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CURRENT DISTRIBUTION OF THE INTRODUCED ROCK LIZARDS OF THE *DAREVSKIA* (*SAXICOLA*) COMPLEX (SAURIA, LACERTIDAE, DAREVSKIA) IN ZHYTOMYR REGION (UKRAINE)

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Current Distribution of the Introduced Rock Lizards of the *Darevskia* (*saxicola*) Complex (Sauria, Lacertidae, Darevskia) in Zhytomyr Region (Ukraine). Nekrasova, O. D., Kostiuşhyn, V. A. — In the autumn of 2015 current distribution of the lizards of *Darevskia* (*saxicola*) complex, introduced in 1960s in Zhytomyr administrative region of Ukraine was studied. During the period from introduction until now *Darevskia* (*saxicola*) complex has spread along the left bank of the Teteriv River on the territory about 3.7 km lengths. Beside this was found an isolated population of this species, which located about at 4 km direct distance or 8.5 km shore line distance from the main area of occurring this species. It is supposed that this secondary introduction took place occasionally or intentionally due to holidaymakers (e. g. climbers, fishermen). The publication provides description of the lizards on 15 morphological characteristics and information on the results of spatial modeling potential distribution the rock lizards.

Key words: Alien species, distribution, rock lizards *Darevskia* (*saxicola*) complex, Ukraine.

Introduction

Due to global climate change and anthropogenic species introduction, accidental or intentional, new animal species appeared in many regions. For example, the following alien species of the reptiles, *Podarcis muralis*; *Tenuidactylus* (*Cyrtopodion*) *fedtschenkoi* (Strauch, 1887) (Duz et al., 2012), *Trachemys scripta* (Schoepff, 1792) (Nekrasova, 2013) were found in Odessa Region, in the south of Ukraine.

An intentional introduction of lizard species from the Caucasus to Zhytomyr Region of Ukraine 50 years ago is another peculiar case of that kind. Its purpose was not only to enrich the reptile fauna of the region, but study the process of acclimatization and hybrid complexes of lizards. Initially, in 1963, 129 individuals of parthenogenetic species *Darevskia armeniaca* (Mehely, 1909) from Semenov mountain pass of the Northern Armenia (Darevsky, Sherbak, 1968) were released near Denyshy Village (Zhytomyr Region) on the rocks in the canyon of the Teteriv River (fig. 1, 2, point 1). In 1968, 11 males of bisexual species *D. mixta* (Mehely, 1909) from the area near Abastumani city, located in Western Georgia (Darevsky, 2006) were also released there. Both species belonged to the Caucasian rock lizards of the *Darevskia* (*saxicola*) complex. Later *D. mixta* was never found in the area of introduction. Two years later, *D. armeniaca* was found successfully acclimatized and spread more than 1 km from the releasing point along the rocky bank of the river (Darevsky, Shcherbak, 1968). In 1987, a new location of *D. armeniaca* was found by M. L. Golubev near Tryhirya Village (the Trigur'e) (fig. 2, point 11), which is in a few kilometers upstream from initial place, but on right bank of the Teteriv River (collection of Zoological Museum of the National Academy of Science of Ukraine, No. 3035, 25.06.1987). In addition, during detailed analysis of the Caucasian rock lizards, collected in the place of introducing in 1980, 2002 and 2004, one more parthenogenetic species — *D. dahli* (Darevsky, 1957) (Dotsenko, Darevsky, 2005) was found. It is necessary to stress that in Armenia (Semenov mountain pass) both species — *D. armeniaca* and *D. dahli* — are present. *D. armeniaca* and *D. dahli* are supposed to be resulted from natural hybridization with participation of *D. mixta* as one of parent species (Darevsky, 2006). Latest publications on morphology and DNA analysis of Caucasian rock lizards from Denyshy Village (Zhytomyr Region) deposited in Zoological Museum of NMNH confirmed presence of only two species, *D. armeniaca* and *D. dahli* (Darevsky, 1967; Malysheva, Dotsenko, 2010; Dotsenko, et al., 2008–2009). Besides publications mentioned above, Demidova, Melnichenko (2015 a, b) studied daily and seasonal cycles of the lizards species activity. Current distribution of the introduced species has not been studied so far and is the main aim of this paper.

Material and methods

Two field trips in the area were conducted in 20.09 and 4.10.2015 to study current distribution of the introduced lizards. Despite of quite late autumn, warm, sunny and dry weather ensured high level of lizard activity and allowed to conduct full scale survey in the area. In total 12 sites along right and left banks of the Teteriv River, including the place of species releasing, and surrounding areas were studied. Localization of the sites and their names are presented on fig. 2.

Besides current distribution of introduced species, their morphological characteristics were also studied *in vivo*. In total 39 lizards were collected. Standard morphological parameters (6 morphometric and 9 features of pholidosis; Darevsky, 1967) were analyzed for 25 lizards of the *Darevskia (saxicola)* complex (11 *D. armeniaca* — 3 ad, 8 juv and 14 *D. dahli* — 6 ad, 8 juv) from the sites 1 and 2 (fig. 2).

The lizards were examined by the following characters (Darevsky, 1967; Roytberg, 1994; Dotsenko et al., 2008–2009): A) Morphometric: 1 — length of body (L); 2 — length of caudal (Lcd); 3 — length of the contact between the shields of the interparietale (In) and the shields of the occipitale (Oc) (L : In–Oc); 4 — the maximum width of the occipitale (W : Oc); indexes: 5 — L / Lcd ; 6 — $L : In–Oc / W : Oc$; B) Pholidosis characters: 7 — number of granulae superciliaries (Gsc); 8 — percent of specimens had incomplete or short series of numbers of granulae superciliaries (% Gsc); 9 — additional shield between the nasale (Ns) and frontonasale (Fn) (Ns–ad–Fn); additional shield occipitale (Oc) (ad–Oc); 10 — number of small scales located in the same transverse row between the Temporal (T) and central Massetericium (M) (Rtem); 11 — number of scales Supratemporalia (after St1) (St2); 12 — number of scales median Gularia (Collar); 13 — number of ventral scales (Ventri); 14 — number of big scales surrounding anteriorly the large anal shield (PreA); 15 — number of rows of small scales of the thigh between the femoral pores (Fp) and the external increase of scales on the ventral side (more than one column) (FV).

Only part of collected lizards are stored in the collection of I. I. Schmalhausen Institute of Zoology, NAS of Ukraine, for digital images using Olympus SP570UZ camera were taken for all of them. Measurements of morphological characteristics were done on images using the program Adobe Photoshop CS5 v. 12.0.1. Statistical processing of data was conducted with Statistica for Windows v. 8.0. Cartographic support was made with OziExplorer v. 3.95.4m and DIVA GIS (<http://www.diva-gis.org>) (cartographic modeling).

Results and discussion

Species number and distribution

As it was mentioned above, according to scientific publications, within 3–4 years period after introduction (1963–1966) lizards of *Darevskia (saxicola)* complex spread to 1 km from the initial place (Darevsky, Shcherbak, 1968). After that nobody studied the process of their further distribution. Our data, collected in autumn 2015, shows that lizards spread to the east along the rocky bank of the Teteriv River up to 0.9 km (fig. 2, from site 2 to site 1). Distribution to the west direction was much bigger — up to 2.8 km along the river bank, to the bridge crossed the Bobrovka River (fig. 2, from site 2 to site 4). Near the

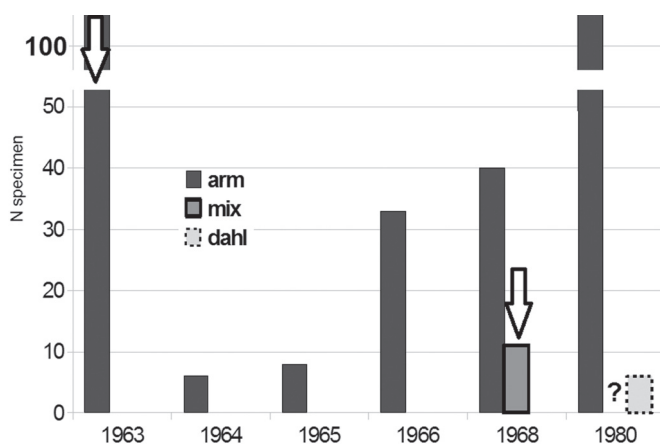


Fig. 1. Chronological scheme and changes in the number of rock lizards *Darevskia (saxicola)* near Denyshy Village (after Darevsky, Shcherbak, 1968; Dotsenko, Darevsky, 2005; Darevsky, 2006): **arm** — *D. armeniaca*, **dahl** — *D. dahli* and **mix** — *D. mixta*, ↓ — introduction.



Fig. 2. List and location of the studied sites: 1 — cliffs to east of the resort Denysy (28.39 E, 50.20 N); 2 — dam across the Teteriv River near the resort Denysy (28.38 E, 50.20 N); 3 — river bank to the west from the UVD resort (mouth of the Bobrovka River; 28.36 E, 50.21 N); 4 — bridge over the Bobrovka River (28.36 E, 50.21 N); 5 — bay in Buky Village (28.36 E, 50.20 N); 6 — cape in Buky Village (28.35 E, 50.19 N); 7 — cliffs between Buky Village and country houses (28.34 E, 50.19 N); 8 — river bank in Rudnya-Nova Village (28.30 E, 50.19 N); 9 — cape in Rudnya-Nova Village (28.32 E, 50.19 N); 10 — bridge over the Glubochok River (28.36 E, 50.18 N); 11 — river bank in Tryhirya Village (28.37 E, 50.19 N); 12 — right bank of the Teteriv River near dam (28.38 E, 50.20 N). Sites where lizards were found are marked by black color.

bridge were found about 10 juvenile *D. armeniaca*. Thus in total, length of the distribution area of the species is about 3.7 km (distance between sites 1 and 4).

At sites 5 and 6, located within Buky village area was found only *Lacerta agilis* (Linnaeus, 1758), but biotopes of these sites were not appropriate for *D. armeniaca*. Surprisingly the latest species was found at site 7 that includes rocky cliffs up to 15 m heights and forest biotope on above of them, but this site was quite far from the sites 1–4, and separated from them by biotopes unsuitable for *D. armeniaca*. Direct distance between site 7 and closest to him site 4 is about 3.2 km, but distance along the shore line is 5.7 km. The same distances between sites 7 and 2 (area of initial lizards releasing) are 4.0 km and 8.5 km, accordingly. These sites as well separated by water space and unsuitable biotopes for the *D. armeniaca*. The most probable explanation of occurring lizards at site 7 is occasional or intentional introduction from the areas 1–4 by holidaymakers, for example climbers or fishermen. The last ones often use boats, which occasionally, can bring lizards from one to another place. At the site 7 were found juvenile and adult lizards that meaning that species already naturalized in this area too. As it already was mentioned, natural conditions are good for the lizards — rocky cliffs of the south exposition, in combination with forest on the top of them.

Survey of other sites (fig. 2, 8–12) didn't bring positive results — lizards were not found there despite that biotopes in the areas were appropriate for the species. From our point of view the most unclear situation is with regards to site 12, which is directly across the river from site 2, and both sites are linked by dam of hydropower station that cross the river flow. Moreover, as it was already mentioned, in the Zoological Museum of NMNH there are 2 lizards that were caught in 1987 near Tryhirya Village, located between site 11 and 12. Possible reason for absence of the lizards at the site is transformation of natural biotopes, including forest cutting there, especially along the river bank. Another possible reason for this is related to fluctuation number of the lizards and level of their activity in different seasons. In summer time, when there is a peak of species activity and number of the lizards reach 14–20 lizards/m² (Demidov, Melnychenko, 2015), they occupied new areas, but not always colonized them (breed, wintering). Thus site 12 which has the same

biotopes as site 2, but different exposition — northern instead of south as at site 2, maybe not appropriate for whole annual cycle of the *D. armeniaca*, but only for part of it.

In the autumn 2015 the biggest number of the lizards — up to 10–15 lizards/m² — was recorded in the site 2, where animals was initially released in 1960s. Both species lizards of *Darevskia (saxicola)* complex were met with similar frequency in different age groups (n = 39): *D. armeniaca*: ad — 15.4 %, juv — 30.8 %; *D. dahli*: ad — 20.5 %, juv — 33.3 %).

A biotope at site 2 was a combination of rocky cliffs 10–25 m heights (south exposition) and forest on above of them. Altitude of the area is 221–225 m above sea level.

Morphological characteristics

As it already was mentioned, for morphological studies were processed 25 lizards. Juveniles hatched in the autumn 2015, had the following characteristics: *D. armeniaca*: L — 300–340 mm (323 ± 1.2), Lcd — 530 mm, L / Lcd = 0.57; *D. dahli*: L — 250–340 mm (284 ± 1.1), Lcd — 400–670 mm (528 ± 4.4), L / Lcd = 0.42–0.68 (0.53 ± 0.04). Among the juvenile lizards were met individuals that hatched just recently. Body length (L) for adults *D. armeniaca* was — 550–700 mm (625 ± 7.5), Lcd — 950–1000 mm (975 ± 2.5), L / Lcd = 0.56–0.74 (0.64 ± 0.09); for *D. dahli*: L — 500–670 mm (604 ± 3.3), Lcd — 900–1100 mm (1008 ± 4.9), L / Lcd = 0.56–0.68 (0.61 ± 0.03).

Among of all standard morphological parameters (Darevsky, 1967; Dotsenko, et al., 2008–2009) the most important for identification *D. armeniaca* and *D. dahli* lizards (ad and juv) are the following — **L : In-Oc / W : Oc, Gsc, Rtem**, additional scales, **St2, Collar, Ventr, PreA, FV** (table 1). Beside this species also differ by shape and size of the shields on the head — interparietale (**In**) и occipitale (**Oc**). Form of scales interparietale (**In**) depends on the age of the lizards that is why it was used the size of occipitale (**Oc**).

All lizards *D. armeniaca* had incomplete or short series of numbers superciliaries (**Gsc**) 4–7 granul. On the hind legs (thigh) — 3 scales between the femoral pores and the external ones increase of scales (**FV**). Additional shields not found. The form of the occipitale (**Oc**) scales are the truncated triangular.

All lizards *D. dahli* had an additional scales: **ad-Oc** (additional occipitale) — 28.6 %; **Ns-ad-Fn** (additional nasal) — 28.6 %; **ad-Oc & Ns-ad-Fn** — 42.8 %. Lizards had a complete series of superciliaries (**Gsc**) — 12–13 granul. On the hind legs — 4 scales (**FV**). The form of the occipital (**Oc**) scales is the trapezoid.

One of the lizards of *D. armeniaca* was different from others, and was completely green. Its parameters were the following: L — 550 mm, Lcd — 1000 mm of caudal length L / Lcd = 0.55. **Collar** — 23, **Ventr** — 27, **PreA** — 4, **Rtem** — 1, **St2** — 2, **L : In-Oc / W : Oc** — 2.3. It had incomplete or short series of superciliaries (**Gsc**) — 5 granul. On the hind legs (thigh) — 3 scales between the femoral pores and the external increase of scales (**FV**). Additional shields were not found. It also had limb abnormalities — absence of the distal phalanges of the fingers (table 1).

Near Denyshy resort melanistic lizard *D. dahli* was also found, with the black body and brown the upper part of the head and tail (fig. 3). The neck and the abdomen are black and white. Its length: L — 550 mm, Lcd — 700 mm (after regeneration). This type of the melanism is called in the scientific literature as «brown melanism», and described for steppe viper from West Ciscaucasia (Ostrovskikh, 1996).

Table 1. Pholidosis characteristics for lizards *Darevskia (saxicola)* complex (Darevsky, 1967 & original)

Species	Morphological parameters						
	Collar	Gsc	Ventr	PreA	Rtem	L : In-Oc / W : Oc	St2
<i>D. armeniaca</i>	20–23	4–7	27–30	1–2	1–2	1.95–3.93	2–3
	21.3 ± 05	5.1 ± 0.4	28.1 ± 0.3	1.3 ± 0.3	1.1 ± 0.1	2.84 ± 0.23	2.9 ± 0.2
<i>D. dahli</i>	24–29	12–13	28–30	2–3	2–3	1.25–1.95	3–5
	27.1 ± 0.5	12.1 ± 0.1	29 ± 0.11	2.1 ± 0.1	2.1 ± 0.1	1.56 ± 0.07	3.9 ± 0.15

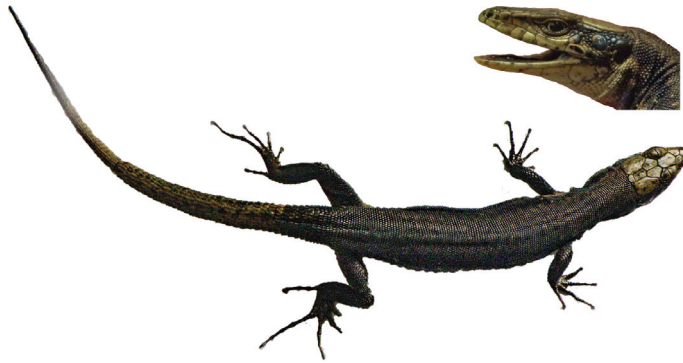


Fig. 3. «Brown melanist» (partially melanist) *D. dahli* from near Denyshy Village.

The scientific literature indicates that melanistic individuals (full or partial) were detected in populations of rock lizards in Crimean and Caucasian mountains (Kukushkin, Sviridenko, 2002; Doronin, 2012 a): *Darevskia lindholmi* (Lantz, Cyren, 1936), *D. pontica* (Lantz, Cyren, 1919), *D. alpina* (Darevsky 1967), *D. brauneri* (Mehely 1909), *D. rudis bischoffi* (Bohme, Budak, 1977) et al. But as in our case, the findings of such individuals are rare. The most common occurrence of melanism of the lizards is associated with a complex of factors — extreme environmental conditions, altitude, soil composition (for example, with high level in soils elements like manganese and iron), edge effects and others (Sharygin, Popov, 2003; Doronin, 2012 a).

Based on the available findings of the rock lizards in Zhytomyr Region (*D. armeniaca* and *D. dahli*) and the Crimea (*D. lindholmi*), and using Diva-GIS program it was conducting modeling of the potential area of distribution of these species in the Ukraine (Kukushkin, 2009; Doronin, 2012 b). Obtained results shows that rocky biotopes at the south of Zhytomyr and Vinnytsa administrative regions (along the Southern Bug River, and partially along Dniester River) are potentially most suitable for living of the lizards. And the most favorable for them is combination of rock cliffs and forest habitats (ecotones) along the river banks. Of the 19 most important climatic factors for distribution of rock lizards are factors associated with annual mean temperature, mean temperature of coldest quarter, precipitation of wettest month and precipitation of wettest quarter.

Conclusions

Darevskia armeniaca spread along the left bank at about 4 km (directly) or 8.5 km along shore line in 1963–2015; an isolated population of *D. armeniaca* separated from the main locality occurs near Buky Village (site 7). It is supposed that this secondary introduction took place occasionally or intentionally due to holidaymakers (e. g., climbers, fishermen).

Introduction of *D. mixta* in 1968 was not successful, and later this species was never found. At the same time in the area of the lizards initial introduction, in 1980, was found *D. dahli*, which also created viable breeding population in the sites 1–2. Perhaps more detailed study will also find this species in other sites — 3, 4 and 7, inhabited by *D. armeniaca*.

The biggest number of *D. armeniaca* was found in the area of initial introduction and around of it (sites 1 and 2) — up to 10–15 lizards/m², in forest ecotone near the river with rocky cliffs of south exposition. Thus the most important environment characteristics for distribution of *D. armeniaca* are the presence of rock cliffs of southern exposition in combination with forest biotopes, and humidity.

Ratio of *D. armeniaca* and *D. dahli* (autumn 2015, sites 1–2) was nearly equal. Number of juveniles was much higher than adults. Juveniles concentrated quite separately from adults, mainly in forest litter at the foot of the cliffs.

In the site 2, near Denyshy resort, a melanist of *D. dahli* was found.

Of the all above mentioned morphological characters, *D. armeniaca* and *D. dahli*, the most easily identified by characteristics of the head — L : In–Oc / W : Oc, Rtem, incomplete or short series of superciliaries (Gsc), additional scales on the head.

Computer modeling of spatial distribution of the introduced lizard species demonstrates that rocky biotopes at the south of Zhytomyr and Vinnytsa Regions along the Southern Bug River, and partially along the Dniester River potentially are the most suitable localities for them.

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