HERPETOLOGIA PETROPOLITANA

Proceedings of the 12th Ordinary General Meeting of the Societas Europaea Herpetologica

12 – 16 August 2003
Saint-Petersburg, Russia

Edited by
Natalia Ananjeva and Olga Tsinenko

Saint-Petersburg, 2005

CONTACT ZONE BETWEEN TWO SUBSPECIES OF THE SAND LIZARD: *Lacerta agilis exigua* EICHW., 1831 AND *Lacerta agilis chersonensis* ANDR., 1832 IN THREE REGIONS OF THE LEFT-BANK UKRAINE

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Keywords: *Lacerta agilis*, subspecies, zone of intergradation, Ukraine.

INTRODUCTION

The Left-bank Ukraine is known as a territory, where contact zone of two subspecies of *L. agilis* exists (Sukhov, 1928; Sukhov, 1948; Tarashchuk, 1959; Szczerbak, 1966; Darevsky et al., 1976). But in present time only general or occasional observations were conducted. General direction of contact zone spread was suggested as "from Kursk between Kharkov and Poltava to Dnepropetrovsk" (Sukhov, 1948), "to the west of the line passing through Vorozhba station (Sumy Oblast') and Dnepropetrovsk" (Tarashchuk, 1959), "in Sumy and Kursk Oblast's and in western parts of Kharkov and Poltava Oblast's..." (Szczerbak, 1966); "Kursk – Dnepropetrovsk – Crimean peninsula" (Darevsky et al., 1976). Views of different authors on its width of transition are different and range from completely negating its existence (Sukhov, 1948), considering it comparatively narrow (Bischoff, 1988), to believing it to be very extended (Darevsky et al., 1976).

Populations of both subspecies with mixed characteristics exist very close to each other in several locations in Russia and Ukraine (Sukhov, 1928; Pereleshin, 1928; Szczerbak, 1966; Darevsky et al., 1976; Gavrilenko, 1970). A hybrid specimen with morphology of *L. a. chersonensis* but sequence of mitochondrial gene cytochrom b of *L. a. exigua* was found to the northeast of Tula (Kalyabina-Hauf and Ananjeva, 2004).

Drabkin and Bobylev (1989) investigated about 20 populations in the 200 km section of contact zone in Central Ukraine and estimated the width of transition as about 40 – 50 km.

MATERIAL AND METHODS

More than 1000 specimens collected from 100 sites in a section of the contact zone of two subspecies of the sand lizard — *L. a. exigua* and *L. a. chersonensis* with general extent approximately 300 km in Kharkov, Poltava, and Dnepropetrovsk Oblast's were analyzed by external morphology features (Fig. 2).

In addition, collections of Museum of Nature at Kharkov University were analyzed. Control samples of *L. a. chersonensis* from sites in the vicinities of Lebedin, Sumy Oblast' and in the vicinities Nemishaevo, Kiev Oblast' (70 and 300 km away from the contact zone respectively); *L. a. exigua* from sites in the vicinities of Slatino, Kharkov, and Balakleya, Kharkov Oblast' (20, 40, and 120 km from contact zone, respectively), and also from a site in Rostov Oblast', Russia (300 km from the contact zone) were used.

Subspecies in contact zone are clearly distinguished by the type of dorsal pattern. *L. a. exigua* has a pronounced unbroken occipital line and between 14 and 17 scales (average 15 – 16) between parietal lines in the middle of the body (a point determined by dividing the total number of ventral scales rows by 2). Occipital line in *L. a. chersonensis* is absent or broken; there are between 8 and 12 scales (average 10 – 11) between parietal lines in the middle of the body. According to these two signs hybrid indexes (HI) for each specimen were calculated.

$$HI_1 = (L.o._{.n} - L.o._{.ch})/(L.o._{.ex} - L.o._{.ch}) \times 100\%,$$

$$HI_2 = (S.l.p._{.n} - S.l.p._{.ch})/(S.l.p._{.ex} - S.l.p._{.ch}) \times 100\%,$$

where $L.o._{.n}$ is presence of occipital line in investigated specimen (0, absent; 1, broken; 2, unbroken and well pronounced); $L.o._{.ch} = 0.23529$ is presence of occipital line in *L. a. chersonensis* (the number determined as the mean for the population from Nemishaevo, Kiev Oblast', approximately 300 km from contact zone); $L.o._{.e} = 2$ is presence of occipital line in *L. a. exigua*; $S.l.p._{.n}$ is number of scales between parietal lines in the middle of the body in investigated specimen; $S.l.p._{.ch} = 10.231$ is number of scales between parietal lines in the middle of the body in *L. a. chersonensis* (the number determined as the mean for the population from vicinities of Kolontaev village, left bank of Merla river, Krasnokutsk dis-

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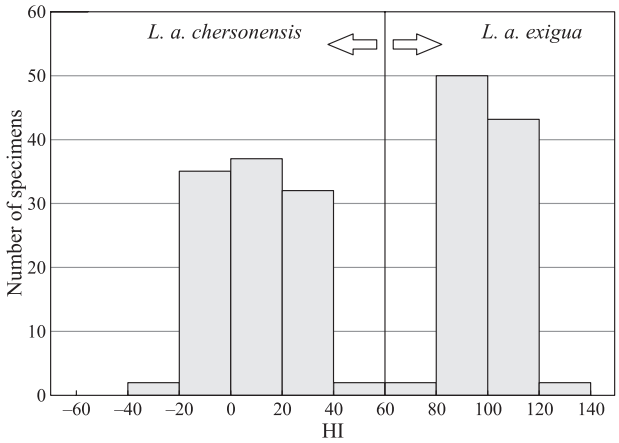

Fig. 1. Distribution of HI in control extracts of *L. a. chersonensis* and *L. a. exigua*.

trict, Kharkov Oblast', site No. 59); and $S.l.p._{ex} = 15.727$ is number of scales between parietal lines in the middle of the body in *L. a. exigua* (the number determined as the mean for the population from vicinities of Chernoglazovka village, Zolokhov district Kharkov Oblast', site No. 96).

Population's hybrid indexes were calculated as the mean of individual HI of specimens. Correlation between population hybrid indexes HI_1 and HI_2 calculated on different signs is high (0.92), so we used the mean. Distribution of HI in control samples *L. a. chersonensis* and *L. a. exigua* is shown in Fig. 1. As we have taken the extreme manifestations of signs as typical for subspecies in order to include slightly deviated populations in the range, value HI of "pure" populations of *L. a. chersonensis* appears slightly bigger then 0% (most frequently 4.5 – 13%), and in *L. a. exigua* slightly smaller than 100% (92 – 97%).

We used 10 – 15 specimens from each site. After investigation the lizards were released in the place of capture. In several cases, when the capture success was low or when we used museum collections, the number of investigated specimens per site was somewhat lower.

RESULTS AND DISCUSSION

On the investigated territory the contact zone is situated on the Dnepr Lowland, Poltava Plane, and southwest edge of Middle Russian Height and spreads from southwest to northeast. *L. a. chersonensis* is distributed to the west and northwest from the contact zone, *L. a. exigua* inhabits the territory to the east and southeast of the contact zone.

The contact zone begins from the left bank of the Dnepr River in the Dnepropetrovsk vicinities (to the south of Dnepropetrovsk the natural border between subspecies is the Dnepr) and passes to the north, northeast and east along the Oril', the Vorskla and the Kolomak rivers. In the vicinities of Pokrovka village (Kolomak district, Kharkov Oblast') and Alekseevka village (Krasnokutsk district, Kharkov Oblast') the contact zone turns to the north, crosses the watershed of the Kolomak and the Merla rivers and switches from the left to the right side of the Merla valley in the area of confluence with the Sukhoi Merchik river. Then, it goes along the Merla – Vorskla watershed and further in Russia passes through Borisovka (territory "Wood on the Vorskla" of natural reserve "Belogor'e," the Vorskla river valley) (Fig. 2).

In spite of a complete set of specimens with intermediate characteristics in the contact zone and absence of evident barriers between subspecies, the zone is very small and is not more than 20 – 30 km wide. Abrupt replace of one subspecies by another takes place within the zone 10 to 15 km wide, in some cases even narrower (sites Nos. 22 – 25, 33 – 36, 47 – 50, 79 – 80) (Fig. 2).

Variability of external morphology patterns seems to depend on the level of isolation and migration of specimens from neighboring populations. Distribution of hybrid index in populations in contact zone is unimodal, but its range depends on structure of the site, too. Distribution of HI on site No. 44, the territory connected with neighboring lizard populations, and on site No. 61, the territory isolated from other populations for quite a long period (at least 25 years) by landscapes that make an insurmountable barrier for lizards is displayed on Fig. 3.

It is generally believed that disjunctions of ranges and subspecies' differentiation in Europe have taken place under the influence of great climate changes in Pleistocene. The total range of species have been divided and isolated in refugia, where populations diverged and gave birth to new taxa (Hewitt, 1999). According to Darevsky et al. (1976) ancestors of *L. a. chersonensis* survived cold periods in the Balkan refugium, and *L. a. exigua* stepped back to Caucasus. Then, after the warming of climate, lizards dispersed from these two refugia, met and have created a wide intergradation zone. But the intergradation zone was found to be not as wide as it was expected. Small width of intergradation zone may indicate that it is relatively young or that there is certain isolation between these subspecies.

An extremely interesting fact is the coincidence of the contact zone with the orographic (relief) borders. The contact zone in the northern part of Kharkov Oblast' parallels the southwestern edge of Middle Russian Height. The contact zone in Poltava and Dnepropetrovsk Oblast's is associated with relief, too. Here the transition from *L. a. exigua* to *L. a. chersonensis* often occurs when absolute altitude

decreases from 100 – 130 m in water shed to 70 – 100 m in the Dnepr, the Oril', and the Vorskla valleys. This dependence could be the result of ecological differences between subspecies.

The borders of phenetically similar lizard population groups coincide with elevations — Middle Russian, Donetskii Kryazh, etc. (Baranov, 1982); our data corroborates the same tendency in the subspecies case. Present reconstructions of ecosystems that existed during the last glacial maximum (24 – 12 thousand years ago) show that forest refugia existed on the East European plane and were associated with the same elevations (Markova et al., 2002). Fossil remnants of *Lacerta agilis* prove that lizards did not disappear completely in Eastern Europe during the whole Pleistocene (Ratnikov, 2002).

In accordance with our hypothesis the presence of the occipital line in the Eurasian green lizards (*Lacerta sensu stricto*) is one of the characteristic features of continental taxa and its absence is common to the members of *Lacerta sensu stricto* comparatively more adapted to humid and warm climate (Rudyk, in preparation). If their ranges overlap, taxa with pronounced occipital line can occupy more dry areas and terrains. It follows from the data published for Romania (Fuhn and Mertens, 1959), Greece (Strijbosch, 2001), Turkey (Schmidtler, 2001), and from our observations in Ukraine.

Thus, during glacial periods *L. a. exigua* probably could survive in small refugia in eminent territories, such as Central Russian Uplands, and after the postglacial softening of climate recolonize those territories faster then *L. a. chersonensis*. A "softer" *L. a. chersonensis* was stepping back to the territories with a milder climate in the South and in the West. Spreading of *L. a. chersonensis* after warming took place mainly along the valleys of big rivers and flatlands.

A remarkable corroboration of such hypothesis is the similar distribution in investigated region several taxa of amphibians and reptiles, which could be split into two groups:

1) new colonists from the west — *Vipera berus* Linnaeus, 1758, *L. a. chersonensis*, *Lacerta viridis* Laurenti, 1768, western form of *Pelobates fuscus* Laurenti, 1768 (Borkin et al., 2003);

2) taxa that probably survived in refugia in Eastern Europe — *Vipera nikolskii* Vedmederya, Grubant et Rudaeva, 1986, *L. a. exigua*, eastern form of *P. fuscus* (Borkin et al., 2003).

The distribution of species of the first group is connected with young and homogenous postglacial landscapes, while the second one is connected with older landscapes of former refugia.

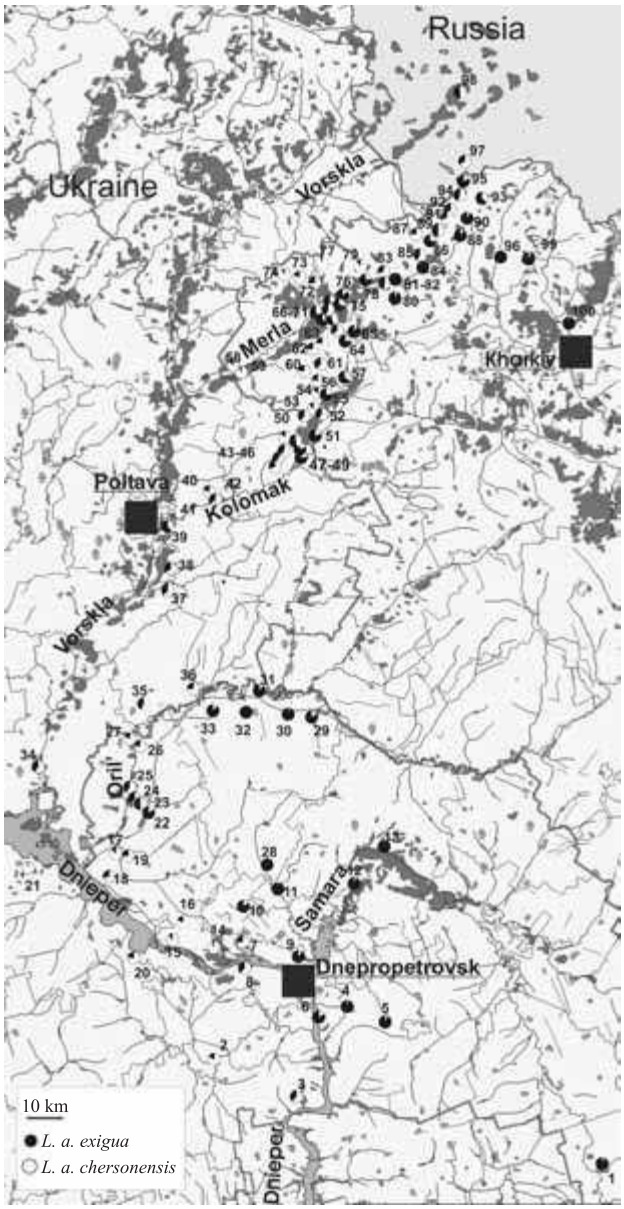

Fig. 2. The contact zone of *L. a. chersonensis* and *L. a. exigua* with collecting sites.

An interesting fact that supports the hypothesis of similar colonization history of *V. nikolskii* and *L. a. exigua* in Left-Bank Ukraine is the discovery of *L. a. chersonensis – L. a. exigua* hybrid population (population HI = = 15.2%, several specimens are well-pronounced hybrids with HI up to 37.8%) together with *V. nikolskii* in the vicinities of Lubny, Poltava Oblast', 122 km to the west of contact zone. Also in the vicinities of Lubny specimens with the sign peculiar to *L. a. exigua*, namely females

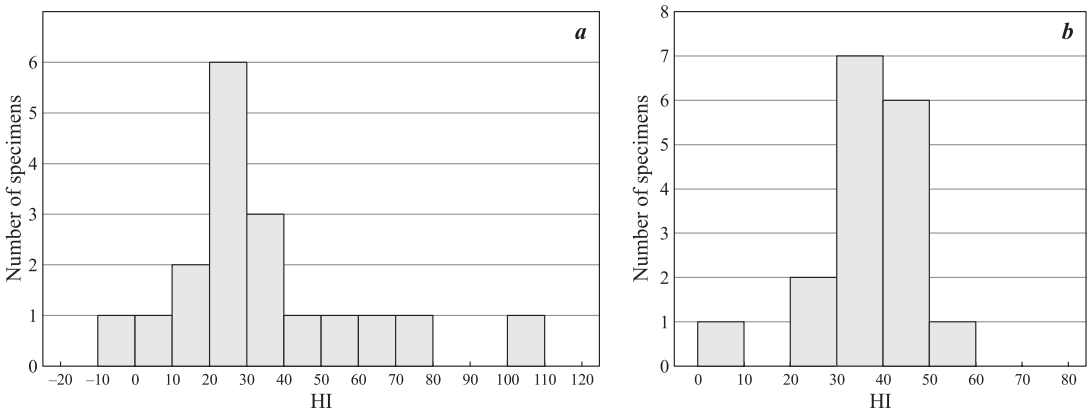

Fig. 3. Distribution of hybrid index (HI) in population from site No. 44, mean HI for population 36.3% (*a*), and site No. 61, mean HI for population 38.8% (*b*).

with green back (abber. *viridicapitilis*, Sukhov, 1928) are common.

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