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MORPHOLOGICAL VARIATION OF THE EASTERN SAND LIZARD, *Lacerta agilis exigua* Eichwald, 1831 (SQUAMATA, LACERTIDAE) IN KAZAKHSTAN

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Submitted ???????????????.

208 specimens of *Lacerta agilis exigua* from 11 localities of Western, Central and Eastern Kazakhstan have been studied, and compared in respect of their body proportions and scalation. The sexual dimorphism of some characters (Ventr., L.ta/L.a) is shown. Maximum body length (SVL) and anal index (L.ta/L.a) is recorded for the specimens from the southern populations (Taldy-Kurgan, Aktyubinsk). A maximum number of scales around the mid-body (Sq) has found in Semipalatinsk, Aktyubinsk, and Uralsk localities. The increasing of Ventr. in two directions: from west to east and from south to north is shown. A cline variation is shown for scale correlation in the postnasal region. The frequency of 2/1 combination increases from east to west, while 1/2 and 1/1 combinations change in opposite direction. The variation of preanals with an additional shield between two enlarged ones is shown for 10 (except of Ayaguz) localities.

Key Words: Squamata, Lacertidae, *Lacerta agilis*, body proportions, scalation, morphological variation, Kazakhstan.

INTRODUCTION

The sand lizard *Lacerta agilis* is one of the most widespread herps of Eurasia. The species range is stretched from Great Britain, Eastern France and northern regions of Balkan Peninsula in the west to Southern Transbaikalia, Western Mongolia, and Northwestern China in the east (Fig. 1); see also Szczerbak et al., 1976; Bischoff, 1988; Munkhbayar et al., 1998). According to recent view (Ananjeva et al., 1998), there are ten subspecies of *L. agilis* combined in two geographical groups. The "eastern" group includes *L. a. grusinica*, *L. a. brevicaudata*, *L. a. boemica*, *L. a. ioriensis*, and *L. a. exigua*. The "western" group consists of *L. a. agilis*, *L. a. argus*, *L. a. boemica*, *L. a. chersonensis*, and *L. a. garzoni*. Taxonomic status of *L. a. argus* from the eastern regions of Central Europe restored by Bischoff (1984), is still debatable (Rahmel, 1988; Milto, 1996).

L. a. exigua has largest range among other subspecies (Fig. 1) and inhabits a territory stretching to the east from the line St.-Petersburg – Moscow – Dnepropetrovsk – Karkinitsky Gulf of the Black Sea and going as far as eastern boundary of species range (Szczerbak et al., 1976; Bischoff, 1988). A south boundary of *L. a. exigua* range passes within Kazakhstan where the lizard occupies mainly steppe and forest-steppe zones.

Until now *L. a. exigua* from Kazakhstan populations remains very poorly studied within the most of its range in the republic. Certain data on the lizard distribution and biology and sparse morphological data are known from Paraskiv (1956) and Berdibajeva (1989). I. S. Darevsky with coathors (Darevsky et al., 1976) gave most complete comparative analysis of *L. a. exigua* morphological variation in Kazakhstan, although the material examined was represented with only five localities (Uralsk, Guryev [= Atyrau], Taldy-Kurgan, Tselinograd [= Akmola, = Astana], and Zayssan Lake).

In present paper we summarize data on body size and scalation of *L. a. exigua* (Fig. 2) from 11 localities of Western, Central and Eastern Kazakhstan and analyze morphological variation of the lizards within a territory of the republic.

MATERIAL AND METHODS

We examined 208 adult specimens collected from 11 localities of Western (WK), Central (CK),

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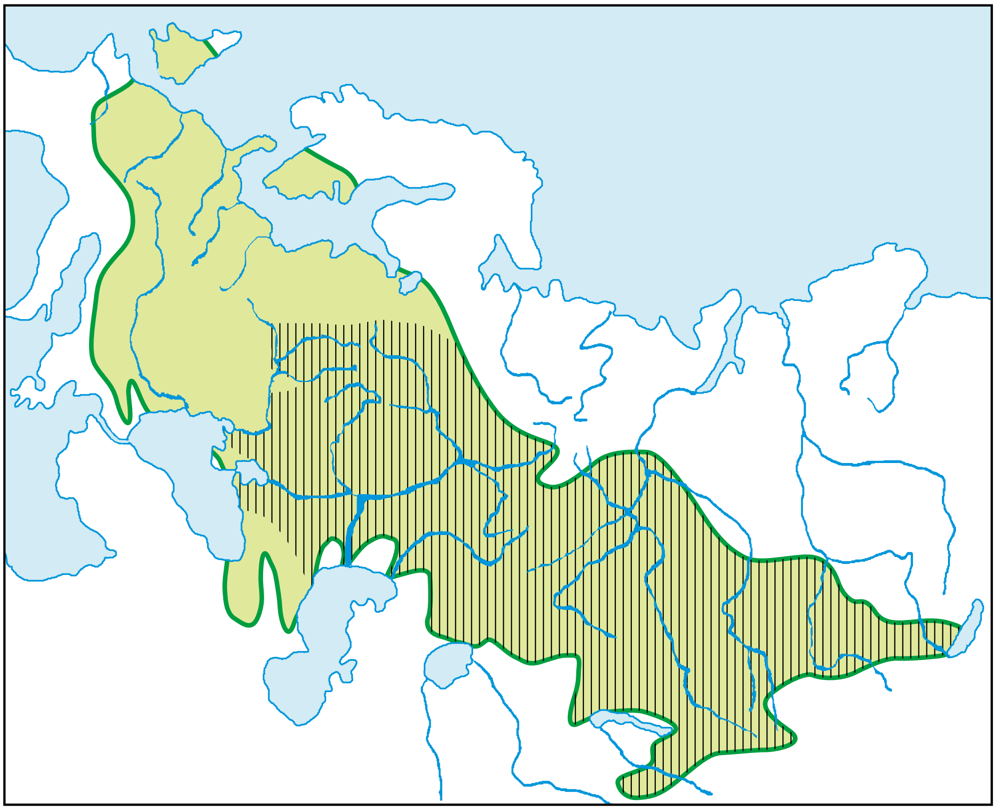

Fig. 1. Distribution of *L. agilis* and *L. agilis exigua* (shading) in Eurasia.

Fig. 2. *L. agilis exigua* (male, Eastern Kazakhstan).

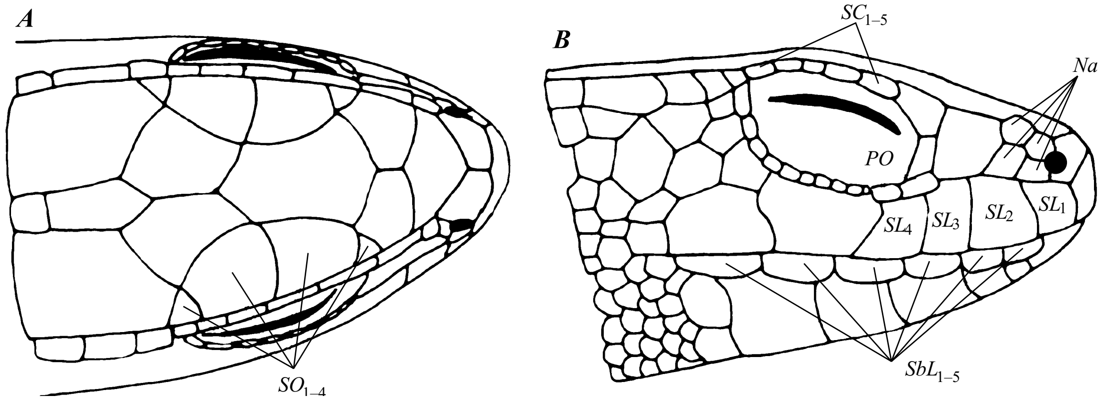

Fig. 3. Head scalation of *L. agilis exigua*: *SO*) supraoculars; *SC*) supraciliars; *PO*) preoculars; *Na*) postnasal combination; *SL*) supralabials; *SbL*) sublabials.

Eastern (EK), and Southeastern (SEK) Kazakhstan. The localities examined are represented with black circle in Fig. 1 (**FROM FOLIUM: Original have no black circles inside Fig. 1!!!**):

1) Uralsk (WK, environs of Uralsk), $n = 13$;

2) Aktyubinsk (WK, environs of Mamir Village and Turgay River), $n = 10$;

3) Akmola (CK, environment of Akmola [= Astana]), $n = 17$;

4) Pavlodar (CK, environs of the villages Lebyazhii, Maiskii, and Ermak), $n = 13$;

5) Semipalatinsk (EK, environs of Semipalatinsk), $n = 13$;

6) Chagan (EK, SNER, environs of the lakes Atomnoe and Chagan), $n = 29$;

7) Karazhir (EK, SNER, Karazhir Guarry), $n = 24$;

8) Kaldzhir (EK, Kaldzhir River), $n = 22$;

9) Shemonaicha (EK, environs of Shemonaicha Village), $n = 43$;

10) Ayaguz (EK, environs of Ayaguz), $n = 10$

11) Taldy-Kurgan (SEK, environs of Matay Village and Alakol Lake), $n = 14$.

Most of the specimens examined were collected during fieldwork in spring-summer period 1997 – 1998 and preserved in 70° ethanol. Additional material was burrowed from the collections of Institute of Zoology (Kazakh Academy of Sciences, Almaty, IZ), Zoological Institute of Russian Academy of Sciences (St. Petersburg, ZISP), and Department of Biology, Kazakh State University (Almaty, noncataloged specimens). For morphological analysis all specimens were sexed, measured for snout-vent length (SVL), and scored for several age- and size independent meristic scale characters: Sq, number of dorsal scales around the mid-body; Ventr., number of ventral scales in the left central longitudinal row from the collar fold to the first scale contacting femoral pores; Pf, number of femoral pores on one side; L.ta/L.a, correlation between width and length of anal shield (anal index). Postnasal and cheek numbers correlation (Na) and pattern of preanal shield arrangement were also taken into consideration (Figs. 3 and 4). Following Darevsky with coauthors (Darevsky et al., 1976), we considered any shield jointed the nostril behind at least in one point as a postnasal shield. For all the characters enumerated we computed the minimum and maximum values (min – max), average value ($M \pm m$), and ration of variation (CV) using Statistics software for Windows.

RESULTS AND DISCUSSION

Sexual dimorphism

Our study did not reveal a sexual dimorphism in body length of the lizards examined (Table 1), although, a reliable difference in body size between males and females is quite widespread phenomenon among squamate reptiles (Darevsky, 1979; Thorpe and Balz, 1987; Garcia-Marquez et al., 1998; Molina-Borja and Rodriguez-Dominguez, 1998; Vrankovic, 1998).

Our study confirmed the data of previous authors (Darevsky et al., 1976; Ushkalova, 1976; Bischoff, 1984, 1988; Munkhbayar et al., 1998) on clear sexual dimorphism in two meristic characters of *L. agilis*: a number of ventral shields (Ventr) and anal index (L.ta/L.a) (Table 1). On Darevsky's opinion (1979), the greater number of ventral shields and less anal in-

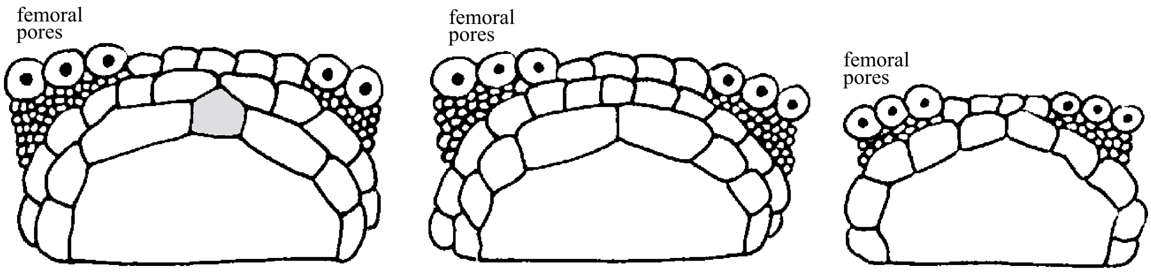

Fig. 4. Preanal arrangement in *L. agilis*: *A*) inner row with two enlarged central scales and intermediate additional scale; *B*) inner row with two enlarged central scales; *C*) homogenous inner row of scales.

dex in females is related to carrying and lying of eggs.

We did not record a clear sexual difference in a number of femoral pores (Pf). Nevertheless, femoral pores in males and females differ in morphology. The femoral pores of males are ovoid in shape (when those of females are round-shaped) and more protrude above the scale surface. The data of Orlova and Terbish (1997), who also did not find sexual differences during their study on *L. agilis* from Mongolia, may support our data on absence of sexual dimorphism in a number of femoral pores. In other hand, the reliable sexual differences in number of femoral pores is found by Munkhbayar et al. (1998) in *L. agilis* from Mongolia and Roytberg (1989) in *L. agilis* and *L. strigata* from Daghestan. It cannot be excluded that femoral pore number correlates with limb length. Carretero et al. (1998) showed a positive correlation between these characters.

Our data did not reveal a sexual dimorphism in a number of scales around the midbody (Sq). However, Darevsky with coauthors (Darevsky et al., 1976) using more abundant material (3658 specimens), showed greater number of scales around midbody in males in comparison with females.

The analysis of external morphology of *L. agilis* from 11 populations of Kazakhstan has shown geographical variation in some characters.

TABLE 1. Sexual Dimorphism of *Lacerta agilis* in Some Morphological Characters (average value)

	Ventr	L.ta/L.a	Pf	Sq	L
Females	29.9 $n = 137$	1.81 $n = 100$	14.07 $n = 135$	41.08 $n = 137$	7.21 $n = 135$
Males	28.5 $n = 54$	2.15 $n = 53$	14.2 $n = 56$	41.6 $n = 55$	7.75 $n = 55$

Note. For abbreviations see *Material and Methods*.

Body length (SVL)

A comparison of average values of SVL among Kazakhstan populations examined shows a presence of W-E cline, e.g., the average SVL of sand lizards from western populations is greater than that of the eastern ones (Table 2). However, the lizards from northeastern Shemonaikha population (No. 9) differ visibly in their very high average value of SVL. The specimens from Aktyubinsk (No. 2) and Taldy-Kurgan (No. 11) have the maximum average values of SVL, in opposite to the specimens from Semipalatinsk (No. 5), Chagan (No. 6) and Ayaguz (No. 10), which have the minimum average values of SVL. The specimens from SNER and surrounding populations (Nos. 5 – 7) do not demonstrate any peculiarities in body length and stay in agreement with general W-E cline defined by us.

Earlier (Darevsky et al., 1976) it was noted a cline variation in body length studied *L. agilis* populations from the whole of the species range. The authors showed that lizards from most south regions of species range have greatest body size. A decreasing of body length goes not only to the east but to the west and to the north as well. Cline W-E variation of body length observed by us in Kazakhstan populations of *L. agilis* is in agreement with cited data (Darevsky et al., 1976) in general. However, we recorded the maximum average value of SVL in the specimens from the localities No. 2 (CK) and 11 (SK) (Table 2). According to climatic data, the territory of Aktyubinsk district does not belong to the zone of continental deserts. Significant annual rainfall and more high average annual temperature in Aktyubinsk district comparatively with northern regions may be considered as optimum for species and so, may indirectly result the high value of average lizard SVL here. Locality No. 11 occupies the most south region of

L. agilis distribution in Kazakhstan and obviously it may be also characterized as optimal zone.

Number of scales around the mid-body (Sq)

The average values of the character do not show cline variation. The minimum values of Sq average value were found in Akmola, Karazhir, and Ayaguz populations. The maximum values of Sq average value were recorded for specimens from Aktyubinsk and Semipalatinsk (Table 2).

A presence of cline variation in Sq was previously shown for a number of lizard species (Szczerbak, 1974; Thorpe and Baez, 1987; Malhotra and Thorpe, 1991; Castellano et al., 1994). The authors proposed the different climatic factors as possible reasons of this variation. Darevsky with coauthors (Darevsky et al., 1976), having in their disposal a great material from the whole of species range of *L. agilis*, noted a visible decreasing of Sq from the west to the east. Significant variation in Sq is not observed within examined territory. Some increasing of Sq value in Semipalatinsk and Aktyubinsk lizards could be explained by fewer altitudes of the localities in comparison with other examined. According to Marquez et al. (1998) and Thorpe and Brown (1991), the populations from sea level have greater value of Sq than those from higher altitudes.

Number of ventral scales (Ventr.)

Our data demonstrate increasing of Ventr. in two directions: from west to east and from south to north. The maximum averages are defined for most of the populations from Eastern Kazakhstan (Chagan, Karazhir, Kaldzhir, and Shemonaikha) and one population from Western Kazakhstan (Aktyubinsk), and the minimum average for Uralsk locality (Table 2). The same variation was already noted for *L. agilis*, when specimen samples from the whole of the species range were compared (Darevsky et al., 1976). Munkhbayar and Borkin (1990) reported similar variation for lizards of the genus *Eremias*.

Number of femoral pores (Pf)

Our data did not show visible variation of the character. An average number of femoral pores is maximum in Semipalatinsk lizards and minimum in Uralsk and Akmola specimens (Table 2). Basing on Suchov (1926) and Darevsky et al. (1976), we propose that the variation is quite weak in general and can be defined in analysis of a number of populations from more enormous area of species range.

TABLE 2. The Morphological Characters of *Lacerta agilis* from 11 Populations of Kazakhstan

	Locality No.										
	1	2	3	4	5	6	7	8	9	10	11
n	13	10	16	12	13	29	24	43	22	10	14
SVL	58.0–92.5	73.6–87.5	60.0–85.0	63.0–80.0	51.3–75.2	60.1–73.7	52.4–80.7	610–94.4	55.7–81.0	55.2–89.3	58.7–94.8
	74.0	79.4	72.6	70.1	65.5	67.8	68.2	77.0	69.4	66.8	80.8
	0.36	0.18	0.18	0.18	0.19	0.10	0.15	0.14	0.23	0.24	1.29
	43.73	7.34	10.5	8.68	8.96	8.62	10.52	11.76	15.31	11.18	12.25
Sq	38–44	39–45	35–44	38–42	41–45	39–44	37–43	36–45	36–44	36–45	39–44
	41.6	42.2	39.76	40.81	43.0	41.52	39.88	41.19	40.11	39.08.	40.92
	0.54	0.61	0.8	0.48	0.44	0.31	0.34	0.36	0.41	0.81	0.45
	4.12	4.58	8.27	3.86	3.08	3.86	4.28	5.74	4.82	7.19	3.82
Ventr	25–30	28–31	27–31	27–31	27–33	28–34	28–32	27–33	27–32	27–31	27–30
	28.0	29.8	28.29	29.0	29.1	30.55	29.50	29.67	29.75	28.8	28.5
	0.4	0.33	0.38	0.4	0.68	0.28	0.23	0.24	0.35	0.47	0.29
	5.13	3.47	4.54	4.64	6.57	4.99	3.87	5.29	4.67	5.12	3.83
Pf	11–16	13–16	12–16	12–16	13–16	12–16	11–16	11–16	12–16	12–16	12–16
	13.52	14.15	13.52	13.7	14.75	14.31	13.9	13.85	13.89	14.15	13.73
	0.18	0.2	0.17	0.26	0.27	0.14	0.18	0.12	0.12	0.25	0.27
	6.13	6.18	7.33	7.93	7.89	7.13	9.33	6.25	5.65	8.03	10.08
L.ta/L.a	1.42–2.68	1.12–2.5	1.5–2.68	1.5–2.27		1.33–2.91	1.34–2.83	1.3–2.54	1.51–2.33	1.34–3.3	1.5–2.57
	1.96	1.75	1.97	1.78		1.85	1.93	1.97	1.8	1.96	2.05
	0.06	0.17	0.09	0.07		0.07	0.08	0.05	0.08	0.19	0.08
	9.9	28.65	18.89	13.59		19.11	20.67	18.19	20.24	30.23	15.13

Note. 1–11) localities examined (see *Material and Methods*); SVL) snout-vent length; Sg) number of dorsal scales around the mid-body; Ventr) number of ventral scales in the left central longitudinal row from the collar fold to the first scale contacting femoral pores; Pf) number of femoral pores on one limb) L.ta/L.a, correlation between width and length of anal shield.

Correlation between width and length of anal shield (L.ta/L.a, anal index)

We did not observe significant variation in this character. Maximum average value is recorded for Taldy-Kurgan specimens having the maximum average value of body length (Table 2). In previous literature it was also noted a positive correlation between L.ta/L.a and body size of animals (Darevsky et al., 1976). Absolute maximum value is registered for specimens from Eastern Kazakhstan including SNER populations (Ayaguz, Chagan, Karazhir). Absolute minimum value is shown for Aktyubinsk (Table 2).

Preanal shield arrangement (Pr.an)

All the specimens examined have the preanals arranged into two semicircles. Two central shields of inner semicircle are enlarged. Some specimens have additional pentagonal shield between two enlarged ones (Fig. 4*A*). Earlier S. M. Čugunov (1911) noted a presence of additional shield between two enlarged central preanals in *L. a. exigua* specimens from Altay Mountains. According to our data preanal arrangement does not show cline variation, although some geographical variation was observed. Maximum number of the specimens with additional shield was recorded from Chagan, Karazhir, and Akmola localities (Table 3). The minimum percent of the character is recorded for Kaldzhir and Taldy-Kurgan lizards. Additional preanal is unknown for the specimens from Ayaguz.

Previous authors (Bogdanova, 1960; Darevsky et al., 1976; Bischoff, 1984, 1988) usually combined the variations recorded into two groups: 1) presence of two central enlarged preanal shields (Fig. 4*B*) and 2) homogenous row of preanals (Fig. 4*C*). The arrangement of preanals into two semicircles described here is, in general, typical for all subspecies of eastern group of *L. agilis*. In the subspecies of western group the preanals, as a rule, are arranged in single semicircle. As was considered previously (Darevsky et al., 1976), enlarged preanals of inner semicircle show cline variability. 100% presence of this character was recorded for sand lizard from the Caucasus. To the west, north and east directions the percent of the specimens with the character decreased gradually (radial variation). However, basing on our data we doubt this statement. All the populations examined by us refer to eastern group of *L. agilis*. Nevertheless, we found all the specimens (100%) with enlarged preanals. Our doubt could be supported with study on the most eastern populations of *L. agilis* from Mongolia (Munkhbayar et al., 1998; Orlova and Terbish, 1997). The authors mentioned found 100% presence of enlarged preanals in Mongolian lizards as well.

Correlation of postnasals and cheeks (Na)

Totally, 7 different combinations were defined in present study, namely: 2/0, 1/1, 1/2, 2/2, 2/1, 2/3, 2/4. The combination 2/2 is considered as basic for *L. a. exigua* (Darevsky et al., 1976; Bischoff, 1984, 1988; Munkhbayar et al., 1998). Our data successfully confirmed this statement. The most of the populations examined have 15 – 75% specimens with 2/2 combination. The only population with low percent of 2/2 specimens was from Pavlodar (7.6%). Other combinations (2/1, 1/2, 2/3, 2/4) were rarely recorded (0 – 40%). Suchow (1926) wrote that a number of postnasals and cheeks depended upon a habitat of *L. agilis.* According to our data on Kazakhstan sand lizards, three combinations (2/0, 1/1, 1/2) demonstrate a cline variation. 2/0 combination (= complete absence of cheeks) clinally varies from W to E. It has maximum percent in western populations (Uralsk — 23.07% and Aktyubinsk — 40.0%) and minimum — in most eastern Kaldzhir — 6.8%. Darevsky with coauthors (Darevsky et al., 1976) considered Western Georgia and Eastern Kazakhstan as centers of 2/0 prevalence. However, if for Western Georgia these authors noted up to 60% of cheeks absence, we do not confirm the same for specimens of Eastern Kazakhstan. It could be appropriately to remind that we did not include into our research the populations from mountain region of Eastern Kazakhstan. It is suggested to be a correlation between cheeks absence and locality altitude. For example, Munkhbayar with coauthors (Munkhbayar et al., 1998) counted 2/0 combination in 27% specimens from Mongolian Altay Mountains. Although, other authors (Orlova and Terbish, 1997) studied *L. agilis* from the same regions did not confirmed Munkhbayar's et al. data. A question, "Is eastern Kazakhstan a center of 2/0 combination prevalence?" is still open.

TABLE 3. The Rate (%) of *L. agilis* Specimens from Kazakhstan Populations with Additional Preanal Shield

Locality	1	2	3	4	5	6	7	8	9	10	11
%	15.38	10	30.76	17.6	7.69	34.84	25.0	13.9	4.54	–	7.1

Note. 1 – 11) No. of populations (see *Material and Methods*).

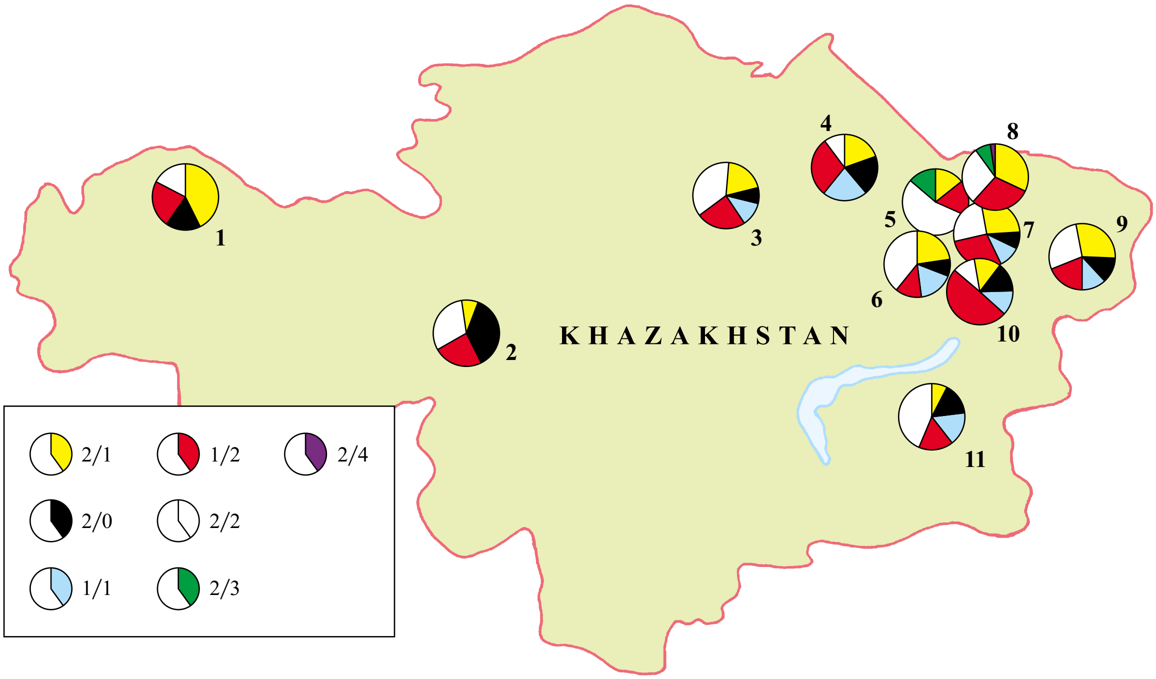

Fig. 5. Diagram showing the distribution of postnasal combinations in *L. agilis exigua* from Kazakhstan.

For 1/1, 1/2 and 2/1 combinations a presence of radial variation from prevalence centers was defined (Darevsky et al., 1976). On the contrary, our data show an increasing of 1/1 and ½ combinations to W-E direction (Chirikova et al., 1998). 2/1 combination is in agreement with previous authors (Darevsky et al., 1976). It is of maximum percent (46.15%) in most western population from Uralsk and it gradually decreases to the east (Fig. 5). Basing on the finds of some other authors (Munkhbayar et al., 1998; Khromov and Korneychuk, 1998) of very high percent of 2/1 combination in sand lizards from Mongolia and Northeastern Kazakhstan, we suggest a possibility of two centers of 2/1 prevalence in Kazakhstan — western and eastern. 2/3 combination was registered in Shemonaicha and Semipalatinsk specimens. The only lizards with 2/4 combination were from Shemonaicha.

APPENDIX

The specimens of *Lacerta agilis exigua* examined are listed below. IZ (110): 712, 1106, 1111, 1741 – 1743, 1753, 1755 – 1758, 1803, 1832 – 1834, 1930, 2777, 2778, 2788, 2789, 2791 – 2794, 3050 – 3056, 3175, 3177 – 3179, 3180, 3545, 3575, 3576, 3690, 3691, 3692, 3787, 3689, 4013, 4014, 4016, 4250, 4254, 4351, 4256 – 4261, 4291 – 4297, 4353, 4471, 4557 – 4559, 4561, 4563, 4566, 4568 – 4571, 4573 – 4575, 4578 – 4590, 4592 – 4610, 4612 – 4619; ZISP (33): 21506 – 21514 (field Nos. 6, 7, 10 – 18, 52, 130 – 140, 142, 147, 250 – 257); and 65 noncataloged specimens.

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