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Regular research paper

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## DID THE NORTHERN RANGE OF DISTRIBUTION OF TWO TROPICAL ORTHOPTERANS (INSECTA) CHANGE RECENTLY?

**ABSTRACT:** Many thermophilous species are predicted to shift their ranges to higher latitudes and altitudes in response to climate warming. The range trend was analysed for two orthopteran species *Ruspolia nitidula* (Scopoli, 1786) and *Aiolopus thalassinus* (Fabricius, 1781) of tropical origin at their northern limits. Their northern range seems to have been stable for more than 100 years irrespective that they are good fliers and in spite of a rapid increase of records within their northern range supported by hard data. In 2000–2006, the authors found *R. nitidula* on 87 localities (only 19 had been known before 2000) and *A. thalassinus* on 35 localities (9 before 2000) in Slovakia. The authors consider that this increase of records is more due to intensified mapping, and it does not support the hypothesis that the global warming affects the spreading of the species. For both these endangered thermo-hygrophilous species, habitat choice, population dynamics, phenology, threats and conservation aspects were analysed and discussed in the context of their main ranges.

**KEY WORDS:** Orthoptera, global warming, range trends

### 1. INTRODUCTION

During the last 120 years, annual temperatures increased in SW Slovakia more than 1 °C and the continual increasing also in the future is predicted (Lapin and Melo 1999). According to this general fact (IPCC, 2001), most species are expected to shift their ranges in response, rather than adapt to warmer temperatures *in situ* (Huntley 1991). For example, amongst insects, some generalists like south European butterflies (Warren et al. 2001), bugs (Kirby et al. 2001) and dragonflies (Hickling et al. 2005) have shifted their ranges northwards, and it is expected that other winged insect species will show a similar response to climate change. However, few studies have focused on orthopterans (Cannon 1998; Hickling et al. 2006).

Bush cricket *Ruspolia nitidula* (Scopoli, 1786) and grasshopper *Aiolopus thalassinus* (Fabricius, 1781) are species of paleotropical and mediterranean origin (Ingrisch and Köhler 1998). *R. nitidula* is considered as a rare inhabitant of wetlands in S Europe, N Africa and W Asia, and *A. thalassinus* is occurring in warm wet meadows and salt marshes in S Europe (Mařan 1965; Detzel 1998; Ingrisch and Köhler 1998). *R. nitid-*

*ula* figures in European national Red Lists as an endangered (EN) or critically endangered (CR) species, *A. thalassinus* is less endangered, but it is rare mainly on the northern edge of its range (Berg and Zuna-Kratky 1997; Bazyluk and Liana 2000; Krištín 2001; Maas *et al.* 2002). *R. nitidula* reaches the northern edge of its range in Europe in Slovakia. The first notes on its occurrence date from the 19<sup>th</sup> century (Chyzer 1897), later from 1931 (Vávra 1931) and then data are lacking until 1952–1962 (Gulička 1954; 1967; Mařan 1965). *A. thalassinus* reaches the northern edge of its range in Europe in Poland, where the first data came from the 19<sup>th</sup> century (Liana 1976; Bazyluk and Liana 2000). Similarly, its first occurrence in Slovakia concerns this period (Pungur 1899; Schneeberg 1931; Gulička 1954; 1967; Mařan 1954). Hence, for both species, the northern range limits seem to have been stable for more than 100 years.

Much published and unpublished data on the distribution of these species were collected in 1997–2006 at the northern range limits (Berg and Zuna-Kratky 1997; Krištín and Sárossy 2002; Maas *et al.* 2002; Chládek and Gavlas 2004; Krištín 2004; Krištín *et al.* 2004a, b). The explanation for this recent increase is difficult. Some authors hypothesised that the spread of *R. nitidula* within its recorded distribution is due to global warming (Chládek and Gavlas 2004; Gavlas 2005). Others assign it to more intensive research activity (Berg and Zuna-Kratky 1997; Maas *et al.* 2002; Krištín and Sárossy 2004), extending the knowledge of the ecology, abundance and phenology of these species (i.e. Mařan 1965; Braun *et al.* 1995; Detzel 1998).

The aim of this paper is: 1) to test the warming effect and/or the other cause like intensity of recording; 2) to analyse the distribution, habitat choice and phenology of *R. nitidula* and *A. thalassinus* in Slovakia, at the northern edge of their ranges.

## 2. MATERIAL AND METHODS

Between May and October 1995–2006, we checked out 418 localities in 175 mapping squares (one square area = 132 km<sup>2</sup>) using the Slovak Fauna Databank (41% of total

number of squares in Slovakia, Figs 1, 2). *R. nitidula* was mapped using acoustic identification (also with an ultrasound bat-detector at frequencies 95–120 kHz) mainly during dusk and at night. Stridulating individuals were regularly checked in the field. The species *A. thalassinus* was monitored and collected by sweeping the herbal layer (less so by individual collection). We collated the already-published data on the distribution of both species in Slovakia from 1897 to 2006, and also our data (Krištín *et al.* 2007).

The assessment of habitat choice in *R. nitidula* was expressed through: 1) habitat type, 2) altitude, 3) maximum distance from the woody plants or forest edge (or solitary trees), 4) nearest woody plant species in the adjacent forest stand and 5) height of herbal layer. For *A. thalassinus* we registered: 1) habitat type, 2) altitude, 3) height of herbal layer. *R. nitidula* abundance was recorded using two methods: i) by assessment of small-plot density on 1000 m<sup>2</sup> on a selected study area in wet meadows in S Slovakia (locality 1, Fig. 1; for a description of the plot see Krištín and Sárossy 2002) using the sweeping the herbal layer over the whole season (June – October), ii) by assessment of large-scale density using acoustic detection (August 2005) on transects along the selected roads in the Central Slovakia (locality 2 – 61 km transect) and in the Eastern Slovakia (locality 3 – 21 km transect, Fig. 1). Abundance of *A. thalassinus* was checked by sweeping the herbal layer at selected breeding sites (localities 1–3, Fig. 2) over the whole season (June – October) and by estimating the number on 1000 m<sup>2</sup> plots. The phenology of occurrence and development in *R. nitidula* were checked from June to October: i) at regular, 7–14 day intervals in the locality 1 (Fig. 1) in 2001, ii) irregularly within its whole range in Slovakia in 2000–2006 (as was done for *A. thalassinus*).

## 3. RESULTS AND DISCUSSION

### 3.1. Distribution in Slovakia

At the northern edge of its range in Central Europe, the species *R. nitidula* has been found in five countries up to 49° N (Slovakia, Czech Republic, Austria, Hungary, Ukraine

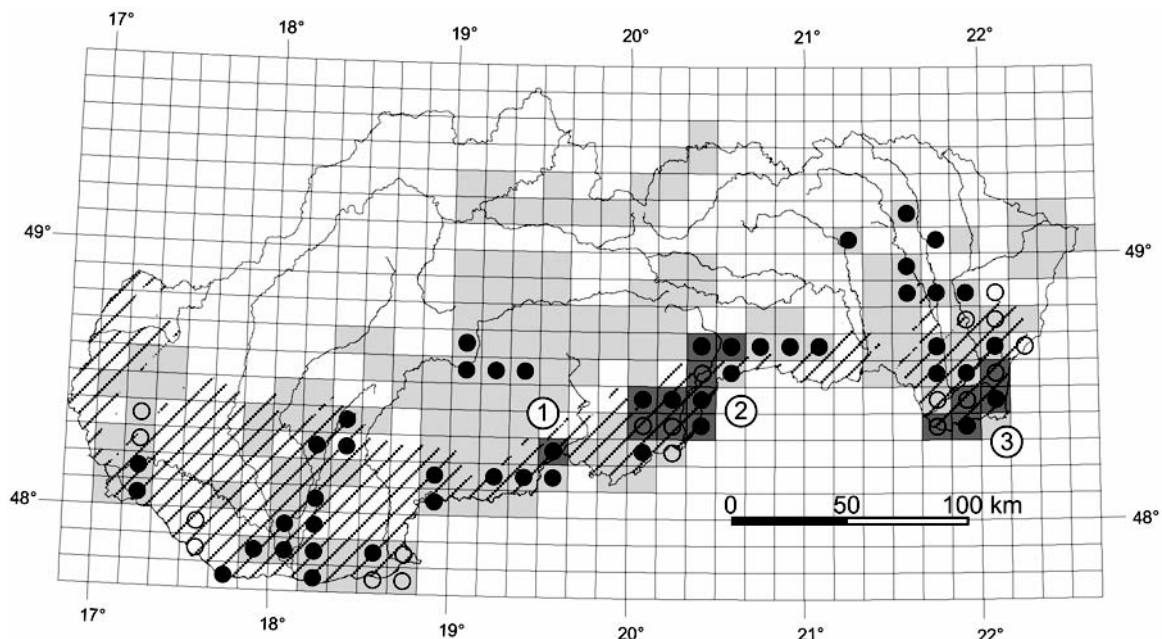


Fig. 1. Distribution of *Ruspolia nitidula* in Slovakia in mapping squares of the Slovak Fauna Databank (empty circles = data before 1962 (up to 2000), full circles = data after 2000, light grey = area covered by own research, dark grey = squares with selected study plots, hatched area = Pannonian bioregion, numbers = localities covered by detailed ecological research).

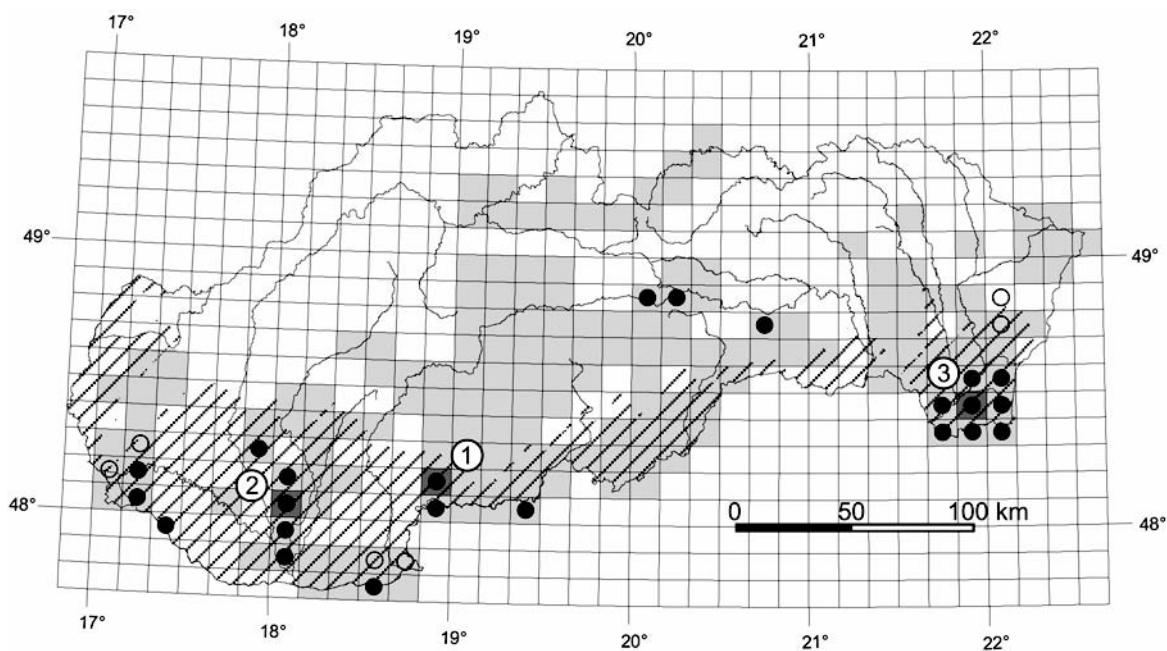


Fig. 2. Distribution of *Aiolopus thalassinus* in Slovakia in mapping squares of the Slovak Fauna Databank (for explanations see Fig. 1).

– Nagy 2005; Kočárek *et al.* 2005), but not yet in Poland (Bazyłuk and Liana 2000). Before 1962, this species had been found in Slovakia only at 19 localities (reviewed by Krištín and Sárossy 2004). Subsequently until 2000, there were no published data on its occurrence, apart from one record mentioning an occurrence in August 1982 in the Danube area (Chládek and Gavlas 2004). In 2000–2006, suitable localities were mapped more intensively, and we found this species on 87 localities (we confirmed pre-1962 findings in ten localities). Summarizing all known published and our unpublished data, the species was found in total at 100 localities in 67 squares of the Slovak Fauna Databank (16% of all squares; Fig. 1). This increased number of known localities may reflect the fact that this species has clearly extended its range. However, when we take into account the knowledge of this species' vocalisation and which acoustic detecting techniques were used in the 19<sup>th</sup> and 20<sup>th</sup> century, it is very possible that the species had been overlooked. Consequently, possibly it was more intensive research that has detected this elusive species in greater number of localities; this apparent increase is not an indication of northward spreading. The number of localities in Austria in which this species has been found has also increased rapidly, and this is also associated with an intensification of mapping. This evidence can be regarded as debatable, but finally, it supports improved species detection (Braun *et al.* 1995; Berg and Zuna-Kratky 1997).

At the northern edge of the range of *A. thalassinus* in Central Europe, the species has been found in six countries up to 53° N (Poland – Bazyłuk and Liana 2000; Austria, Hungary, Ukraine – Nagy 2005; Czech Republic – Kočárek *et al.* 2005). Before 1962, this species had been found in Slovakia only at 9 identified localities in W and E Slovakia floodplains (Pungur 1899; Schneeberg 1931; Gulička 1954; 1967; Mařan 1954). Until 2000, there were no further published data on its occurrence. In 2000–2006 suitable localities were mapped more intensively, and we found this species at 35 localities (we confirmed pre-1962 findings in three localities). Summarizing all known published and our unpublished data, the species had been

found in a total of 41 localities in 29 squares of the Slovak Fauna Databank (6.7% of all squares; Fig. 2). This increased number of known localities might have reflected a positive range trend for this species, if it had been mapped regularly. However, when we take into account the lack of monitoring effort in suitable localities in the 19<sup>th</sup> and 20<sup>th</sup> century, we suggest that the species had been overlooked. More likely, like the previous species, the increase in known localities is more probably the result of intensive research being carried out at dusk, when this species is most active (cf. Gulička 1954) than an indication of a northward spread. Intensification of mapping in Austria and Germany has increased the number of localities where it has been found (Berg and Zuna-Kratky 1997; Maas *et al.* 2002), which supports our contention.

### 3.2. Habitats

The stenotopic species *R. nitidula* was found in Slovakia mainly in lowland habitats at altitudes 99–352 m a.s.l. (mean  $\pm$  SD = 165  $\pm$  60 m a.s.l., n = 92 localities). Chládek and Gavlas (2004) mentioned that it also has occurred in Slovakia up to 430 m a.s.l. German findings come from 400–450 m a.s.l. (wet meadows close to Lake Bodensee; Detzel 1998), but further south in Switzerland it was found at 200–1000 m a.s.l., mainly in wet meadow habitats up to 500 m a.s.l. (Thorens and Nadig 1997). During its larval development it prefers wet meadows and wetlands as well as riparian hygrophilous vegetation along lowland streams (52% of frequency), but it also occurs in wet ditches along roads (40%), from which the data were not previously obtained. We recorded it even in ruderal vegetation in human settlements (5%) and at xerothermous localities (3%), where we found only fast-flying adults. Considering its excellent flying ability, we suppose that it may migrate to such unusual habitat types from the surrounding wet meadows, where it lays its eggs and where the larvae hatch (Mařan 1965; Detzel 1998).

Considering the height of the herbal layer, in Slovakia the species prefers a height of 10–50 cm (87% of localities, n = 23), avoids

stands lower than 10 cm and it is rare in stands taller than 50 cm (13%). In the localities where it is most abundant (loc. 1, Fig. 1), it occurs mainly in grass stands of *Agropyron repens* and *Alopecurus pratensis*, whereas in Germany it was closely associated with *Molinia caerulea* (Detzel 1998). It is frequently found in association with woody vegetation, because at many localities (83%), it occurred within 10 m of the nearest tree. Adjacent woody stands, as expected, comprised mainly of willows (*Salix* spp., 70%,  $n = 23$  localities) and poplars (*Populus* sp., 26% of localities), which were dominant in the studied localities at riparian forest edges. Characteristic accompanying orthopteran species at Slovak breeding sites of *R. nitidula* were: *Conocephalus fuscus* (Fabricius, 1793), *Conocephalus dorsalis* (Latreille, 1804), *Chorthippus albomarginatus* (Degeer, 1773), *Chrysochraon dispar* (Germar, 1834), *Tettigonia caudata* (Charpentier, 1842), *Mecostethus parapleurus* (Hagenbach, 1822), *Platycleis montana* (Kollar, 1833), *Aiolopus thalassinus* (Fabricius, 1781).

Breeding site localities and habitats of *A. thalassinus* should be distinguished from those of fast-flying adults (which are active very far from the hatching site), especially in this species (Liana 1976; Detzel 1998; Maas *et al.* 2002). We found hatching sites and larvae habitats at altitudes of 99–140 m a.s.l. (mean  $\pm$  SD =  $114 \pm 12$  m a.s.l.,  $n = 11$  localities). Adults' habitats were located within a 98–1948 m a.s.l. band ( $324 \pm 498$  m a.s.l.,  $n = 31$ ). Five of these localities were at altitudes of: 800 m (August 22, 2001), 1200 m (August 6, 2004), 1440 m, 1620 m and 1948 m a.s.l. (August 21, 2001). Hatching sites of this species in Slovakia are in warm lowland country and are represented exclusively by saltmarshes (64%) and wet meadows (36%,  $n = 11$  localities), confirming the assumption made by Mařan (1954). Adults (without sex differentiating) we found not only on the same habitats as larvae (wet meadows, 46% and saltmarshes, 34%), but also on adjacent xerothermous sandy dunes (6%), and in extremely mesophilous meadows above 800 m a.s.l. (14%,  $n = 35$  localities). We suppose that it occurs there only for a short period and does not breed. It is known that it can be attracted into extreme habitats by lights, e.g.

into city centres (Schneeberg 1931); we confirmed this behaviour in closed pine forest near Danube, where it was trapped during moth light-trapping (July 22, 2003, 10:30 pm). German findings came mainly from altitudes up to 230 m a.s.l. (wet meadows in the Rhone valley; Detzel 1998; Maas *et al.* 2002). Further south, in Switzerland it was found at 380–600 m a.s.l., mainly in wet meadow habitats (Thorens and Nadig 1997).

Considering the height of the herbal layer, in Slovakia the species evidently prefers a height of less than 10 cm (59% of localities,  $n = 29$ ) and in grasslands a height range of 10–50 cm (38%). Only rarely does it migrate into stands taller than 50 cm (3%). The most abundant occurrence in the herbal layer was in saltmarsh stands of *Artemisia santonicum*, *Camphrosoma annua*, *Carex praecox*, *Festuca pseudovina*, *Tripolium pannonicum* (loc. 2, Fig. 2), where we also observed egg laying (September 30, 2002). In Germany it was classed as a thermo-, hygro- and geophilous species, bonded to a low herbal layer or bare ground, usually in the pioneer succession stages (Detzel 1998; Maas *et al.* 2002).

Characteristic accompanying orthopteran species at Slovak breeding sites of *A. thalassinus* were: *Platycleis vittata* (Charpentier, 1825), *C. albomarginatus*, *Chorthippus apricarius* (Linnaeus, 1758), *Omocestus petraeus* (Brisout de Barneville, 1856) (loc. 2, Fig. 2.), *Tettigonia caudata*, *R. nitidula*, *Doclostaurus brevicollis* (Eversmann, 1848) (loc.3, Fig. 2), *C. fuscus*, *Euchorthippus pulvinatus* (Brisout de Barneville, 1856) (loc. 1, Fig. 2). Unexpectedly, the species was found also at high mountain localities, where – we surmise – it penetrated from long distances away to occur in an assemblage of *Psophus stridulus* (Linnaeus, 1758), *Omocestus viridulus* (Linnaeus, 1758), *Metrioptera brachyptera* (Linnaeus, 1758) species.

### 3.3. Abundance and phenology

Before 1962, maximal abundance of *R. nitidula* recorded was 15 individuals per one visit per locality (Mařan 1965; Gulička 1967), apparently because it was active nocturnally and its behaviour was little known. Assessing small-plot density on 1000 m<sup>2</sup> by

sweeping the herbal layer, we found a maximum density of 45 individuals  $\times$  1000 m<sup>-2</sup>. Furthermore, assessing large-scale density by means of acoustic detection on transects along selected roads, we found a maximum density of 5.5 males  $\times$  km<sup>-1</sup> (loc. 2, Fig. 1, August 24, 2005), with the highest local density being 15.3 males  $\times$  km<sup>-1</sup>. The highest density at the northern limit of its range was recorded in southern Bavaria (1226 ind.  $\times$  ha<sup>-1</sup>; Treiber and Albrecht 1996), but it is difficult to compare density data received using different census techniques.

In Slovakia, the species was found between June 28 and October 1, the highest abundance was found during late July and in August. Male nymphs were found until August 12, female nymphs until the end of August; more females than males survived until the end of September. The first adults were found on July 26. There was no seasonal difference in hatching between males and females. Nymphal-stage females were more abundant than males (sex ratio = 2:1, loc. 1, Fig. 1). At the adult stage the sex ratio was 1:1.

In 1953–1962, very high numbers of *A. thalassinus* were found in breeding sites of this species in Slovakia (e.g. saltmarshes and wetlands in W and E Slovakia – Mařan 1954; Gulička 1954; 1967). Until then, there had been only isolated findings, each of 1–3 individuals, mainly outside the breeding sites.

We carried out small-plot density mapping of the species, obtaining a maximum density of >100 adults  $\times$  1000 m<sup>-2</sup> at the saltmarsh of loc. 2 (Fig. 2, September 30, 2002), and > 50 nymphs  $\times$  1000 m<sup>-2</sup> at loc. 1 (Fig. 2, August 8, 2001). The species is a very good flier, making it almost impossible to assess the density of adults and extent of its minimum territory. The populations in the best breeding sites can exceed 1000 nymphs of 4<sup>th</sup> instar  $\times$  ha<sup>-1</sup> (loc. 1–3, Fig. 2).

In Slovakia, the species was found between July 9 (nymphs of the 4<sup>th</sup> instar, loc. 1 and 3, Fig.1), and October 10 (loc. 2). The first adults were found on July 22, the highest adult density was recorded from late August to the end of September, i.e. ca 14 days later than for *R. nitidula*. Similar seasonal occurrence of the species has been reported in

similar conditions from Germany (Detzel 1998; Maas *et al.* 2002).

### 3.4. Threat factors, conservation and trends in distribution of *R. nitidula* and *A. thalassinus*

The analysis of habitats of the studied species resulted in finding that the most important threats are: drying of wet meadows and wetlands, destruction of saltmarshes (for *A. thalassinus*), intensification of agricultural use of lowlands (e.g. by regular ploughing of meadows, early and frequent mowing) and destruction of riparian stands in lowland river floodplains (for *R. nitidula*).

The comparison of vegetation cover in lowland biotopes has been much simplified by cutting the productive grasses and by introducing the alien plants. The protection of orthopteran populations requires the cultivation of wet meadows, wetlands and salt marshes to be limited. The regular monitoring, conservation and mapping of suitable localities is necessary, as well as the monitoring of the abundance of the local populations, primarily at the nymphal stage (in July).

Collating the historical and current data about the occurrence of these specialised although fragile species of tropical origin, we can conclude that no spreading has occurred to the north, as well as nor positive northward range trend occurred. However, the population size of these species and altitudinal trends of their distribution along altitude gradient can not be quantify strictly because the density data from the past are lacking.

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