

Changes in the noctuid moth fauna (Lepidoptera: Noctuoidea: Erebidae, Noctuidae) of the Karkonosze National Park (SW Poland) at the turn of the 20th century

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Abstract: Faunistic analysis of records of noctuid moths (Lepidoptera: Noctuoidea: Erebidae, Noctuidae) from the Karkonosze National Park (Karkonosze Mts., southern Poland) obtained at the turn of the 19th century, in the late 20th century and the last two years has revealed changes in this assemblage: 18 species were never recorded before in this national park, and 9 of them were new to the Polish Karkonosze Mts. as a whole. A further 11 species were found that had been recorded at the turn of the 19th century but not confirmed in the late 20th century.

Key words: noctuid moths, faunistic records, new localities, the Sudetes

Introduction

Extensive research into the distribution, ecological requirements and threats to butterflies and moths in Poland in the late 20th century provided conclusive evidence for their diminishing diversity. This has been caused mainly by the degradation and subsequent shrinking of the natural environments inhabited by particular species, especially stenotopic ones, which inhabit small, isolated and often relictual localities (Buszko & Nowacki 2000, 2002, Głowaciński & Nowacki 2004). To a large extent, this concerns lepidopteran species living in montane ecosystems, which by definition are limited in area. In this respect, the Karkonosze National Park (KNP), conserving the naturally most valuable parts of the Polish Karkonosze Mountains (Czech - Krkonoše, German - Riesengebirge) hosts a number of nationally unique ecosystems supporting stenotopic butterflies and moths.

The lepidopteran fauna of the Karkonosze Mts. was already relatively well researched by the turn of the 19th century (Borkowski *et al.* 2004). Historical information related to this region's noctuid moths is given in Marschner

(1932–1934), Wocke (1872) and Wolf (1935–1944). Those authors collated much of the information published in late 19th century review papers and acquired from the collections of the many lepidopterologists who studied this region's butterflies and moths. Several of the noctuid species they recorded are extremely rare in central Europe and, as far as Poland is concerned, are known only from a few localities in the mountains.

Human activities in the 20th century drastically reduced the world's natural resources. The ecosystems of the Karkonosze region were no exception, and the radical transformation in the late 19th – early 20th centuries of the natural lower montane forest ecosystems to unnatural spruce monocultures had especially devastating consequences. A hundred years later, whole swathes of these forests, even within the KNP, were dead or moribund (Fabiszewski 1985). This imbalance among the KNP's ecosystems led to a continual decline in its biodiversity. This was confirmed by studies of noctuid species, carried out the Polish Karkonosze Mts. in the late 20th century (Chrzanowski 2004, Nowacki 1998), which failed to confirm the presence of many moths that had been recorded there 100 years

earlier. These included the most valuable stenotopic species, occurring exclusively in mountain areas, such as *Xestia alpicola* (Zetterstedt, 1839) and *X. collina* (Boisduval, 1840) or *Euxoa birivia* (Denis & Schiffermüller, 1775) and *Trichosea ludifica* (Linnaeus, 1758), which were still present there in the 1960s (Borkowski 1985). Nowacki (1998) reported a number of species from nearby localities, albeit beyond the physiographical boundary of the Karkonosze Mts., mainly in the Jelenia Góra basin, e.g. Cieplice and Jelenia Góra, and also Górzyniec in the Izera Mts. For obvious reasons, we have omitted these species from the present paper; in addition, we have not included certain records from the paper by Wolf (1935–1944) which, though labelled “Riesengebirge” (Karkonosze Mts.), were actually from localities beyond these mountains.

In the 25 years since that time, both government decisions and regional initiatives have led to concerted efforts being made to restore the natural equilibrium of the Karkonosze ecosystems, especially the lower montane forests of the KNP (Raj 2019). In this context, we formulated the following research hypothesis: since the main factors, earlier responsible for environmental degradation in the KNP, have been steadily diminishing over the last 25 years, a gradual recovery of the populations of most of the noctuid species recorded in the Karkonosze Mts. at the turn of the 19th century is likely taking place, although some of the most sensitive, stenotopic species may well have been irretrievably lost. Furthermore, one can assume that some new species, not recorded earlier in the Karkonosze Mts., are now present in the KNP as a consequence of the changes to its ecosystems due, for example, to global climate warming. To test this hypothesis, we carried out fieldwork in an attempt to rediscover species in the KNP that were recorded in the Polish Karkonosze Mts. by Wolf (1935–1944), but not in the late 20th century, when the environmental devastation there was at its

worst, as well as new species, previously never recorded in the study area.

Material and methods

The adult moths (Lepidoptera: Erebidae, Noctuidae) were trapped during fieldwork in 2019 and 2020 at a number of localities in different ecosystems of the KNP, from those characteristic of the lower montane forest zone (500–1000 m a.s.l.), through the upper montane forest zone (1000–1250 m a.s.l.) to the subalpine ecosystems above the tree line (1250–1450 m a.s.l.). The research material was obtained at the following sites (geographical coordinates according to Google Maps): the lower montane forest zone: Chojnik Kseroterm (50.832986, 15.644650), Chojnik Piekielna Dolina (50.835257, 15.639877), Chojnik Podzamcze (50.833499, 15.652518), Jagniątków (50.811945, 15.606499), Karpacz - KNP Information Centre (50.765452, 15.755109), Polana Jeżówka (50.810425, 15.611590) and Polana Krokusowa (50.811931, 15.615630) near Jagniątków; the upper montane forest zone: Kocioł Małego Stawu (50.748082, 15.702857), Mały Śnieżny Kocioł (50.782803, 15.556304), Torfowisko (peat bog) pod Kamiennikiem (50.791284, 15.497290); the subalpine ecosystems: Łabski Szczyt (50.780528, 15.545644). The moths were caught at night, the light of a generator-powered 250 W mercury-vapour lamp attracting them to a white screen. In addition, some of the research material was acquired using accumulator-powered portable light traps equipped with Philips 8 W UV blacklights, which were deployed each night in many different ecosystems. The voucher specimens are in the authors' collections.

Results

Our fieldwork in the KNP revealed the occurrence of 18 noctuid moth species which had never before been recorded in the Karkonosze National Park (indicated by *), and

another two, whose presence was confirmed after more than 100 years. Nine of these species are new to both the KNP and the Polish Karkonosze Mts. as a whole (**), while eleven were recorded in these mountains at the turn of the 19th century (***) .

Below we list the newly recorded species together with the places and dates of the records and the numbers of specimens.

- *Pechipogo strigilata* (Linnaeus, 1758) *, ***

Chojnik Piekielna Dolina, 17.06.2020, 1 ex., Jagniątków, 18.06.2020, 1 ex.

At present, common in most of Poland (Nowacki & Buszko 2019). Previously recorded in the Karkonosze region at Szklarska Poręba (Wolf 1935–1944), and much later at Górzyniec in the nearby Izera Mts. (Nowacki 1998).

- *Acronicta aceris* (Linnaeus, 1758) *, ***

Chojnik Ksero term, 17.06.2020, 1 ex., 9.07.2020, 1 ex., Mały Śnieżny Kocioł, 17.06.2020, 1 ex.

Not very common in most of Poland (Buszko & Nowacki 2017). Previously recorded in the Karkonosze region at Szklarska Poręba (Wolf 1935–1944), and much later in the nearby localities of Cieplice and Górzyniec (Nowacki 1998).

- *Schargacucullia scrophulariae* (Denis & Schiffermüller, 1775) *, ***

Chojnik Piekielna Dolina, 15.06.2020, 1 ex., Karpacz – KNP Information Centre, 9.07.2020, larvae 6 exx., Jagniątków, 8.07.2020, larvae 8 exx.

Infrequent at scattered localities in most parts of Poland (Buszko & Nowacki 2017). Previously recorded in the Karkonosze region at Szklarska Poręba (Wolf 1935–1944).

- *Hoplodrina respersa* (Denis & Schiffermüller, 1775) *, ***

Chojnik Ksero term, 15.06.2020, 3 exx., 17.06.2020, 4 exx., 18.06.2020, 6 exx.,

9.07.2020, 24 exx., 16.07.2020, 64 exx., Chojnik Piekielna Dolina, 15.07.2020, 3 exx., 16.07.2020, 1 ex., Jagniątków, 17.07.2020, 1 ex., Karpacz – KNP Information Centre, 15.07.2020, 1 ex., 30.07.2020, 1 ex., Polana Jeżówka, 15.07.2020, 5 exx., Polana Krokusowa, 17.07.2020, 2 exx.

A stenotopic species with a Ponto-Mediterranean distribution, occurring in xerothermic sward ecosystems on slopes and hills supporting steppe vegetation. Very localized in Poland, mainly in the south and east of the country (Nowacki & Buszko 2019). Previously recorded in the Karkonosze region at Szklarska Poręba (Wolf 1935–1944), and much later at Górzyniec in the nearby Izera Mts. (Nowacki 1998).

- *Agrochola laevis* (Hübner, 1803) *, **

Torfowisko (peat bog) pod Kamiennikiem, 13.09.2020, 1 ex.

Occurs locally all over Poland except in the north-east. Not usually very abundant, rarely found (Nowacki & Buszko 2019). Species new to the Polish Karkonosze Mts.

- *Conistra erythrocephala* (Denis & Schiffermüller, 1775) *, **

Chojnik Ksero term, 24.10.2019, 4 exx., 21.10.2020, 2 exx.

Localized throughout Poland. Not usually very abundant, rarely found (Nowacki & Buszko 2019). Species new to the Polish Karkonosze Mts.; the nearest historical record is from the Kamienna Góra area (Wolf 1935–1944).

- *Lithophane ornitopus* (Hufnagel, 1766) *, ***

Chojnik Ksero term, 21.10.2020, 3 exx., Polana Krokusowa, 21.10.2020, 1 ex.

Not very common anywhere in Poland (Buszko & Nowacki 2017). Previously recorded in the Karkonosze region at Szklarska Poręba (Wolf 1935–1944), and much later at Górzyniec in the nearby Izera Mts. (Nowacki 1998).

- *Polymixis xanthomista* (Hübner, 1819) ***

Karpacz - KNP Information Centre, 8.09.2020, 1 ex., 16.09.2020, 1 ex., 17.09.2020, 1 ex., Łabski Szczyt, 13.09.2020, 1 ex.

A highly stenotopic species with a Ponto-Mediterranean distribution, rare, and restricted to rocky xerothermic sward environments. In Poland, recorded at single localities, mainly in the southern half of the country from the Sudetes to the Pieniny and Tatra Mts. (Nowacki & Buszko 2019). Historical records in the Karkonosze region from Chojnik and Jagniątków (Wolf 1935–1944).

- *Apamea syriaca* Osthelder, 1933 *, **

Chojnik Kseroterm, 15.06.2020, 1 ex.

Another highly stenotopic species with a Ponto-Mediterranean distribution occurring in xerothermic sward environments. Its distribution in central Europe has expanded northwards in recent years. The first Polish records come from the early 21st century, but only from xerothermic localities in the Roztocze region (Nowacki 2006) and the Świętokrzyskie Mts. (Nowacki & Nowacka 2012), and more recently from xerothermic sward habitats in the valley of the River Nida (Nowacki & Wąsala 2020). Species new to the Polish Karkonosze Mts.

- *Apamea epomidion* (Haworth, 1809) *, **

Torfowisko (peat bog) pod Kamiennikiem, 15.07.2020, 1 ex.

Occurs all over Poland, but infrequently and at scattered localities (Buszko & Nowacki 2017). Species new to the Polish Karkonosze Mts.

- *Apamea unanimitis* (Hübner, 1813) *, **

Chojnik Kseroterm, 16.07.2020, 1 ex.

Occurs all over Poland, but infrequently and at scattered localities (Buszko & Nowacki 2017). Species new to the Polish Karkonosze Mts.; the nearest historical record is from Jelenia Góra (Wolf 1935–1944).

- *Celaena haworthii* (Curtis, 1829) *, **

Jagniątków, 19.09.2020, 1 ex.

Occurs all over Poland, but infrequently and at scattered localities (Buszko & Nowacki 2017). Species new to the Polish Karkonosze Mts.

- *Rhizedra lutosa* (Hübner, 1803) *, **

Karpacz - KNP Information Centre, 30.09.2020, 1 ex.

Not common in Poland; recorded at scattered localities in all parts of the country (Buszko & Nowacki 2017). Species new to the Polish Karkonosze Mts.

- *Hadena compta* (Denis & Schiffermüller, 1775) *, ***

Jagniątków, 21.07.2020, 1 ex.

Rather uncommon, though recorded in most parts of Poland (Buszko & Nowacki 2017). Previously recorded in the Karkonosze region at Szklarska Poręba (Wolf 1935–1944), and much later at Górzyniec in the nearby Iżera Mts. (Nowacki 1998).

- *Hadena perplexa* (Denis & Schiffermüller, 1775) *, ***

Chojnik Kseroterm, 15.07.2020, 1 ex.

Not very common in much of Poland (Buszko & Nowacki 2017). Previously recorded in the Karkonosze region at Szklarska Poręba (Wolf 1935–1944), and much later at Górzyniec in the nearby Iżera Mts. (Nowacki 1998).

- *Mythimna sicula* (Treitschke, 1835) *, **

Chojnik Kseroterm, 18.05.2020, 2 exx., 19.05.2020, 4 exx., 20.05.2020, 3 exx., 15.06.2020, 3 exx., 17.06.2020, 2 exx., 9.07.2020, 2 exx.

A Ponto-Mediterranean species, occurring throughout the Mediterranean and Black Sea regions, as well as Asia Minor. The second half of the 20th century witnessed a gradual

northward expansion in central Europe (Nowacki & Buszko 2019). In Poland known only from the province of Lower Silesia, where it was first recorded at Wojcieszów in the Kaczawa Mts. (Kokot & Malkiewicz 1999), and later near Chojnów (Malkiewicz *et al.* 2002) and Kletno (Malkiewicz & Kania 2010). Species new to the Polish Karkonosze Mts.

- *Diarsia dahlia* (Hübner, 1813) *, ***

Karpacz - KNP Information Centre, 20.08.2020, 1 ex.

Localized and rare in Poland, mainly in the north and east of the country (Nowacki & Buszko 2019). Previously recorded in the Karkonosze region at Szklarska Poręba (Wolf 1935–1944).

- *Noctua interjecta* Hübner, 1803 *, **

Jagniątków, 30.07.2020, 2 exx., 12.08.2020, 1 ex., 19.09.2020, 1 ex., Chojnik Podzamcze, 17.08.2020, 3 exx.

An Atlantic-Mediterranean species, occurring in western Europe from the Iberian Peninsula and the British Isles to north-central Europe as the subspecies *N. interjecta caliginosa* (Schawerda, 1919). Throughout the Mediterranean Basin and in central Europe as far as the Alps, Sudetes and Carpathians it occurs as the subspecies *N. interjecta interjecta* (Hübner, 1803). Late 20th century Polish records relate to *N. interjecta caliginosa*, which was recorded solely at single localities and only in the western part of the country. At present, this species is expanding rapidly across the country in an easterly direction and has been recorded at many localities as far as central Poland (Nowacki & Buszko 2019). Species new to the Polish Karkonosze Mts.

- *Rhyacia simulans* (Hufnagel, 1766) ***

Kocioł Małego Stawu, 11.09.2020, 1 ex., Łąbski Szczyt, 17.08.2020, 1 ex., Mały Śnieżny Kocioł, 13.07.2020, 1 ex., 19.08.2020, 1 ex.

Localized across the whole of Poland. Usually not very abundant and rarely come

across (Nowacki & Buszko 2019). Previously recorded in the Karkonosze region at Szklarska Poręba and on the Równia pod Śnieżką peneplain (Wolf 1935–1944).

- *Euxoa obelisca* (Denis & Schiffermüller, 1775) *, ***

Chojnik Kseroterm, 12.09.2020, 1 ex., Mały Śnieżny Kocioł, 13 IX 2020, 1 ex.

Localized across the whole of Poland. Usually not very abundant and rarely found (Nowacki & Buszko 2019). Previously recorded in the Karkonosze region at Szklarska Poręba (Wolf 1935–1944).

Discussion

Despite the evident impoverishment of the noctuid moth fauna in the lower montane forest ecosystems caused by their severe degradation during the 20th century, the species diversity of the noctuid assemblage in the KNP as a whole has now begun to recover. Evidence for this is the rediscovery of 11 species, 10 of which inhabit the lower montane forest ecosystems, that were recorded at the turn of the 19th century (Wolf 1935–1944), but not confirmed in the late 20th century by Nowacki (1998) or Borowiak & Chrzanowski (2007). Importantly, our fieldwork in 2019–2020 yielded 18 noctuid moth species never before recorded in the KNP, 9 of which are new to the Polish Karkonosze Mts. The stenotopic species among them – *A. laevis*, *A. syriaca*, *C. haworthii*, *D. dahlia*, *H. respersa*, *M. sicula* and *P. xanthomista* – are especially worth highlighting, as they are rare and occur at just a few localities in Poland (Nowacki & Buszko 2019). Moreover, the finding of some of these species new to the Karkonosze Mts., specifically *A. syriaca*, *M. sicula* and *N. interjecta*, is due to the shift in their central European distributions. The first Polish record of *A. syriaca* came from the Roztocze region in 2006 (Nowacki 2006), since when it has been gradually spreading across southern Poland and recorded at a few localities (Nowacki

& Buszko 2019). Again, the first Polish record of *M. sicula* was from the Kaczawa Mts. (Kokot & Malkiewicz 1999), since when it has been gradually expanding over south-western Poland; it, too, is known from a small number of localities (Nowacki & Buszko 2019). *N. interjecta* - in fact, the subspecies *N. interjecta caliginosa* (Schawerda, 1919) - can now be found from western France and England through Belgium, the Netherlands, Denmark, Norway, Germany and the countries around the Baltic Sea, i.e. southern Sweden, Finland, Lithuania, Latvia and Estonia, and across most of Poland (Nowacki *et al.* 2019). In the late 20th century, this species was rarely recorded in Poland, only at single localities in western Poland from the Baltic Coast down to Lower Silesia (Nowacki 1994). In the last 30 years, however, this species has been expanding rapidly eastwards across Poland and the countries around the Baltic. It is now known from several tens of localities from north-eastern Poland through the centre of the country down to Upper Silesia (Blaik *et al.* 2009, Nowacki *et al.* 2019).

The results endorse our research hypothesis and show that positive changes have been taking place in the KNP, enabling the recovery of populations of many noctuid moths recorded in the Karkonosze Mts. at the turn of the 19th century. We did not investigate the specific reasons for these changes, which are various and complex depending on the species. Nonetheless, it is highly probable that the main, extrinsic reason for these positive changes has been the steadily falling level of atmospheric pollution in the Sudetes region in the last 25 years. On the other hand, the intrinsic, wholly positive cause of these changes is the intensive restoration of the lower montane forest ecosystems once typical of the KNP, which has been taking place over the past 30 years (Raj 2019). Unfortunately, we were unable to confirm the presence of the extremely rare, stenotopic species *X. alpicola*, *X. collina*, *E. birivia* and *T. ludifica*: their localized, isolated populations in the

Karkonosze Mts. are probably now extinct. Two simultaneous adverse factors could have been responsible for this: severe environmental degradation and global warming. The first appearance in the KNP of some new species never before recorded in the Polish Karkonosze Mts. is worth mentioning. Here, too, we can assume that on the one hand, this is a localized effect due to the restoration of the degraded lower montane forests, and on the other the effect of global warming, which has been responsible for range shifts in a great many species in central Europe.

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