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Article

Long-term dynamics of the composition, occurrence, and abundance of butterfly species (Lepidoptera, Papilionoidea) in the vicinity of Ukhta, Republic of Komi

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Abstract. This article presents the results of long-term observations of the dynamics in composition, abundance, and occurrence of butterfly species in the vicinity of Ukhta, Republic of Komi. It was found that from 1959 to 2024, the number of recorded species increased from 53 to 78. The core composition of the local fauna has been fully identified and includes 60 species; the rest are seasonal migrants and adventive species that have penetrated the study area over the past three decades. A significant portion of adventive species have successfully naturalized in local natural communities.

Keywords: local fauna, weather, climate, population dynamics, landscape activity

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Научная статья

Многолетняя динамика состава, встречаемости и численности видов булавоусых чешуекрылых (Lepidoptera, Papilionoidea) в окрестностях г. Ухты, Республика Коми

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Аннотация. В статье представлены результаты многолетних наблюдений за динамикой состава, численности и встречаемости булавоусых чешуекрылых в окрестностях г. Ухты, Республика Коми. Установлено, чтов период с 1959 по 2024 гг. число зарегистрированных видов увеличилось с 53 до 82. Коренной состав локальной фауны выявлен полностью и насчитывает 60 видов, остальные относятся к категории сезонных мигрантов и адвентивных видов, проникших на изучаемую территорию в последние три десятилетия. Значительная часть адвентивных видов успешно натурализовалась в местных природных сообществах.

Ключевые слова: локальная фауна, погода, климат, динамика численности, ландшафтная активность

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Introduction

Butterflies (Papilionoidea) are among the most studied insects in terms of taxonomy and faunistics. They are characterized by a rapid response to changes in environmental conditions (fluctuations in range boundaries and population sizes), which determines their high bioindicative properties and potential use in ecological monitoring.

The history of studying butterflies in the Republic of Komi spans over a century. Currently, the species composition of the superfamily has been almost fully identified, a comprehensive analysis of the territorial distribution of species along the latitudinal gradient from southern taiga to hypoarctic tundras has been conducted, and exhaustive lists of zonal, belt, and local faunas have been compiled. The accumulated material has laid the foundation for studying and analyzing the variation in species diversity of this insect group not only in space but also over time.

In recent decades, the method of local faunas has become increasingly widespread in the comparative analysis of faunistic materials. Similar to the concept of "local flora" in botany (Morozova, 2008), local fauna represents a convenient working unit reflecting the results of inventorying animal species diversity at a specific geographic point (locality) (Chernov and Penev, 1993).

It is believed that long-term studies of local faunas only increase the representation of accidental and migrating species in the lists, whose presence is often determined by variable climatic conditions (Makarov and Matalin, 2009). In terms of inventorying species composition, this judgment can be considered valid. However, confirming the habitat status of species (permanent, temporary, periodic, accidental) and establishing trends in species diversity changes in a given geographic area is only possible through long-term observations. Modern weather and climate fluctuations and anthropogenic transformation of landscape and biotope conditions lead to a decline in the number and even extinction of some species, while simultaneously facilitating the expansion of the ranges of others. Through seasonal migrations and ephemeral presence in territories, many species gradually adapt to new environmental conditions and ultimately naturalize in local natural communities. Long-term monitoring of local faunas of different taxonomic groups makes it possible to record such changes in the species composition and structure of the animal population, and ultimately contributes to assessing the state of regional biodiversity and the overall ecological situation.

The purpose of this work is to describe and analyze long-term changes in the structure of the Ukhta local butterfly fauna that have occurred over 60 years since the beginning of observations.

Study area, materials, and methods

The article is based on materials about butterflies collected by K.F. Sedykh in Ukhta (Republic of Komi, N 63.58° E 53.66°E) and its surroundings from the mid-20th to the early 21st century, both published (Sedykh, 1974, 1977; Sedykh and Sedykh, 1959) and preserved in diary entries, as well as the results of field studies conducted by the authors since 1990.

Butterflies inhabiting Ukhta and its surroundings are considered in this article as the Ukhta local fauna. In zoological works, which traditionally study not the fauna as a whole but only individual taxonomic groups, the territorial size of the local fauna can vary depending on the ecological-chorological features and the degree of study of the selected animal taxa. In this work, the local butterfly fauna is considered as the composition of species identified in all habitat types within a radius of 10–15 km from the selected geographic point (locality). This size of the local fauna is explained by the features of landscape-biotopic distribution and the methodology for recording species in this insect group.

The discussed territory is located in the center of the Republic of Komi, at the border of the middle and northern taiga subzones (Fig. 1). According to one of the latest physical-geographical zoning schemes, it is part of the Timan landscape region of the Russian Plain (Krivtsov and Vodorezov, 2016), and previously belonged to the Nizhneukhtinsky landscape district of the Timan northern taiga province (Isachenko, 1964). The vegetation cover of the watersheds is dominated by spruce and spruce-birch forests; on the stony slopes of the Timan Ridge (up to 200 m a.s.l.) and floodplain terraces, pine forests grow, sometimes with a noticeable presence of larch. The wide and flat depressions separating the uplands and ridges are occupied by sphagnum bogs, usually overgrown with sparse pine. In the floodplains of the rivers – Ukhta, Yarega, Chuti, Domonik, Chibyu, Lyayol, Sedyu – meadow communities, especially poly-dominant tall-grass and grass-forb, as well as willow thickets, are common. Local natural landscapes have been significantly transformed by humans. The territory is covered by a dense network of roads, intersected by a railway, oil and gas pipelines, and power lines. Almost all forest stands have



Fig. 1. Map of the study area. The circular contour indicates the accepted boundaries of the Ukhta local fauna. 1–4 – locations of transects where long-term counts of butterfly abundance were conducted.

been logged over the past 100 years; about half of the area is occupied by urbocenoses (the city of Ukhta, satellite settlements Shudayag, Yarega, Nizhny Domonik, Pervomaisky, Vodny, Vetlosyan, Dalny, Sedyu, dacha areas), abandoned and cultivated agrocoenoses, various economic and recreational buildings with accompanying infrastructure.

Data on species representation (abundance, occurrence, polytope) in the local fauna over the long-term period vary greatly. In the first publication (Sedykh and Sedykh, 1959), a non-strict expert assessment is provided for each species found: very common, common, rare, very rare, single. In subsequent works by K.F. Sedykh (1974, 1977), only species findings in the study area are indicated. Since 1990, the authors of the article have been conducting regular quantitative counts of butterfly imagines on linear plots (transects) using developed methods (Pollard, 1977; Pollard and Yates, 1993; Sevilleja et al., 2019). The article provides estimates of the relative abundance and occurrence of species in the vicinity of Ukhta for 1998, 2016, and 2024, reflecting the state of the local fauna at the beginning, middle, and end of the authors' observation period.

To level out differences in the procedure for recording species, which inevitably arise during long-term studies, they are presented in a generalized form using landscape activity scores. The landscape

activity of a species is an assessment of its occurrence (commonness) and average abundance (mass) taking into account the mosaicism or homogeneity of its distribution in the corresponding local faunas (Tatarinov and Kulakova, 2020).

Landscape activity scores of species:

1) Inactive – findings of single specimens of the species, based on which it is impossible to determine its habitat status or adequately assess the number and nature of the territorial distribution of the local population grouping within the studied local fauna.

2) Low-active – a low-numbered (relative abundance in topic groupings up to 5%) species, inhabiting less than 10% of its characteristic habitat types within the studied local fauna.

3) Medium-active – a moderately numerous (relative abundance in topic groupings 5–10%) species, inhabiting at least 50% of its characteristic habitat types within the studied local fauna.

4) Highly active – a numerous (relative abundance above 15%) or moderately abundant (10–15%) species, included in the "background core" of topic groupings in most (at least 75%) of its characteristic habitat types within the studied local fauna.

We specifically emphasize that the concept of "landscape activity" of species, used by us in relation to butterflies, is not a complete analogue of this concept in floristics. Here it is only a convenient integral indicator that allows us to get a general idea of the number and occurrence of the species within the territorial boundaries of the local fauna. For some species, the article provides information on the long-term dynamics of their abundance (density, ind./ha) on four selected transects.

When discussing the role of weather and climate factors in the long-term dynamics of butterfly species diversity, we used openly available data from instrumental observations at the Ukhta weather station[1].

The scientific nomenclature of butterflies is presented according to the "Catalogue of the Lepidoptera of Russia" (2019) with minor changes. The semantic content of concepts and the classification of adventive and neobiont butterfly species are presented in one of our previous works (Tatarinov and Kulakova, 2023).

Results

The first published list of butterflies in the Ukhta local fauna contained 53 species (Sedykh and Sedykh, 1959); over the next three decades, it was supplemented by another 12 species (Sedykh, 1974, 1977). As of 2024, a total of 82 species with varying abundance, occurrence, and habitat status have been recorded in Ukhta and its surroundings (Table 1). According to this indicator, the local fauna is one of the richest in the Republic of Komi. Of the total list, 60 species (74% of the composition and about 85% of the numerical abundance) can be called native (resident, sedentary), as they are represented here by stable populations that obviously formed long before the beginning of the observation period. The composition of native species, which is considered a stable component of the local fauna (Makarov and Matalin, 2009), was almost completely identified by K.F. Sedykh. Later, we discovered local sedentary groupings of the fritillary *Neptis rivularis* and the blue *Cupido minimus*, and also established the presence of a cryptic species – the wood white *Leptidea juvernica*.

Monitoring observations in Ukhta and its surroundings have shown that the representation of most (~80%) native butterfly species has not changed significantly over the past three decades. This primarily applies to the so-called "background" species, which are quite numerous, eurytopic, and generally common in the study area. High and medium landscape activity was maintained throughout the years by whites *Pieris napi*, *Leptidea sinapis*, *Anthocharis cardamines*, blues *Callophrys rubi*, *Cyaniris semiargus*, *Polyommatus icarus*, pearl-borders *Brenthis ino*, *Clossiana selene*, *C. euphrosyne*, although fluctuations in the abundance of imagines of these species were observed on transects in different years (Fig. 2).

In urbocenoses, agrocoenoses, and anthropogenic stations (ruderals, wastelands, etc.), the abundance of nymphalids *Araschnia levana*, *Nymphalis urticae*, *Polygonia c-album*, whites *Pontia daplidice*, and yellows *Colias hyale* has slightly increased. The last two species have begun to appear here annually, including as part of the spring-early summer phenological complex of imagines, so it can be assumed that they have successfully naturalized in local conditions and thus moved from the category of ephemerobionts and colonobionts to the category of agrobionts. In meadow and forest-edge habitats, the skipper *Hesperia sylvanus* and the brimstone *Gonepteryx rhamni* have become more common and numerous. In the last decade, we have discovered new local population groupings of the

[1] Weather and climate. Web page. URL: http://www.pogodaiklimat.ru/today/russia/komi/ukhta (accessed: 20.04.2026).

Table 1. Composition and representation of species of the Ukhta local butterfly fauna from 1959 to 2024. Species Representation Assessments: s – single, r – rare or very rare, c – common or very common (Sedykh and Sedykh, 1959); (+) – listed without abundance or occurrence assessment in the works of K.F. Sedykh (1974, 1977); (–) – not found; 1–4 – landscape activity scores of species (see text for details).* – averaged assessment for species with pronounced interannual dynamics in abundance and a two-year development cycle. Dynamics of species representation during the specified period: inc – increased, dec – decreased, st – remained relatively stable, fl – fluctuated, ? – undetermined. Species habitat status: n – native species, sm – regular seasonal migrant, ao – accidental single occurrences, a – agrobiont successfully naturalized in local natural communities during the observation period, ep – epeobiotic species, eph – ephemerobiotic species, cl – colonobiotic species, un – species with unclear habitat status.

Species	Assessment of species representation in different years					Dynamics	Species habitat status as of 2024
	1959	1974, 1977	1998	2013	2024		
FAMILY HESPERIIDAE							
Pyrgus alveus (Hüer, 1803)	c	+	1	1	–	?	un
P. centaureae (Rumbur, 1839)	–	+	1	1	1	st	n
P. malvae (Linnaeus, 1758)	c	+	3	3	3	st	n
Carterocephalus palaemon (Pallas, 1771)	c	+	3	3	3	st	n
C. silvicola (Meigen, 1829)	–	+	2	3	3	st	n
Hesperia comma (Linnaeus, 1758)	–	–	2	2	1	dec	n
Ochlodes sylvanus (Esper, 1777)	–	+	2	3	4	inc	n
Thymelicus lineola (Ochsenheimer, 1808.)	–	–	2	2	2	inc	n
FAMILY PAPILIONIDAE							
Papilio machaon Linnaeus, 1758	c/s	+	2	3	3	fl	n
Iphiclides podalirius (Linnaeus, 1758)	–	–	–	–	1	?	ao
Parnassius mnemosyne (Linnaeus, 1758)	–	+	3	1	1	dec	n
FAMILY PIERIDAE							
Leptidea morsei (Fenton, 1882)	–	+	2	2	3	st	n
L. juvernica Williams, 1946	–	–	–	2	2	?	n
L. sinapis (Linnaeus, 1758)	c	+	4	4	4	st	n
Pieris brassicae (Linnaeus, 1758)	c	+	3	–	–	dec	un
P. napi (Linnaeus, 1758)	c	+	4	4	4	st	n
P. rapae (Linnaeus, 1758)	c	+	4	3	2	dec	n
Pontia daplidice (Linnaeus, 1758)	–	+	1	2	2	inc	ep

Species	Assessment of species representation in different years					Dynamics	Species habitat status as of 2024
	1959	1974, 1977	1998	2013	2024		
Aporia crataegi (Linnaeus, 1758)	r	+	3*	3*	3*	fl	sm
Anthocharis cardamines (Linnaeus, 1758)	c	+	3	3	3	st	n
Colias hyale (Linnaeus, 1758)	r	+	1	2	2	inc	ep
C. palaeno (Linnaeus, 1758)	c	+	4	4	4	st	n
Gonepteryx rhamni (Linnaeus, 1758)	r	+	2	3	3	inc	n
FAMILY LYCAENIDAE							
*Fixsenia prun*i (Linnaeus, 1758)	–	–	1	2	2	inc	cl
Callophrys rubi (Linnaeus, 1758)	c	+	4	4	4	st	n
Lycaena phlaeas (Linnaeus, 1761)	–	–	2	1	–	?	un
L. helle ([Denis et Schiffermüller, 1775])	c	+	4	4	3	st	n
L. hippothoe (Linnaeus, 1761)	r	+	2	2	2	st	n
L. virgaureae (Linnaeus, 1758)	c	+	3	3	3	st	n
Celastrina argiolus (Linnaeus, 1758)	r	+	2	3	3	inc	n
Cupido minimus (Fuessly, 1775)	–	–	1	2	2	?	n
C. alcetas (Hoffmannsegg, 1804)	–	+	2	2	2	st	n
*Glaucopsyche alexi*s (Poda, 1761)	–	–	–	1	2	inc	cl
Aricia artaxerxes (Fabricius, 1793)	c	+	3	3	3	st	n
A. nicias (Meigen, 1830)	c	+	4	3	2	dec	n
Agriades optilete (Knoch, 1781)	c	+	4	4	4	st	n
Plebeius argus (Linnaeus, 1758)	r	+	3	3	3	st	n
P. idas (Linnaeus, 1758)	c	+	3	3	3	st	n
Eumedonia eumedon (Esper, 1780)	c	+	3	3	3	st	n
Cyaniris semiargus (Rottemburg, 1775)	c	+	4	4	4	st	n
Polyommatus icarus (Rottemburg, 1775)	c	+	4	4	4	st	n
P. amanda (Schneider, 1792)	–	+	2	2	2	st	n

Species	Assessment of species representation in different years					Dynamics	Species habitat status as of 2024
	1959	1974, 1977	1998	2013	2024		
FAMILY NYMPHALIDAE							
Limenitis populi (Linnaeus, 1758)	–	–	2	3	3	inc	a
Neptis rivularis (Scopoli, 1763)	–	–	–	1	2	?	n
Argynnis paphia (Linnaeus, 1758)	–	–	2	3	2	inc	a
A. adippe ([Denis et Schiffermüller, 1775])	–	+	2	2	2	st	n
A. aglaja (Linnaeus, 1758)	c	+	3	3	3	st	n
Issoria lathonia (Linnaeus, 1758)	s	+	1	–	–	?	un
Brenthis ino (Rottemburg, 1775)	c	+	4	4	4	st	n
Boloria aquilonaris (Stichel, 1908)	c	+	3	3	3	st	n
Clossiana eunomia (Esper, 1799)	s	+	3	3	3	st	n
C. angarensis (Ershoff, 1870)	–	+	–	1	1	?	n
C. euphrosyne (Linnaeus, 1758)	c	+	4	4	4	st	n
C. selene ([Denis et Schiffermüller, 1775])	c	+	4	4	4	st	n
C. titania (Esper, 1793)	c	+	2	2	2	st	n
C. freija (Thunberg, 1792)	r	+	3	2	1	dec	n
C. frigga (Thunberg, 1792)	s	+	1	1	1	?	n
C. thore (Hübner, 1803)	–	–	–	1	1	?	n
Nymphalis antiopa (Linnaeus, 1758)	c	+	4	3	4	st	n
N. xanthomelas (Esper, 1781)	–	–	1	3*	1	fl	sm
N. urticae (Linnaeus, 1758)	r	+	3	4	4	st	n
N. io (Linnaeus, 1758)	–	–	–	–	1	inc	sm
Polygonia c-album (Linnaeus, 1758)	c	+	3	4	4	inc	n
Vanessa atalanta (Linnaeus, 1758)	s	+	1	1	1*	fl	sm
V. cardui (Linnaeus, 1758)	c	+	2*	3*	3*	fl	sm
Araschnia levana (Linnaeus, 1758)	c	+	3	3	4	inc	n

Species	Assessment of species representation in different years					Dynamics	Species habitat status as of 2024
	1959	1974, 1977	1998	2013	2024		
Euphydryas ichnea (Boisdüval, 1833)	–	+	–	2	2	st	n
E. maturna (Linnaeus, 1758)	c	+	3	3	3	st	n
Melitaea diamina (Lang, 1789)	c	+	3	3	3	st	n
M. athalia (Rottemburg, 1775)	c	+	3	3	3	st	n
FAMILY SATYRIDAE							
Pararge aegeria (Linnaeus, 1758)	–	–	–	1	2	inc	eph
Lasiommata maera (Linnaeus, 1758)	–	+	1	1	2	?	n
L. petropolitana (Fabricius, 1787)	c	+	3	3	3	st	n
Coenonympha glycerion (Borkhausen, 1788)	–	–	–	1	1	?	eph
C. tullia (Müller, 1764)	c	+	2	2	2	st	n
Maniola jurtina (Linnaeus, 1758)	–	–	1	2	2	inc	a
Hyponephele lycaon (Rottemburg, 1775)	–	–	–	–	1	?	
Aphantopus hyperantus (Linnaeus, 1758)	–	–	–	–	1	?	un
Erebia embla (Thunberg, 1792)	r	+	3*	2*	2*	dec	n
E. ligea (Linnaeus, 1758)	c	+	4*	4*	2*	st	n
E. euryale (Esper, 1805)	c	+	4*	4*	3*	st	n
Oeneis jutta (Hübner, 1806)	c	+	3*	2*	2*	st	n
TOTAL	**53**	**63**	**70**	**76**	**78**		

fritillary *Neptis rivularis*, the pearl-border *Clossiana thore*, and the satyr *Lasiommata maera*, which has increased their representation in the local fauna.

At the same time, we have to state that in the vicinity of Ukhta, over the past three decades, the representation of browns *Erebia euryale* and *E. ligea* has noticeably decreased (Fig. 3). In the first years of our quantitative counts, they undoubtedly dominated in terms of abundance in the butterfly population of meadow and forest-edge habitats. On some plots, the density of chronological subpopulations of each species in even years exceeded 100 ind./ha. The subpopulation of the odd year *E. ligea* here is extremely few in number (< 10 ind./ha), and for *E. euryale* it is absent. The limiting factors that led to a decrease in the number and occurrence of these species in the local fauna have not yet been established.

From 1991 to 2024, there was a decrease in the landscape activity of some other species. Among them, unfortunately, is the protected Apollo *Parnassius mnemosyne*, for which the extinction of local population groupings in the floodplain habitats of the Chuti and Ukhta rivers has been recorded. This is directly related to the high economic and recreational load that these natural communities are currently experiencing. We also note the complete disappearance from the study area of the white *Pieris brassicae* and a sharp decline in the number and occurrence of another garden white – *P. rapae*. We associate this phenomenon, first of all, with the reduction in the study area of the sowing areas of cruciferous crops – cabbage, mustard, etc., on which these species develop.

As of 2024, more than a quarter of butterfly species (26%) from the Ukhta local fauna are seasonal migrants (accidental, sporadic, and regular) or belong to various categories of neobionts that have penetrated the study area after 1991 and represent the labile component of the fauna.

Regular seasonal migrants in the Ukhta local fauna are nymphalids *Vanessa cardui* and *V. atalanta*. Every year, in varying numbers, they appear at the beginning of the growing season and, as a rule, leave offspring that, after completing preimaginal development, migrate south. This category should also include the white *Aporia crataegi*, for which a 10–13-year cycle of abundance fluctuations from temporary "disappearance" to outbreaks of mass reproduction in local faunas has been established

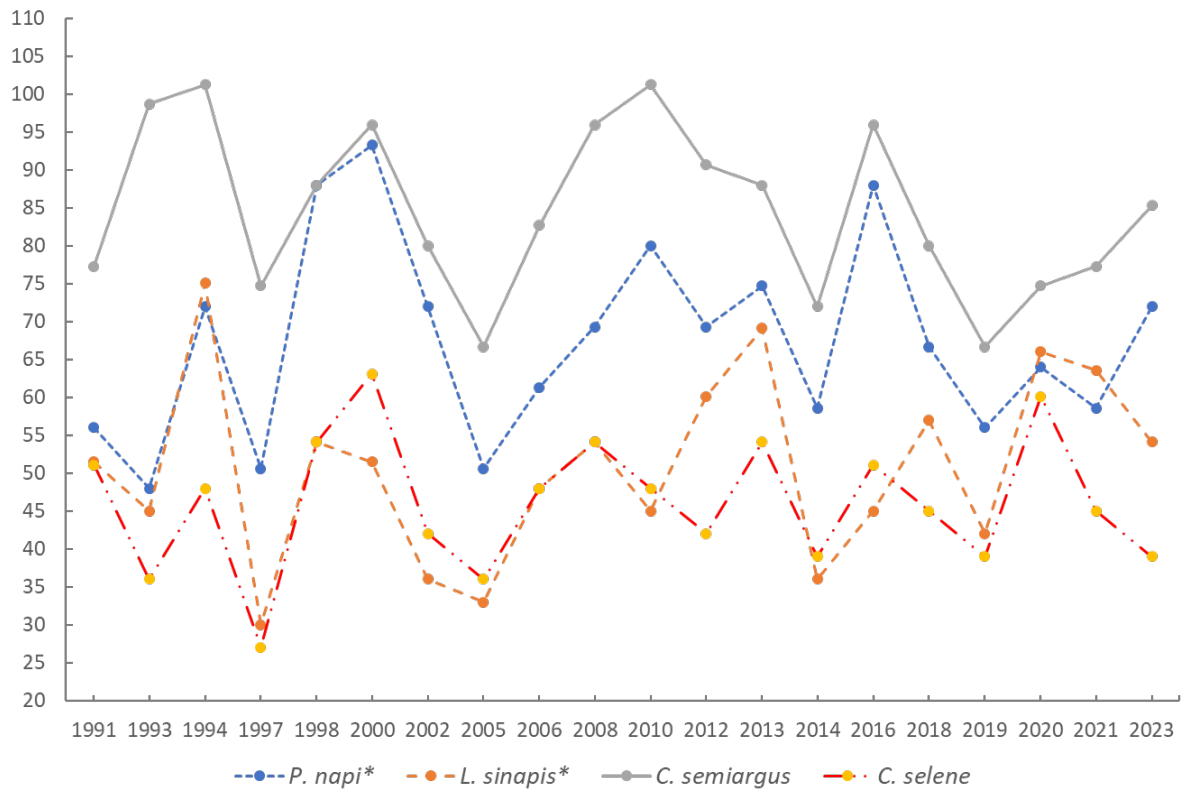


Fig. 2. Long-term dynamics of the abundance of "background" butterfly species on transect No. 2. The x-axis shows the years of observation, and the y-axis shows the calculated density of the species, ind./ha. * – data for imagines of the first (spring-early summer) generation.

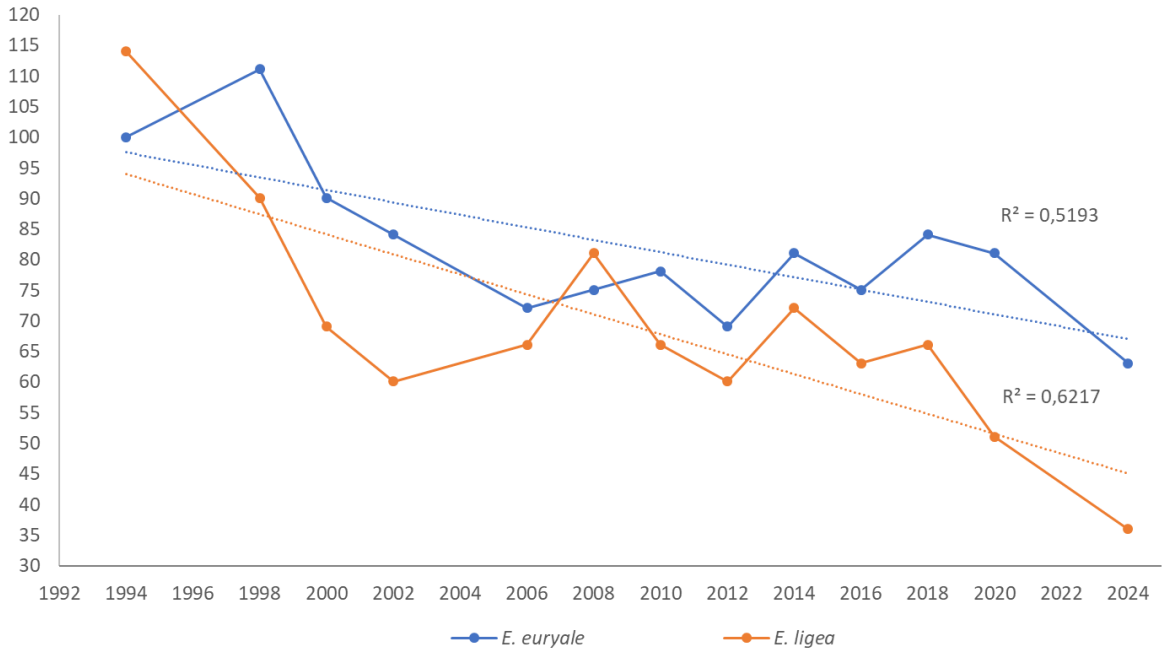


Fig. 3. Long-term dynamics of the abundance of browns *Erebia euryale* and *E. ligea* on transect No. 1. The x-axis shows the years of observation, and the y-axis shows the calculated density of the species, ind./ha. The dotted line indicates the polynomial trend line. R^2 – approximation reliability.

in the northeast of the Russian Plain, the Urals, and Western Siberia (Solonkin, 2023; Tatarinov and Kulakova, 2023). In the vicinity of Ukhta, peaks in the abundance of this white were observed in 2001 and 2012–2013. Since 2020, the nymphalid *Nymphalis io* has been regularly recorded in the vicinity of Ukhta, and in April 2023, 7 individuals that successfully overwintered in urban development conditions were found.

We currently classify single encounters of imagines of the swallowtail *Iphiclides podalirius* in the vicinity of Ukhta as accidental flights. This species penetrated the territory of the Republic of Komi in the 1990s and has already successfully naturalized in taiga biocenoses up to the middle reaches of the Vychegda River. The appearance of the first butterflies at the border of the middle and northern taiga in 2021 and 2024 indicates very high rates of dispersal of this species to the north and the near prospect of its addition to the permanent composition of the Ukhta local fauna as a neobiont.

Over the past three decades, about a dozen new butterfly species have penetrated the study area from the south. Many of them are trying to adapt or have already successfully naturalized in local conditions. These include the skipper *Thymelicus lineola*, the chequered skipper *Fixsenia pruni*, the blue *Glaucopsyche alexis*, and the satyrs *Pararge aegeria*, *Aphantopus hyperantus*, *Hyponephele lycaon*, and *Coenonympha glycerion*.

Discussion

When discussing the possible causes of long-term changes in the structure of the Ukhta local fauna, it is first necessary to focus on the role of weather and climate fluctuations that occurred during the observation period. The level of species richness of butterflies, like many other taxonomic groups of animals and plants, in the North is primarily determined by the heat supply of the territory (Chernov, 1989; Chernov and Penev, 1993). Therefore, it is quite logical to consider the role of the following temperature indicators:

1) average July temperatures, when the flight of the main mass of butterfly imagines of this local fauna occurs;

2) average January temperature, which can affect the survival of species during the winter period;

3) average annual air temperature, which in the long term allows us to judge the presence or absence of stable changes in the temperature regime of the study area.

The results of instrumental observations at the Ukhta weather station indicate that over the past 60 years there have been significant fluctuations in the average temperatures of the warmest (July) and coldest (January) months, although no stable trend toward an increase or decrease in these indicators has been identified (Fig. 4). It is with this that we associate the periodic fluctuations in the abundance of some background species on transects, when weather conditions directly affected the activity of imagines during field work and ultimately were reflected in the survey results. As an illustration, we present the results of observations of the interannual dynamics of the density of three butterfly species on transect No. 4 in connection with the dynamics of the average daily air temperature in July and January (Fig. 5). As we can see, the abundance of imagines on the transect correlates well with July temperature indicators, while the connection with January temperatures is less obvious.

The decline in the number of some butterfly species is directly related to natural successional processes occurring in natural communities. The influence of the overgrowth of secondary mixed-grass meadows on the structure of the butterfly population during restorative succession was discussed in detail in our special article (Tatarinov and Kulakova, 2018). Similar phenomena are observed in bog areas. Earlier, we also published materials of observations on the long-term dynamics (from 1990 to 2006) of the composition and abundance of butterflies on two sphagnum bogs located within the territorial boundaries of the Ukhta local fauna (Tatarinov and Kulakova, 2009). Since the mid-90s, one of the bog plots, where transect No. 3 is located, has been inside a large dacha area and, due to changes in hydrological conditions, has begun to overgrow with pine. This has led to a decrease in the number and occurrence of hypoarctic-boreal species characteristic of taiga bogs – yellow *Colias palaeno*, blue *Agriades optilete*, pearl-borders *Clossiana eunomia*, *C. freija*, *C. angarensis*, *Boloria aquilonaris*, satyrs *Erebia embla*, and *Oeneis jutta*. To date, the bog has turned into a sphagnum pine forest, and since 2006, the number of most of the named species has decreased catastrophically (Fig. 6). Pearl-borders *C. freija* and *C. angarensis* have apparently become extinct on this plot, and judging by the slope of the trend lines, the same fate awaits the yellow *C. palaeno*, pearl-border *B. aquilonaris*, and satyr *Oe. jutta* in the near future. However, this example is rather an exception for the Ukhta local fauna. As is known, bog massifs and the associated animal and plant populations suffer primarily from drainage works. In the vicinity of Ukhta, they were carried out to a limited extent, so most local bogs still retain the natural structure of the butterfly population.

Despite significant fluctuations in the average temperature indicators of the warmest (July) and coldest (January) months in different years, a certain trend toward warming in the study area is still traced and is especially noticeable in the last quarter century. This is clearly demonstrated by the graph of average annual temperatures (Fig. 7), but the low values of approximation reliability (R^2) do not yet allow us to speak of a positive temperature trend. Overall climate warming has a positive effect, first of all, on the possibilities of naturalization of adventive butterflies. Almost all species that have penetrated the study area have successfully mastered local ecological niches as colonobionts and agrobionts.

Against the background of general climate warming, cases of seasonal migrations of species from subboreal regions have also become more frequent. Some of them have shown mass reproduction, and on regional and even multiregional scales. In 2013, the painted lady *Nymphalis xanthomelas* flew in large numbers throughout the territory of the Republic of Komi (Tatarinov and Kulakova, 2013). In 2018, the mass reproduction of the red admiral *Vanessa atalanta* covered the Russian Plain from the Volga region to the coast of the Barents Sea. In the study area, the highest recorded density of this species was recorded on August 3, 2018, on transect No. 2 – 411 ind./ha; on August 7, on transect No. 4, it was 383 ind./ha. Annual migrations accompanied by periodic outbreaks of abundance are also observed in the painted lady *Vanessa cardui*.

Without questioning the existence of a positive relationship between climate parameters and the dynamics of abundance and occurrence of species, we are still not inclined to overestimate its significance in the dispersal and naturalization of butterflies. Success in this process is largely predetermined by the availability of immigration routes and habitats on new territories that meet their ecological preferences. It is known that many animals and plants actively disperse along river valleys and terraces and find suitable conditions in intrazonal and anthropogenic habitats beyond the main range. According to Yu.I. Chernov (1978), this is a regular process of dispersal capabilities, which can contribute to the rapid expansion of the range during climatic shifts. Currently, similarly and jointly with river valleys, the function of quasi-natural corridors is performed by a complex of linear transport and industrial structures (railway, highways, oil and gas pipelines, power lines) connecting the study area with southern territories. It is the factor of geodiversity that currently contributes to the enrichment of the Ukhta local fauna due to

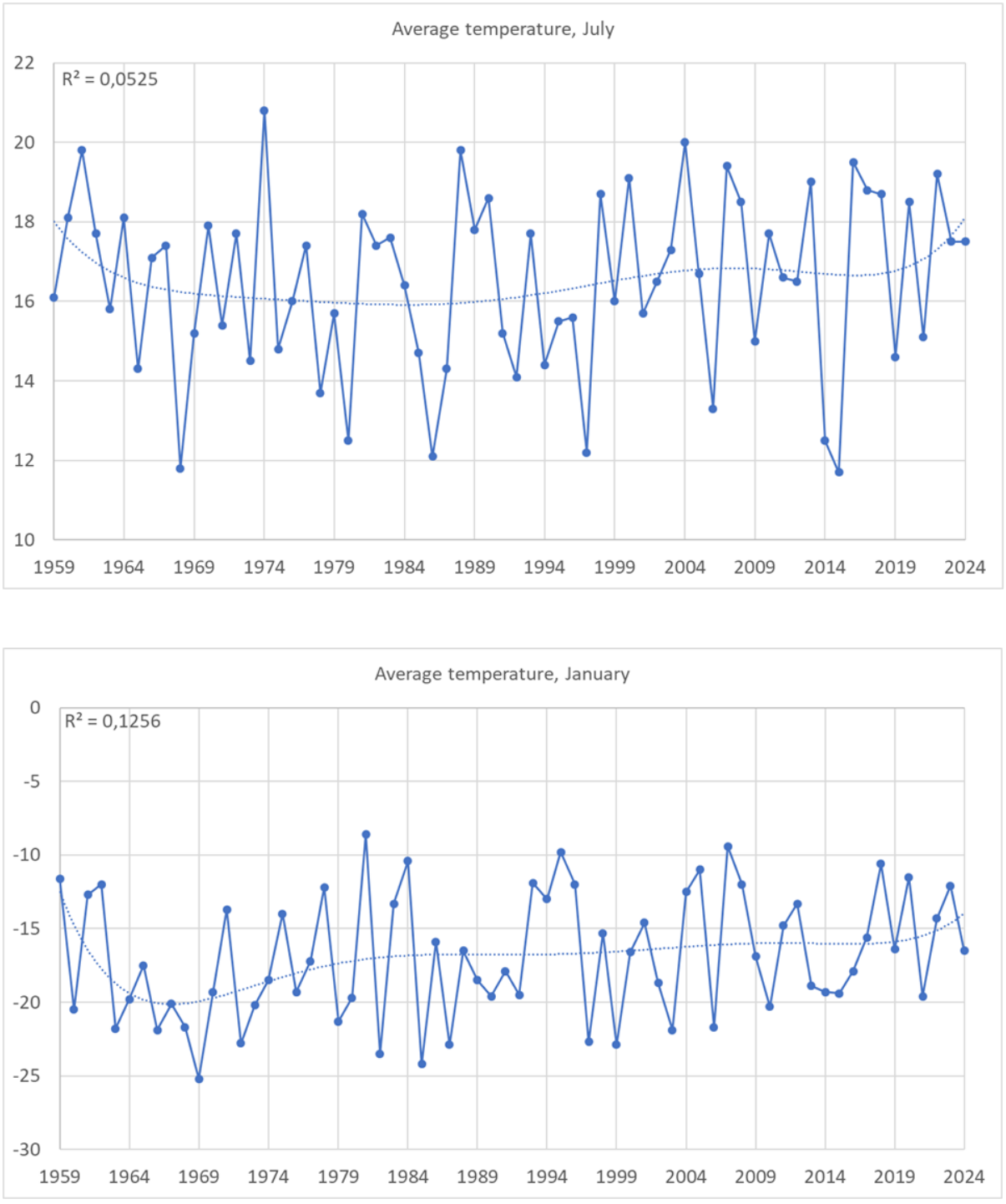


Fig. 4. Long-term dynamics of average monthly temperatures in the vicinity of Ukhta. The dotted line indicates the polynomial trend line. R^2 – approximation reliability.

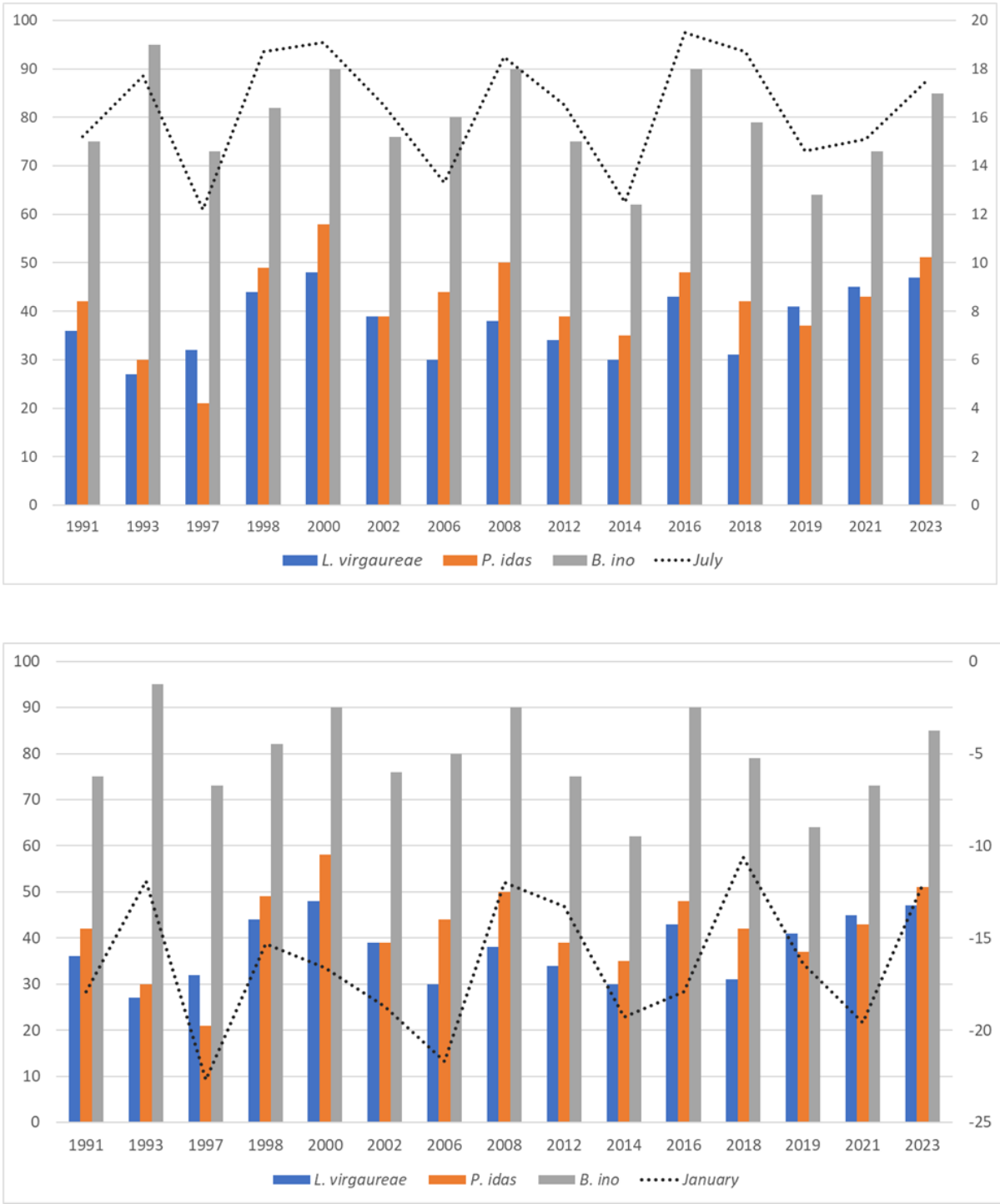


Fig. 5. Interannual dynamics of the abundance of three butterfly species on transect No. 4 in relation to the dynamics of the average daily air temperature in July (**A**) and January (**B**). The x-axis shows the years of observation, the main y-axis shows the calculated density of the species, ind./ha, and the secondary y-axis shows the temperature values, °C.

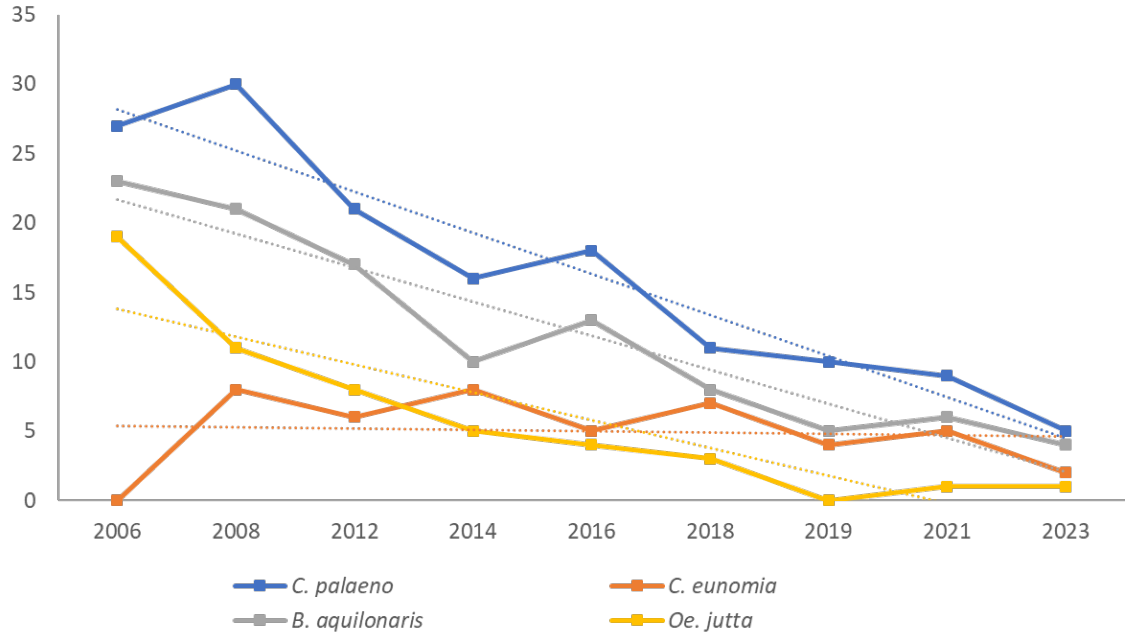


Fig. 6. Long-term dynamics of the abundance of hypoarctic-boreal butterfly species on transect No. 3. The x-axis shows the years of observation, and the y-axis shows the calculated density of the species, ind./ha. The dotted lines indicate the trend lines for each species.

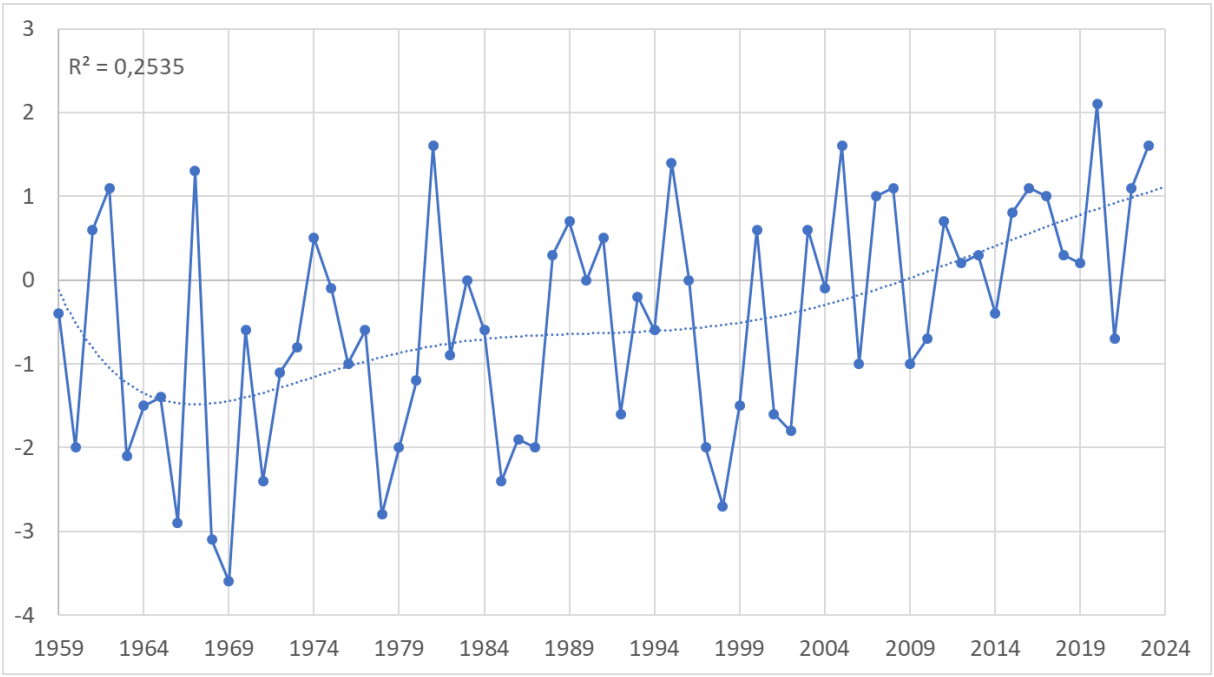


Fig. 7. Long-term dynamics of the average annual temperature in the vicinity of Ukhta. The dotted line indicates the polynomial trend line. R^2 – approximation reliability.

neobionts and seasonal migrants, largely determining the nature of changes in the species composition and structure of the butterfly population here. The dispersal and naturalization of neobiont butterflies is also facilitated by the spread of adventive plants in the region, which are included in the number of food plants for imagines and caterpillars, as well as the adaptation of species to new food species (Tatarinov and Kulakova, 2023).

Conclusion

The species diversity of butterflies in the Ukhta local fauna is one of the highest in the Republic of Komi. This is primarily explained by the 60-year history of its study, which has created the foundation for analyzing the long-term dynamics of species composition and abundance.

It has been established that the landscape activity of most native species has not undergone significant changes over the past 30 years. The decline in the number of some species occurred against the backdrop of restorative successional processes taking place in the vegetation cover of their habitats.

The overall level of species richness in the Ukhta local butterfly fauna has increased from 53 to 82 over the past 60 years, mainly due to adventive species that, against the backdrop of a marked trend toward climate warming, have begun to actively disperse from southern regions along natural (river valleys) and quasi-natural corridors (railways, roads, power lines, oil and gas pipelines). Most of them have found suitable habitats and the necessary food base for development here and are gradually naturalizing in local natural communities.

Long-term observations in other regions of the European Northeast of Russia (Tatarinov and Kulakova, 2023, 2024) confirm the regional scale of such changes in the structure of local butterfly faunas: the dispersal and naturalization of adventive species are occurring along the entire latitudinal gradient from the southern taiga to the forest-tundra and tundra zones.

It can be confidently predicted that if the trend toward climate warming continues, changes in the fauna and population of butterflies in the vicinity of Ukhta will persist and even increase. In the short term, the appearance and naturalization of new adventive species can be expected here, which will undoubtedly affect the composition of the local fauna and the spatial-typological structure of the population.

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