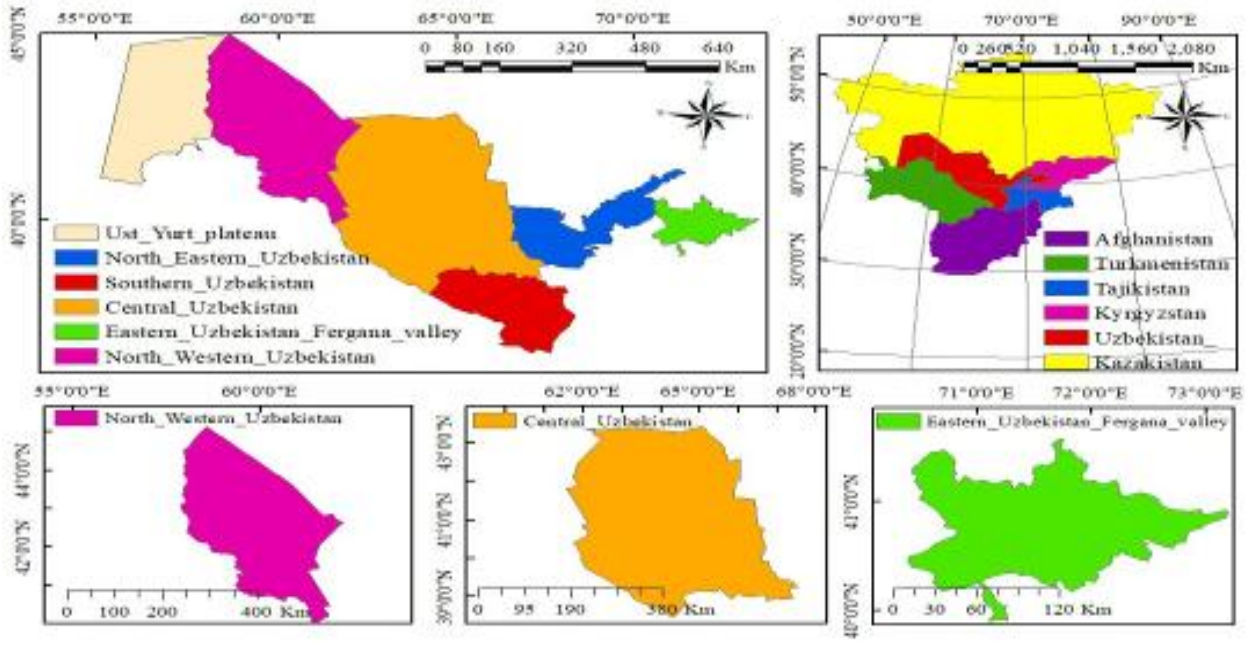

Figure 1. Distribution of hawk moths in the geographical areas of Uzbekistan.

Generally, the Uzbekistan climate corresponds to the Palearctic Region, particularly Central Asia, and the country's internal regions have significant differences due to their locations, topography, precipitation levels, wind patterns, and seasonal variations (Rakhimov and Elmuratova, 2019). For instance, northwestern Uzbekistan, composed mainly of flatlands, has a desert climate. Spring arrives slightly later in this region compared with other parts of Uzbekistan. In mid-March, the average temperature in northwestern Uzbekistan reaches 15 °C–20 °C, whereas in Central Uzbekistan, it is 25 °C–28 °C, and in the Fergana Valley, it ranges from 23 °C–27 °C. During the summer, in northwestern Uzbekistan, the highest recorded temperature was 48 °C, while in Central Uzbekistan, it reached 37 °C, and in the Fergana Valley, it was 36 °C. Similarly, autumn arrives earlier in northwestern Uzbekistan, occurring 15–20 days before it does in other regions of the country. As a result, the vegetation cover and entomofauna of these regions also differ. Moreover, the soil types across these areas vary significantly.

The study samples' collection commenced during the late evening and early morning hours, from 8:00 p.m. to 4:00 a.m., in spring, summer, and autumn. Various entomological equipment and traditional methods used aided the sample collection, including different types of entomological nets, insect traps, white fabric screens, and various insect-attracting lamps (LED 500 W, DRELL 400, Xenon 250). The samples' collection and processing transpired following the guidelines of Golub (2012). Species identification utilized scientific websites and catalogs, including Pittaway (2009) (Sphingidae of the Western Palaearctic), Kitching (2025) (Sphingidae Taxonomic Inventory), and Melichar (Sphingidae Museum). The coordinates of the sampling locations, as determined, used the applications 'Maps.me' and 'Google Earth.' The Jaccard coefficient equation assessed the similarity levels of the collected samples across the different regions.

RESULTS AND DISCUSSION

Research on compiling a modern checklist on the hawk moth population distributed in Uzbekistan continued from 1998 to 2024 (Shermatov *et al.,* 2021; Omonov, 2022; Bekchanov, 2023). During this study period, over 1632 hawk moth samples collected came from the northwestern, northeastern, eastern, central, and southern regions of Uzbekistan. Additionally, more than 92 biological specimens preserved in the collection at the Institute of Zoology, Academy of Sciences, Uzbekistan, underwent analysis (Omonov and Rakhimov, 2024).

From the analyzed hawk moth samples totaling 1632, collecting 791 occurred between 1998 and 2021 (Bekchanov, 2023), while the 841 collection was between 2021 and 2024. In northwestern Uzbekistan, obtaining samples resulted in 231 in spring, 186 in summer, and 94 in autumn. For central Uzbekistan, the collection breakdown per season was 169 samples in spring, 233 in summer, and 117 in autumn (Omonov and Rakhimov, 2024). In eastern Uzbekistan (Fergana Valley), acquiring 154 samples succeeded in spring, 317 in summer, and 131 in autumn (Shermatov *et al.,* 2021). Overall, the seasonal analysis revealed 554 samples (34%) were specimens collected in spring, 736 samples (45%) in summer, and 342 samples (21%) in autumn (Figure 2).

By analyzing the 1632 collected specimens based on different regions, 791 specimens came from the northwestern region, 443 from the central and southern regions, and 342 from the eastern region (Fergana Valley). In terms of landscape distribution, 563 specimens (35%) were sampled from deserts, 441 (27%) from mountainous regions, and 628 (38%) from the lowlands and agro-landscapes. The analysis confirmed the presence of 27 hawk moth species in Uzbekistan. Among these, the identification of 21 species resulted during this research, with six species determined through past research (Table 1). Furthermore, the species *Hyles svetlana* (Shovkoon, 2010), as recorded in the

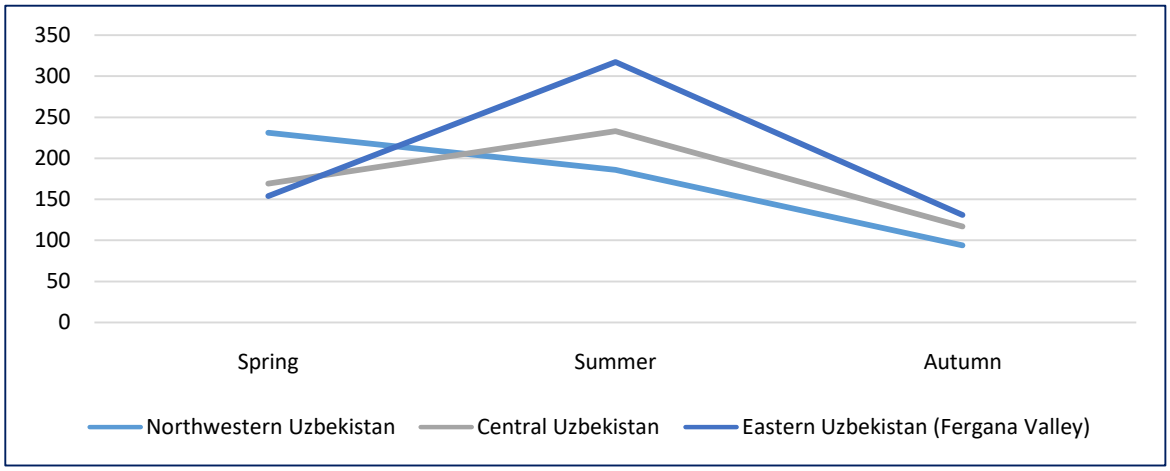

Figure 2. The seasonal occurrence dynamics of hawk moths in three different regions of Uzbekistan.

Table 1. Analysis of the hawk moths' distribution in three different regions of Uzbekistan.

No.	Species	Northwestern Uzbekistan	Central Uzbekistan	Eastern Uzbekistan (Fergana Valley)
1	*Agrius convolvuli* (Linnaeus, 1758)	++	+++	+
2	*Acherontia atropos* (Linnaeus, 1758)	+++	-	-
3	*Acosmeryx naga ssp.* (Moore, 1858)	-	++	++
4	*Dolbina grisea* (Hampson, 1893)	-	++	-
5	*Deilephila elpenor* (Linnaeus, 1758)	+	+++	++
6	*Deilephila porcellus* (Linnaeus, 1758)	-	+++	++
7	*Laothoe populi populi* (Linnaeus, 1758)	+	+++	+++
8	*Laothoe philerema* (Djakonov, 1923)	++	++	++
9	*Macroglossum stellatarum* (Linnaeus, 1758)	++	+++	+++
10	*Mimas tiliae orientalis* (Linnaeus, 1758)	+	++	-
11	*Marumba quercus* (Denis and Schiffermüller, 1775)	-	++	-
12	*Proserpinus proserpina* (Pallas, 1772)	-	+++	+
13	*Smerinthus kindermannii* (Lederer, 1853)	-	+++	+
14	*Smerinthus ocellata ocellata* (Linnaeus, 1758)	+	-	++
15	*Sphinx ligustri* (Linnaeus, 1758)	+	+++	-
16	*Hyloicus pinastri* (Linnaeus, 1758)	+	-	-
17	*Sphingonaepiopsis kuldjaensis* (Graeser, 1892)	-	++	++
18	*Theretra alecto* (Linnaeus, 1758)	+++	+++	+++
19	*Hyles euphorbiae* (Linnaeus, 1758)	-	+++	+++
20	*Hyles centralasiae* (Staudinger, 1887)	++	+++	-
21	*Hyles zygophylli* (Ochsenheimer, 1808)	++	+++	+
22	*Hyles hippophaes* (Esper, 1780)	+	+++	++
23	*Hyles hippophaes bienerti* (Staudinger, 1887)	-	+	-
24	*Hyles livornica* (Esper, 1780)	-	+	++
25	*Hyles gallii* (Rottemburg, 1775)	-	+	-
26	*Hemaris fuciformis fuciformis* (Linnaeus, 1758)	+	++	-
27	*Hemaris ducalis* (Staudinger, 1887)	-	++	++

Notes: "+" - Species identified during the research; "++" - Species mentioned in the literature; "+++" - Species identified in both literature and research; "-" - Species not identified in the research.

Table 2. The hawk moths' distribution based on the Jaccard coefficient in three different regions of Uzbekistan.

Regions	Northwestern Uzbekistan	Central Uzbekistan	Eastern Uzbekistan (Fergana Valley)
Northwestern Uzbekistan	1	-	-
Central Uzbekistan	0.23	1	-
Eastern Uzbekistan (Fergana Valley)	0.12	0.50	1

territories of Kazakhstan bordering Western Uzbekistan, suggested the highest probability of its occurrence in the Ustyurt Plateau, Uzbekistan. These results highlighted the necessity of conducting further research in these areas (Shermatov *et al.,* 2021; Bekchanov, 2023; Omonov and Rakhimov, 2024).

Across the three different regions of Uzbekistan, the similarity of hawk moth distribution attained scrutiny. According to the obtained results, the hawk moths found in northwestern and central Uzbekistan belong to the five different species (*Laothoe populi, Sphinx ligustri, Hyles hippophaes, Deilephila elpenor,* and *Theretra alecto*), with a Jaccard coefficient similarity index of 0.23. The hawk moths found in northwestern and eastern Uzbekistan (Fergana Valley) belong to the two species (*Laothoe populi* and *Theretra alecto*), with a similarity index of 0.12. However, the hawk moths prevalent in central and eastern Uzbekistan (Fergana Valley) belong to eight different species (*Laothoe populi, Smerinthus kindermannii, Agrius convolvuli, Proserpinus proserpina, Macroglossum stellatarum, Hyles zygophylli, Hyles euphorbiae,* and *Theretra alecto*), with a similarity index of 0.50 (Tables 1 and 2) (Shermatov *et al*., 2021; Bekchanov, 2023; Omonov and Rakhimov, 2024).

Shetkin (1960) made a significant contribution in studying the Lepidoptera fauna of Tajikistan, providing information on 90 (75) species of butterflies in the section of his monograph 'Higher Lepidoptera of the Sands of the Vakhsh Valley.' Among the identified butterflies, 262 species were nocturnal, with 10 species (*Agrius convolvuli, Smerinthus kindermannii, Dolbina grisea, Macroglossum stellatarum, H. centralasiae, H. chamyla, H. hippophaes, H. zygophylli, H. livornica,* and *Theretra alecto*) belonging to the family Sphingidae. The said author also provided numerous pieces of information about the identified species, particularly regarding their phenology, morphology, and host plants, which are highly valuable to specialists today (Shetkin, 1960; Omonov, 2024).

However, certain taxonomic issues related to species identification have successful authentication by the researchers currently studying hawk moths. For instance, the species *Hyles lineata* (Fabricius, 1775), mentioned by Shetkin (1960), incurred mistaken identification instead of *Hyles livornica* (Esper, 1780). Recent studies have confirmed that *Hyles lineata* (Fabricius, 1775) is characteristic of North and South America, whereas *Hyles livornica* (Esper, 1780) is the species found in Central Asia (Haxaire, 1993).

The issues comprising hawk moth adaptation to natural conditions are evolutionarily intriguing. Specific stages of butterfly development, along with their adaptation and morphological structures, serve as examples of this phenomenon. According to Shetkin (1960), the butterflies' adaptation in the Vakhsh Valley showed distinction by the unique aspects of their biology. In this region, most of the hawk moth population produces 2–3 generations per season. Their first generation emerges from pupation in early May, while the second generation emerges in mid-July to early August. These past findings were particularly valuable for the present research, as the studied areas share climatic conditions and vegetation cover with those of the middle course of the Zarafshan River, given that these regions were neighboring territories (Shetkin, 1960; Omonov, 2024).

The hawk moths' difficulty of adapting to extreme conditions of the desert can be because very few species of hawk moths prevailed in desert environments. The said

conclusion also gained support from evidence presented in past studies on the Kyzylkum Desert (Davletshina *et al.*, 1979). According to the literature, the species *Hyles centralasiae* (Staudinger, 1887) was commonly causing significant damage to the plant *Eremurus sogdianus* during its larval stage. In 1964, this species occupied a vast area in the southwestern part of the Kyzylkum Desert, Uzbekistan. At the end of the plant's growing season, caterpillars burrow into the soil and pupate. Some of these pupae emerge as first-generation moths in May, while the second generation emerges in August.

Additionally, some pupae remain dormant in the soil and hatch the following spring. Shetkin (1960) observed the pupae of the species *Hyles centralasiae* could remain dormant for 2–3 years before emerging (Omonov *et al.* 2023). Furthermore, the said study identified several hawk moth species occurring in the Kyzylkum Region, Uzbekistan, including *Smerinthus kindermannii, Hyles livornica, Hyles euphorbiae, Hyles centralasiae, Hyles zygophylli,* and *Macroglossum stellatarum.*

CONCLUSIONS

Hawk moth specimens totaled 1632, belonging to 21 species and 16 genera, collected from 1998 to 2024 from the northwestern, central, and eastern regions of Uzbekistan. Overall, 27 species of hawk moths have successful recordings in Uzbekistan, in which 21 species were evidently wild, while six species were nonexistent. However, these six species have proof of documentation in past studies and remain preserved in the core collection of the Institute of Zoology, Academy of Sciences, Uzbekistan. The similarity in hawk moth species composition among the northwestern, central, and eastern regions of Uzbekistan also had a successful analysis.

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