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RESEARCH ARTICLE

New data on the distribution and ecology of *Lignyoptera fumidaria* (Hübner, 1825) in the steppe zone of Northern Kazakhstan

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Abstract

New data on the distribution and biology of *Lignyoptera fumidaria* (Hübner, 1825) in the steppe zone of Northern Kazakhstan is presented. As a result of surveys conducted in October 2025, two new localities of the species were identified in the Aiyrtau District, located 300 km south of previously published records within the region. A mass aggregation of approximately 250 males was recorded within an area of about 3 ha. Adult activity was observed under persistently sub-zero temperatures (down to −6 °C). The new findings significantly expand the current knowledge of the species' range in Western Siberia and Kazakhstan and highlight its potentially underestimated distribution within the steppe zone.

Keywords

Cold tolerance, daily activity, late-autumn flight, *Lignyoptera fumidaria*, new localities, Northern Kazakhstan, steppe ecosystems

Introduction

Lignyoptera fumidaria is a late-autumn geometrid moth exhibiting pronounced sexual dimorphism: males possess fully developed wings, are capable of active flight, whereas females have strongly reduced wings, and lead a predominantly ground-

dwelling lifestyle. This morphological specialization defines important aspects of population organization and detection. Males typically aggregate in areas where females occur, while females themselves are rarely recorded using standard survey techniques. In Europe, adult flight usually occurs in October–November, and occasionally extends into December (Manci et al. 2015; Manci et al. 2023). According to several studies, the species is associated with xerophytic grasslands, steppe habitats, and open xerothermal slopes, where it forms local and often persistent populations (Beshkov and Nahirnić-Beshkova 2022). The distribution range of *L. fumidaria* includes the Pannonian Plain, the Carpathians, the Balkans, Romania, Ukraine, southern European Russia, southern Western Siberia, and the Altai region (Vasilenko 2001; Hausmann 2011; Skou and Sihvonen 2015; Knyazev and Ivonin 2025). Its eastern range margin remains insufficiently studied. In Eastern Kazakhstan, only isolated records are known from the Katon-Karagay District and the surroundings of Serebryansk, where the species inhabits montane forest-steppe landscapes (Knyazev et al. 2021). In Northern Kazakhstan, the species had not been previously recorded and was not mentioned in earlier faunistic surveys (Knyazev 2015; Knyazev and Zuban 2016; Knyazev and Zuban 2019; Zuban et al. 2022; Knyazev 2024). The first confirmed record from the region was published in 2024, extending the known western limit of its distribution in Kazakhstan (Zuban et al. 2024). However, that record was based on single-night observations and did not allow characterization of the local population structure, temperature-related parameters of adult activity, or daily behavioral patterns. Overall, the species remains insufficiently studied in the southern part of Western Siberia and the steppe zone of Northern Kazakhstan. Its late-autumn flight, in combination with diurnal and nocturnal activity, suggests that its actual distribution along the eastern margin of the range may be underestimated. The present study aims to document new records of *L. fumidaria* in the steppe zone of Northern Kazakhstan and to refine the temperature conditions and daily patterns of adult activity.

Materials and methods

Field surveys were conducted on 10 October 2025 in the steppe zone of the North Kazakhstan Region, within the lake-associated landscapes of Lake Bolshoy Koskol (53.391183°N, 68.395744°E) and Lake Malyi Koskol (53.310225°N, 68.419973°E), located within the administrative boundaries of the Aiyrtau District (Fig. 1). The locality is represented by grass-halophyte steppe vegetation with the presence of *Limonium* sp. and *Glycyrrhiza* sp., indicating weakly saline soils. Narrow strips of Phragmites australis reed communities occur in depressions, forming small hydromorphic microhabitats. The study included daytime survey routes along linear transects 100–300 m in length, with simultaneous recording of air temperature and the onset and peak of adult activity. Identification of specimens was based on morphological characters consistent with diagnostic features of Geometridae and comparison with published descriptions of *Lignyoptera fumidaria*.

Material examined. Kazakhstan, North Kazakhstan Region, Ayiyrtau District: Bolshoy Koskol Lake, 53.391183°N, 68.395744°E, 10.X.2025, 2 ♂, leg. I.A. Zuban; Malyi Koskol Lake, 53.310225°N, 68.419973°E, 10.X.2025, 2 ♂, leg. I.A. Zuban. All collected specimens are deposited in the personal collection of the author. Male genitalia of one specimen from Lake Bolshoy Koskol are illustrated in Figs 4–5.

Additional observations: Visual surveys on 10.X.2025 recorded approximately 250 actively flying males at Bolshoy Koskol Lake and 8 males at Malyi Koskol Lake.

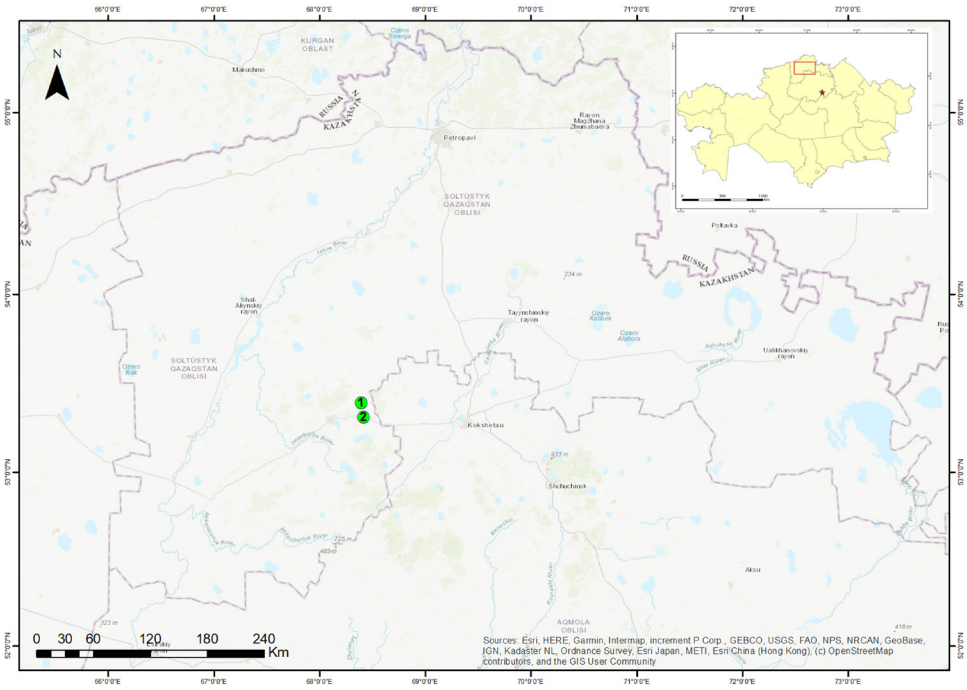

Figure 1. Map of the field survey sites in the steppe zone of Northern Kazakhstan.

Results

New localities and abundance

Two local populations of *Lignyoptera fumidaria* were recorded for the first time in the steppe zone of Northern Kazakhstan, in the surroundings of Lakes Bolshoy Koskol and Malyi Koskol (Figs 2–3). Near Lake Bolshoy Koskol, a mass aggregation of males was observed in a steppe area of approximately 2.7 ha situated between reed stands and a hay meadow along the eastern shore. During the early morning hours (immediately after sunrise), only single individuals were recorded; however, 1–2 hours after sunrise, flight intensity increased sharply. At that time, around 250 ac-

tively flying males were simultaneously observed within the surveyed area. At Lake Malyi Koskol, population density was noticeably lower. In a steppe pasture plot located between the northern lakeshore and the village of Antonovka, eight males were recorded. Despite the lower density, adult activity remained stable throughout the observation period, indicating the presence of a distinct local population.

Figure 2. Habitat of *Lignyoptera fumidaria* in Northern Kazakhstan, vicinity of Lake Bolshoy Koskol, 10 Okt 2025 (photo by I. A. Zuban).

Daily activity and temperature range of flight

The daily activity pattern of adults in the vicinity of Lake Bolshoy Koskol demonstrated the following dynamics. The first individuals were observed immediately after sunrise (around 06:10 local time) at air temperatures down to −6 °C. During this period, only isolated males were active, flying low (0.3–0.5 m) above the vegetation or along the edge of the hay meadow, with short and infrequent flights. As the air warmed, activity increased rapidly. One hour after the beginning of observations, at −4 °C, several dozen actively flying males were recorded over the site. Peak activity occurred between 10:00 and 11:00, when air temperature ranged from −3 to 0 °C. During this period, hundreds of individuals were simultaneously observed over the 2.7-ha area, exhibiting rapid flight at heights of 1.2–1.5 m with horizontal move-

ments of up to 20–25 m. At the second site (near Lake Malyi Koskol), observations were carried out from 11:30 to 13:00, and adult activity during this period was comparable to the peak levels recorded near Lake Bolshoy Koskol at air temperatures of up to 4 °C.

Figure 3. Habitat of *Lignyoptera fumidaria* in Northern Kazakhstan, vicinity of Lake Malyi Koskol, 10 Okt 2025 (photo by I. A. Zuban).

Discussion

Summary data on the distribution of *Lignyoptera fumidaria* presented in the literature indicate that the species occupies the Euro-Siberian sector of the Palearctic, extending from eastern Austria and Hungary through Romania and the Balkans, Ukraine and southern European Russia (from Crimea to the Southern Urals), including Northern Kazakhstan, and further eastward to the Altai region of Russia and Eastern Kazakhstan (Hausmann 2011; Skou and Sihvonen 2015; Beshkov and Nahirnić-Beshkova 2022; Zuban et al. 2024). In most parts of its range, the species is considered rare and localized, occurring mainly in remnants of steppe and xerothermal meadow habitats. In several sources, *L. fumidaria* is directly charac-

terized as a steppe relict (Manci et al. 2015; Manci et al. 2023). The new records from the surroundings of Lakes Bolshoy and Malyi Koskol occupy a geographically important position in the central part of the steppe zone of Northern Kazakhstan. They lie approximately 300 km south of previously published records for the North Kazakhstan Region (Zuban et al. 2024) and considerably west of the known occurrences in Eastern Kazakhstan (Knyazev et al. 2021). This suggests that the newly documented sites represent not an isolated peripheral outpost but part of a continuous steppe corridor forming the eastern margin of the species' Euro-Siberian distribution. Considering these new data, the range of *L. fumidaria* within the steppe and forest-steppe zones of Kazakhstan and southern Western Siberia may be viewed as more continuous than previously assumed; the observed *patchiness* of records is likely attributable to insufficient targeted surveys during the late-autumn period. Published data from Eastern Kazakhstan and Europe indicate that adult activity is usually recorded at positive late-autumn temperatures 9–16 °C (Knyazev et al. 2021), predominantly at night and at light sources (Manci et al. 2015; Manci et al. 2023). Our observations substantially expand this understanding: for the first time, a very daytime flight at consistently sub-zero temperatures has been documented (down to −6 °C at initial observations and 3–0 °C during peak activity). Such conditions have not previously been reported for the species in Eastern Kazakhstan, the Balkans, or Romania (Beshkov and Nahirnić-Beshkova 2022; Manci et al. 2023).

Figure 4. *Lignyoptera fumidaria* (Hübner, 1825), ♂ North Kazakhstan Region, vicinity of Lake Bolshoy Koskol, 10 Okt 2025.

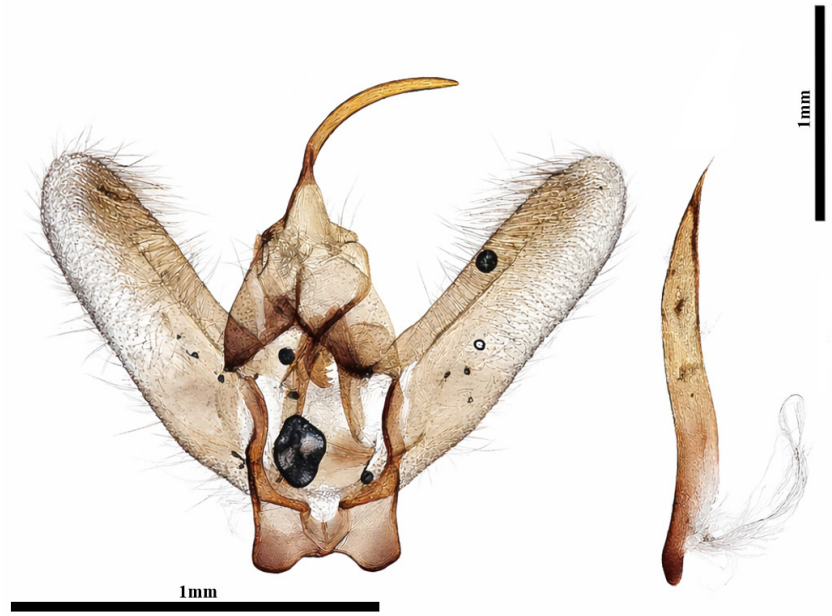

Figure 5. Male genitalia of *Lignyoptera fumidaria* (Hübner, 1825), North Kazakhstan Region, vicinity of Lake Bolshoy Koskol, 10 Okt 2025.

Combined data from 2024–2025 for Northern Kazakhstan allow us to infer a high degree of behavioral plasticity of the species under sharply continental climatic conditions. Several factors may explain this pattern. One possibility is regional climatic adaptation within local populations. Another factor may be the microclimatic warming of open steppe surfaces, which provides suitable conditions for flight activity even when air temperatures remain below zero. A further explanation is methodological, as the predominance of nocturnal sampling in earlier studies may have resulted in an underestimation of daytime activity.

Thus, the findings demonstrate that *L. fumidaria* is capable of intensive daytime flight at sub-zero temperatures – an important factor to consider in monitoring and planning future research on the species.

Conclusion

Because of the surveys conducted, *L. fumidaria* has been reliably recorded for the first time in the steppe zone of Northern Kazakhstan. The new findings confirm the stable presence of the species in the region and significantly expand current understanding of its distribution in southern Western Siberia. Previously undocumented for this region, active flight at negative temperatures and distinct daytime activity were recorded. This behaviour suggests a high level of adaptation

to the late-autumn conditions of open steppe landscapes.

The newly obtained data support the interpretation of the steppe zone of Northern Kazakhstan not as a peripheral segment of the species' range but as an integral part of the Euro-Siberian steppe corridor. The results highlight the need for further targeted field studies, including systematic daytime surveys, to refine our knowledge of the species' distribution and ecology.

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