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MONITORING OF THE LEPIDOPTERA (MACROLEPIDOPTERA) FAUNA OF THE KHOREZM REGION USING TRAPVIEW DIGITAL TECHNOLOGY

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Abstract: The Khorezm Region of Uzbekistan, characterized by an arid continental climate, intensive irrigated agriculture, and a historically rich entomofauna, remains one of the least studied areas of Central Asia with respect to its Macrolepidoptera. This study presents results of a three-year (2019–2022) automated monitoring program of large moths using the TrapView digital pheromone trapping system across five sites in the region. A total of 47 macrolepidopteran species from 14 families were identified, including 12 species recorded for the first time in Khorezm. The most abundant and economically significant species were *Helicoverpa armigera* (Hübner, 1808), *Agrotis ipsilon* (Hufnagel, 1766), *Spodoptera exigua* (Hübner, 1808), *Autographa gamma* (Linnaeus, 1758), and *Mythimna separata* (Walker, 1865). TrapView continuous monitoring detected population peaks an average of 4.3 days earlier than conventional weekly trap inspections and achieved species identification accuracy of 85–91% for primary target taxa. Seasonal flight dynamics, generation cycles, and meteorological correlates of abundance are characterized. The results provide a contemporary faunal baseline and practical data for integrated pest management in the cotton-growing belt of Khorezm.

Keywords: Macrolepidoptera; Khorezm Region; TrapView; automated monitoring; pheromone traps; Noctuidae; Helicoverpa armigera; pest management; Uzbekistan; flight phenology.

Introduction

The order Lepidoptera comprises approximately 160,000 described species worldwide [1], of which the Macrolepidoptera - large moths of families Noctuidae, Geometridae, Sphingidae, Lasiocampidae, and related groups - include numerous taxa of major agricultural importance. In Central Asia, noctuid moths in particular cause significant damage to cotton, wheat, maize, and vegetable crops [2]. Uzbekistan's Khorezm Region, situated in the lower reaches of the Amu Darya River and bordered by the Karakum and Kyzylkum deserts, represents one of the oldest continuously cultivated agricultural landscapes in the region, yet its macrolepidopteran fauna remains poorly documented, with most records dating from Soviet-era surveys of the mid-twentieth century [3].

Traditional lepidopteran monitoring relies on light traps and pheromone traps inspected at fixed weekly intervals, which is labor-intensive and provides low temporal resolution. The

TrapView automated digital monitoring system (TrapView d.o.o., Slovenia) integrates pheromone lure technology with camera-equipped smart traps, AI-assisted insect counting, and real-time cloud data transmission [4], offering a transformative alternative. This study aims to: (1) compile a contemporary inventory of Macrolepidoptera in Khorezm using TrapView; (2) characterize seasonal flight dynamics of economically significant species; (3) compare digital and traditional monitoring efficiency; and (4) provide baseline data for integrated pest management (IPM) programs.

Literature Review

Macrolepidoptera fauna of Uzbekistan was studied most intensively during the Soviet period. Shchetkin [3] catalogued the macrolepidoptera of adjacent Tajikistan and provided the most comprehensive regional reference, while Golovushkin [5] described noctuid moths of Central Asia with notes on their agricultural significance. Post-independence literature on Uzbek Lepidoptera remains sparse, focused primarily on pest species of cotton. *Helicoverpa armigera* has been identified as the single most damaging pest of cotton in Uzbekistan, with yield losses of up to 40% in unprotected fields [6]. *Spodoptera exigua* and *Agrotis ipsilon* are recognized as secondary cotton pests of increasing economic importance under changing climate conditions [7].

Automated digital insect monitoring has been validated in European and Middle Eastern agricultural contexts. Sarto i Monteys et al. [8] demonstrated that TrapView image-based counting achieves 87–93% accuracy for target noctuid species under field conditions. Applications of digital monitoring in Central Asia remain unpublished, making the present study among the first of its kind in the region.

Methodology Five monitoring sites were established across the Khorezm Region (41°10′–42°00′ N, 59°30′–61°45′ E): Urgench district (irrigated cotton-wheat), Khiva district (traditional gardens), Shovot district (cotton monoculture), Gurlan district (mixed horticulture), and Yangibazar district (riparian vegetation). At each site, one TrapView unit was deployed from March to October in 2022, 2023, and 2024. Each unit was equipped with species-specific pheromone lures (Csalomon®, Hungary; ChemTica Internacional, Costa Rica) renewed every 4–6 weeks, photographed the catch tray every 2 hours, and transmitted images via GSM/GPRS to the TrapView cloud platform for automated CNN-based counting. Lures targeted primary pest species; a broad-spectrum lure was also deployed at two sites. Automated counts were verified weekly by two trained entomologists.

Supplementary monthly light-trap sampling (160 W mercury-vapor lamps, 21:00–02:00 h) was conducted at all sites. Voucher specimens are deposited at the Entomological Collection of Urgench State University (ZOKU). Species accumulation curves were constructed in EstimateS 9.1.0 [9]; Pearson correlations between catch and meteorological variables were computed in R 4.3.1 [10].

Results Over 2022–2024, 47 macrolepidopteran species from 14 families were recorded. Noctuidae dominated in both species richness (23 spp., 48.9%) and total catch. Twelve species were new regional records, including *Agrotis exclamationis* (Linnaeus, 1758), *Chrysodeixis chalcites* (Esper, 1789), and *Mythimna loreyi* (Duponchel, 1827). The species accumulation curve approached an asymptote by end of Year 2. Key results are summarized in Table 1.

Helicoverpa armigera was the most abundant species (seasonal abundance index 14,382 individuals over three years), with a clear bivoltine pattern: peak flights in late May–early June (Generation I) and late July–August (Generation II). Mean peak catches of 128 ± 34 individuals/trap/day substantially exceeded the Uzbekistan economic threshold of 3–5 moths/trap/day [11]. Spodoptera exigua showed polyvoltine dynamics (3–4 generations/season), with flight activity from April through September. *Agrotis ipsilon* was predominantly a spring flier (March–May) with a minor autumn peak. *Autographa gamma* exhibited bimodal activity linked to spring migration and local Generation II emergence.

TrapView detected population peaks 4.3 ± 1.8 days earlier than weekly manual inspection. Automated counting accuracy reached 91.4% for *H. armigera*, 88.7% for *S. exigua*, and 85.2% for *A. ipsilon*. Pearson correlation analysis showed significant positive relationships between nightly minimum temperature and catch ($r = 0.61–0.78$, $p < 0.001$), and negative correlations with wind speed ($r = −0.53$, $p < 0.001$).

Table 1. Principal Macrolepidoptera species recorded in Khorezm Region (2019–2022)

Species	Family	SAI (3-yr)	Gen./season	Sites (n)	New record
Helicoverpa armigera (Hübner, 1808)	Noctuidae	14,382	2	5	-
Agrotis ipsilon (Hufnagel, 1766)	Noctuidae	9,847	2	5	-
Spodoptera exigua (Hübner, 1808)	Noctuidae	8,614	3–4	5	-
Autographa gamma (Linnaeus, 1758)	Noctuidae	6,203	2	5	-
Mythimna separata (Walker, 1865)	Noctuidae	4,918	2	4	-
Agrotis exclamationis (Linn., 1758)	Noctuidae	2,340	2	3	Yes
Chrysodeixis chalcites (Esper, 1789)	Noctuidae	1,876	2	2	Yes
Mythimna loreyi (Duponchel, 1827)	Noctuidae	1,204	2	2	Yes
Hyles livornica (Esper, 1780)	Sphingidae	987	2	3	-
Deilephila elpenor (Linn.,	Sphingidae	743	2	3	-

Species	Family	SAI (3-yr)	Gen./season	Sites (n)	New record
1758)					
Idaea aversata (Linn., 1758)	Geometridae	812	2	3	-
[+ 36 additional species]	[various]	-	-	-	-

SAI = Seasonal Abundance Index (total captures, all sites, 3 years). Sites: 1=Urgench, 2=Khiva, 3=Shovot, 4=Gurlan, 5=Yangibazar.

Discussion The 47 species recorded substantially expand the known macrolepidopteran fauna of Khorezm; earlier catalogues listed 31 species for the region [3], and 12 new records are confirmed by voucher specimens. Dominance of Noctuidae in abundance and richness is consistent with patterns reported from arid agricultural landscapes throughout Central Asia and the Middle East [12,13]. The detection of *Chrysodeixis chalcites* and *Mythimna loreyi* - reported as emerging pests in neighboring Kazakhstan and Turkmenistan over the past decade [14] - signals ongoing range expansion likely facilitated by climate warming and warrants prompt development of control thresholds for Uzbekistan.

The 4.3-day advantage of TrapView in detecting population peaks over weekly inspection has direct practical consequences: given the rapid larval development rates of *H. armigera* and *S. exigua* under Khorezm summer temperatures, earlier peak detection allows timely pesticide application before economically damaging larval cohorts establish in crops [11]. The system's continuous operation also eliminates the weekend inspection gaps and observer fatigue that routinely compromise conventional monitoring data quality. Accuracy rates of 85–91% for the three primary target species are comparable to those reported by Sarto i Monteys et al. [8] in European settings, confirming the transferability of the technology to Central Asian conditions.

Limitations include the relatively small number of sites (five) and the taxonomic bias inherent to species-specific pheromone lures. Light-trap supplementation partially addressed this, though with its own temporal and spatial constraints. Future work should incorporate a broader lure portfolio and extend monitoring to natural and semi-natural habitats.

Conclusion This study delivers the first systematic, multi-year macrolepidopteran dataset for the Khorezm Region of Uzbekistan based on automated digital trapping. Forty-seven species of Macrolepidoptera from 14 families were recorded, including 12 new regional records. TrapView continuous monitoring outperformed traditional weekly inspection in peak detection timing and provided a temporal resolution adequate for real-time IPM decision support. The high seasonal abundance of *H. armigera*, *S. exigua*, and *A. ipsilon*, frequently exceeding established economic thresholds, underscores the urgent need for expanded digital monitoring networks across Uzbekistan's cotton belt. Wider deployment of TrapView and integration of real-time phenological data into national plant protection advisory systems are strongly recommended.

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