

THE WESTERN GREEN LIZARD *Lacerta* (*viridis*) *bilineata* Daudin, 1804 (Sauria: Lacertidae) IN SLOVENIA AND CROATIA

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Through a review of egg incubation times and the colour patterns of hatchlings of green lizards from the left side of the Soča (Isonzo) River, and the island of Cres, it has been found that they belong to a recently established species, *Lacerta (viridis) bilineata* Daudin 1802. It is from now on a member of the list of the herpetofauna of Slovenia and Croatia. At the same time *L. viridis* (Laurenti 1768) has been confirmed on the sand dunes around Đurđevac (Croatia). On the basis of the known distribution of green lizards and types of habitat in the case of the finds to date, the possible contact areas between the two taxa are considered.

Key words: *Lacerta, bilineata, viridis*, Slovenia, Croatia

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Na temelju dužine inkubacije jaja i pregledom obojenosti tek izvaljenih zelenih guštera s lijeve obale rijeke Soče (Isonzo) i s otoka Cresa, utvrđeno je da oni pripadaju nedavno ustanovljenoj vrsti *Lacerta (viridis) bilineata* Daudin 1802, od sada na popisu herpetofaune Slovenije i Hrvatske. Istovremeno je *L. viridis* (Laurenti 1768) potvrđena na pjeskarama oko Đurđevca (Hrvatska). Prema poznatom rasprostranjenju zelembača i tipovima staništa kod dosadašnjih nalaza, raspravlja se o mogućem području kontakta između te dvije svojte.

Ključne riječi: *Lacerta, bilineata, viridis*, Slovenija, Hrvatska

For a long time, *Lacerta viridis* (Laurenti 1768) was considered in Europe a single species that was widely distributed from Spain to Turkey (MERTENS & WERMUTH, 1960; NETTMANN & RYKENA, 1984). This is also how it was treated in the list of reptiles of ex-Yugoslavia (BRELIH & DŽUKIĆ, 1974).

The first signs of taxonomically important differences between the western and the eastern populations of *L. »viridis«* were found during the search for molecular markers to distinguish the sibling species *L. trilineata* Bedriaga 1886 (MAYER & TIDEMANN 1985). Then it was shown that specimens of *L. »viridis«* from central Italy and the Soča (Isonzo) valley differed from specimens of *L. viridis* from eastern Greece and the environs of Vienna (*terra typica* for *viridis*) in muscle protein (MP-E). The same difference was found in hybrids between a male *L. trilineata* and a female *L. »viridis«* from Rovinj. Soon after, RYKENA (1991), through cross-breeding experiments, showed that it was a question of semispecies. Through crossing a specimen from Venice (Italy) with a specimen from Hungary, alongside fertile males, RYKENA (1991) obtained in the F₁ generation at least 4% of sterile females. In lacertid lizards, sterility among hybrids is expressed first in the females, which are heterogametic. In the F₂ generation hatching success was only 27.6%, and in F₃ near 0%. The backcrosses produced hybrids with different levels of sterility. These results correspond to reproductive isolation at the level of semispecies. At the same time, RYKENA (1991) confirmed that hatchlings of the western semispecies have green throats (FIORONI, 1961), unlike typical *L. viridis* specimens, which have whitish throats. Therefore, the western semispecies took over the name *L. (viridis) bilineata* Daudin 1802. RYKENA (1991) concluded that these two taxa probably have an overlap zone (parapatric species) in Slovenia and Croatia, because north of the Alps their ranges do not touch. Similar assumptions were proposed by NETTMANN (1995) and ELBING *et al.* (1997).

AMANN *et al.* (1997) have found on small sample of specimens qualitative differences in four plasmaglobulins and in the allozyme aconitase. Analysis of the allozymes of two populations of the taxon *bilineata* (n = 15) and four populations of *viridis* (n = 20) for 17 loci gave a Nei genetic difference ranging from 0.16 to 0.19. This is, for example, similar to the difference between »good« species of *Podarcis taurica* and *P. erhardi*, and AMANN *et al.* (1997) concluded that their electrophoretic investigations confirmed the species status of *Lacerta bilineata*. Unfortunately, enzyme differentiation is often not a reliable method for the taxonomic estimation of divergence (LORKOVIĆ 1986). Qualitative morphological differences between the taxa *bilineata* and *viridis* have not yet been established, the only certain distinguishing mark being in the colour of the throat and sides of the head of hatchlings and juveniles before the first winter, as well as differences in the duration of egg incubation, thermal requirements and some activity patterns (NETTMANN & RYKENA, 1984; ELBING *et al.*, 1997).

Preparing for the search for the contact area between the taxa *bilineata* and *viridis*, and looking for the possible existence of the hybrid zone, the following specimens were collected in spring and early summer (the locations are marked in Fig. 1): May 14, 1998, a fertilised female from Log Čezsoški, left bank of the Soča (Isonzo) River, Slovenia, leg. S. Tome; July 2, 1998, a fertilised female from Valun, island of Cres, Croatia, leg. Z. Godec; July 7, 1998, two fertilised females from the sand dunes near Đurđevac, Croatia, leg. B. Lazar.

S. Tome made it possible for the female collected from the Soča valley to have 12 young from 16 eggs after 55–56 days (June 13–July 27–28) by incubation at 30–31 °C. The females from the island of Cres and Đurđevac laid their eggs in a laboratory in the Department of Animal Physiology of the Science Faculty in Za-



Figure 1. Preliminary distribution map of the green lizards *Lacerta viridis* (V), *L. (v.) bilineata* (B) and *L. trilineata* (T) in Slovenia (SLO) and Croatia (HR). Locations with confirmed taxonomical status are: Log Čezsoški (1), Rovinj (2), Valun (3), and Đurđevac (4). Numbers mark areas of possible contact between *L. viridis* and *L. (v.) bilineata* (5, 6, ?), and some lowland »island« populations of these taxa (7, 8, 9, 10). Montane, subalpine and alpine habitats without these lizards are marked black.

greb, and they were hatched in an incubator, thanks to the kindness of Dr. Z. Tadić. The Cres female laid 11 eggs, 10 of which were fertile. Of the two probably one year old females from Đurđevac, one laid 4 unfertilised eggs, and the other 6 eggs. All young were hatched on September 18, 1998.



Fig. 2. Juvenile specimen of *Lacerta (viridis) bilineata* from Valun, island of Cres, Croatia. Photo: D. Pelić.



Fig. 3. Juvenile specimen of *Lacerta viridis* from Đurđevac, Croatia. Photo: D. Pelić.

All the hatchlings from Log Čezsoški (Soča valley) had green throats and green sides of the head. This was also the case with the young (Fig. 2) of the female from Valun (island of Cres). The short duration of egg incubation and colour patterns of juveniles confirmed the presence of the western Mediterranean taxon of *L. (viridis) bilineata* in Slovenia and Croatia. The young of the females from Đurđevac (Figure 3) were in colouring typical specimens of *L. viridis*.

DNA of the specimens from these and some other localities, as well as of museum material kept in the Natural History Museum of Slovenia (Ljubljana) and the Croatian Natural History Museum (Zagreb), is now being analysed (PODNAR *et al.*, in preparation). As well as data about distribution of green lizards in Slovenia (TOME 1996), about 60 separate data items have been taken from the literature, in addition to 70 items from results of unpublished recent field research in Croatia and in the neighbouring border area of Bosnia-Herzegovina. These data about the distribution of the *bilineata/viridis/trilineata* complex of species in Slovenia and Croatia (Fig. 1), and data about habitats and heights above sea level of localities, suggest that direct contact between the taxa *bilineata/viridis* might be via the river valleys between Julian Alps and Trnovski Gozd (5) or via the Postojna-Vrhnika pass (6), both in Slovenia. Recent possible contact in Croatia would be prevented by the zone populated by *L. trilineata*. This eastern Mediterranean sibling species lives in the lower belt of the Adriatic coast and on most of the larger islands. The upper height limit at which it has been found is on the western edge of its range in the vicinity of Rijeka at about 500 m a.s.l., and in the south east of Croatia (Dalmatia) at about 900 m a.s.l. We would expect the southern limit of the continental species *L. viridis* above this zone in the border belt of beech and hop-hornbeam forests, where green lizards with blue-throated males have been found syntopically with *Podarcis muralis*. The systematic status of isolated lowland Mediterranean populations with blue-throated males inside the *L. trilineata* range (7 – Kotor near Crikvenica – RUCNER & RUCNER, 1971; 8 – Kozica – HENLE, 1985; 9 – Gornja Klada – TVRTKOVIĆ, unpublished; 10 – Sukošan – HENLE, 1985) will be separately investigated; probably among these there might be populations of *L. (viridis) bilineata*.

Special attention will also be paid to the islands of Veliki Brijun (Brioni Grande) and Cres, in which *L. (viridis) bilineata* and *L. trilineata* – like specimens have both been recorded (BRELIH, 1964; NETTMANN & RYKENA, 1984, personal data). Hybridisation effects seem to be possible in the populations of these island lizards, although the results of recent experimental crossing (only one to date) have resulted in 100% sterile progeny. F₁ hybrids of *bilineata* X *trilineata* mainly have, as well as pairs of longitudinal light lines, a clear occipital stripe like *L. trilineata*. This was found in 15 of the 16 hatchlings in the crossing mentioned, but the throat and side of head colour was unluckily not quoted (NETTMANN & RYKENA, 1974). Unfortunately, neither are there any published data about inheritance of neck and side of head colour in the F₁ hybrids of *bilineata* X *viridis*. An exact picture of the nature of the contacts between *L. (viridis) bilineata* and *L. viridis* and final conclusions about their taxonomical status will be obtained only on a detailed analysis of the morphological, molecular and ecological characteristics of the populations in the contact zone of their ranges.

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REFERENCES

- AMANN, T., RYKENA, S., JOGER, U., NETTMANN, H. K. & VEITH, M., 1997: Zur artlichen Trennung von *Lacerta bilineata* Dudin, 1802 und *L. viridis* (Laurenti, 1768). *Salamandra* **33** (4), 255–268.
- BRELIH, S., 1964: Prispevek k poznavanju kvarnerskih kuščaric (Reptilia, Lacertidae). *Biol. vestnik* **11**, 107–113.
- BRELIH, S. & DŽUKIĆ, G., 1974: Reptilia. Catalogus faunae Jugoslaviae IV/2, SAZU, Ljubljana.
- ELBING, K., NETTMANN, H.-K. & RYKENA, S., 1997: Green lizards in central Europe: status, threats and research necessary for conservation. In Böhme, W., Bishoff, W. & Ziegler, T. (eds): *Herpetologia Bonnensis*, Bonn (SEH), 105–113.
- FIORONI, P., 1961: Zur Pigment und Musterentwicklung bei squamaten Reptilien. *Rev. Suisse Zool.* **68**, 727–874.
- HENLE, K., 1985: Ökologische, zoogeographische und Systematische Bemerkunge zur Herpetofauna Jugoslawiens. *Salamandra* **21** (4), 229–251.
- LORKOVIĆ, Z., 1986: Enzyme Electrophoresis and Interspecific Hybridization in Pieridae (Lepidoptera). *Your. Res. Lepid.* **24** (4), 334–358.
- MAYER, W. & TIEDEMANN, F., 1984: Heart-lactate dehydrogenase: An allozyme marker differentiating *Lacerta trilineata* Bedriaga, 1886, and *Lacerta viridis* (Laurenti, 1768) in Southern Europe. *Amphibia-Reptilia* **6**, 163–172.
- MERTENS, R. & WERMUTH, H., 1960: *Die Amphibien und Reptilien Europas*. Waldemar Kramer, Frankfurt am Main.
- NETTMANN, H. K., 1995: Zur Geschichte einer vermeintlichen Neuentdeckung. *Elaphe* (N. F.) **3**(4), 63–66.
- NETTMANN, H. K. & RYKENA S., 1974: Eine gelungene Kreuzung von *Lacerta t. trilineata* und *Lacerta v. viridis* (Sauria, Lacertidae). *Salamandra* **10**, 83–85.
- NETTMANN, H. K. & RYKENA S., 1984: *Lacerta viridis* (Laurenti, 1768) – Smaragdeidechse. In Böhme, W. (ed.): *Handbuch der Amphibien und Reptilien Europas*. Bd. 2/I: Echsen II (*Lacerta*). Aula, Wiesbaden, 129–180.
- RUCNER, D. & RUCNER, R., 1971: Prilog poznavanju faune nekih šumskih zajednica u Hrvatskoj. *Larus* **23**, 129–201.
- RYKENA, S., 1991: Kreuzungsexperimente zur Prüfung der artgrenzen im Genus *Lacerta* sensu stricto. *Mitt. Zool. Mus. Berlin* **67** (1), 55–68.
- TOME, S., 1996: Pregled razširjenosti plazilcev v Sloveniji. *Annales* **9**, 217–228.

S A Ž E T A K

**Zapadni zelembać *Lacerta (viridis) bilineata* Daudin, 1804
(Sauria: Lacertidae) u Sloveniji i Hrvatskoj**

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Nakon nedavnog otkrića dobivenog pokusima križanja, da se u dosad priznatoj vrsti zelembaća *Lacerta viridis* (Laurenti 1768) kriju dvije morfološki slične i geografski odvojene poluvrste (RYKENA, 1991), utvrđivanjem dužine inkubacije jaja i pregledom karakteristične obojenosti tek izleženih životinja, potvrđena su očekivanja da u zapadnom dijelu Slovenije i Hrvatske živi zapadnoeuropska poluvrsta *Lacerta (viridis) bilineata* Daudin, 1804. Za sada je ona utvrđena u dolini Soče (Log Čezsoški) i na otoku Cresu (Valun), a prema starijim podacima o molekularnoj građi proteina plazme i u Istri (Rovinj) (MAYER & TIDEMANN, 1984). Istočnoeuropska *L. viridis* potvrđena je za sada samo u Podravini (Đurđevac, Hrvatska). Vizualna identifikacija je izvedena prema obojenosti grla i strana glave, koja je u tek rođenih do prve zime starih primjeraka u *L. (viridis) bilineata* zelena, a u *L. viridis* bjelkasta. Uz tu razliku do sada su poznate još osobitosti proteina plazme (globulini i tzv. mišićni protein) te specifični oblik enzima akonitaze, razlike u dužini inkubacije jaja, toplinskim potrebama i aktivnosti.

Potvrda da *L. (viridis) bilineata* živi u Sloveniji i Hrvatskoj tek je prvi rezultat kompleksnih molekularnih, morfoloških i ekoloških istraživanja kojima se nastoji utvrditi granica kontakta i mogućeg preklapanja areala, odnosno moguće postojanje hibridnog pojasa. Konačni rezultati istraživanja prirode kontakta između tih dviju svojti, kojima je tek eksperimentalno utvrđen stupanj reproduktivne izolacije, bit će presudni u određivanju njihovog stvarnog sistematskog statusa a, ujedno, prilog u rekonstrukciji mehanizama evolucije europskih vrsta kralježnjaka.