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Lymnaea likharevi Lazareva, 1967 is a junior synonym of *Lymnaea saridalensis* Mozley, 1934 (Gastropoda: Pulmonata: Lymnaeidae)

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ABSTRACT. *Lymnaea* (*Stagnicola*) *likharevi* Lazareva, 1967 and *Lymnaea* (*Stagnicola*) *saridalensis* Mozley, 1934 – two closely allied lymnaeid species that inhabit Western Siberia and, in many cases, may co-occur in the same habitat. A detailed study of conchological and anatomical variation of the two species from seven syntopic samples has shown that these are non-diagnosable since there is no morphological hiatus to separate them. A new synonymy is established: *L. likharevi* is a junior synonym of *L. saridalensis*. The data on the type series of the studied species as well of *Lymnaea draverti* Mozley, 1934 are provided.

According to Kruglov and Starobogatov [1986], the waterbodies of Western Siberia are inhabited by several species of the (sub-)genus *Stagnicola* Leach in Jeffreys, 1830. Being more or less similar conchologically, the species can be distinguished on the basis of proportions of their copulatory organs. Namely, two of the Western Siberian stagnicolines, *Lymnaea* (*Stagnicola*) *likharevi* Lazareva, 1967 and *L.* (*S.*) *saridalensis* Mozley, 1934, are characterized by a very long penis sheath that is 4–6 times longer than a praeputium [Kruglov, Starobogatov, 1986; Kruglov, 2005]. This trait distinguishes *L. likharevi* and *L. saridalensis* from all other species of stagnicoline snails that occurs in Western Siberia. However, there are no qualitative differences between the two species either in shell characters or in internal structure. Besides, in the southern part of Western Siberia *L. likharevi* and *L. saridalensis* often live syntopically, and one may found them together even in very small waterbodies without any signs of their microhabitat segregation that thought to be needed for ecologically similar species to co-exist in the same locality [Neil, 2001]. Therefore additional research is needed to verify their taxonomic distinctiveness.

Andreyeva *et al*. [2010] did not include *L. likharevi* in their list of the Western Siberian lymnaeid snails. The authors considered *L. likharevi* as a synonym of *L. saridalensis* though they did not provide strong evidence for this opinion. This article is based on thorough study of variation in diagnostically important characters of *L. likharevi* and *L. saridalensis* from habitats situated in Western Siberia (both species have their type localities in this region). The aim of the study is to provide direct arguments for considering *L. likharevi* as a junior synonym of *L. saridalensis*.

Material and methods

Seven large syntopic samples of *L. likharevi* and *L. saridalensis* were studied (Table 1). Most of them were collected by the author and are kept in the collection of the Museum of Siberian Aquatic Molluscs (Omsk State Pedagogical University, Omsk, Russia; MSAM hereafter). In addition, some samples from the collection of the Museum of the Institute of Plant and Animal Ecology of the Uralian branch of RAS (Yekaterinburg, Russia; IPAE hereafter) were studied. Due to courtesy of Dr. Yu.I. Kantor (Moscow) I was able to use photos of syntype shells of *L. saridalensis* and *L. draverti* Mozley, 1934 (both are housed in the collection of the National Museum of Natural History, Smithsonian Institution, Washington, USA; USNM hereafter). The latter spesies was included to the synonymy of *L. saridalensis* by Kruglov and Starobogatov [1986]. Accession number for *L. saridalensis* type series is USNM 469734; accession number for *L. draverti* type series is USNM 469681.

The type series of *L. likharevi* is kept in the Zoological Institute of RAS (Sankt-Petersburg, Russia; ZIN hereafter) and was inspected by me. It includes five samples taken from three waterbodies of Northern Kazakhstan (accession numbers 1–5). In total, the type series contains the holotype and 36 paratypes.

The type localities of three species under investigation are (given as on the labels):

L. draverti – "river Om near Omsk, Russia".

L. likharevi – "[Northern Kazakhstan], Kokchetav Region, Borovoye Lake".

Table 1. Syntopic samples of *L. likharevi* and *L. saridalensis* used in the study.

Табл. 1. Синтопические выборки видов *L. likharevi* и *L. saridalensis*, использованные в работе.

Locality	Sampling date, collector(s), depositary	No. of studied individuals	No. of dissected snails
Novosibirsk Region, Fadikha Lake.*	10.10.2002. Vinarski M.V. MSAM	36	32
Novosibirsk Region, a swamp in the floodplain of the Kargat River.*	10.10.2002. Vinarski M.V. MSAM	58	40
Omsk Region, Trauly Lake.	24.07.2002. Vinarski M.V. MSAM	85	37
Omsk Region, Omsk City, a swamp in the floodplain of the Irtysh River.	21.05.2004. Vinarski M.V., Karimov A.V. MSAM	185	80
Omsk Region, Kabankul' Lake.	19.07.2002. Vinarski M.V. MSAM	300	54
Sverdlovsk Region, a waterbody near Murzinka Station.	26.06.1971. Lazareva A.I. IPAE	39	27
Tyumen Region, vicinity of Labytnangi Town, a lake near Vylposl channel.	19.07.2007. Vinarski M.V., Karimov A.V., Golovanova E.V., Sverlova A.V. MSAM	99	35

*Full descriptions of these localities are given in Yurlova *et al*. [2006].

Table 2. Diagnostic features of *L. likharevi* and *L. saridalensis* according to different authors*.

Табл. 2. Диагностические признаки видов *L. likharevi* и *L. saridalensis* согласно различным авторам.

Author(s)	*L. likharevi*	*L. saridalensis*
Lazareva, 1967	SW/SH ≤ 2.10 BWH/SH ≥ 0.72 ICA = 0.14±0.05	SW/SH ≥ 2.30 BWH/SH ≤ 0.70 ICA = 0.10±0.05
Starobogatov *et al*., 2004	BWW/BWH ≤ 0.51	BWW/BWH ≥ 0.52
Kruglov, 2005	SW/SH < 2.00 ICA = 0.20–0.23	SW/SH > 2.18 ICA = 0.10–0.15

*For abbreviations see Material and Methods.

L. saridalensis – "Saline lake 13 km SW of Pavlodar, steppe Sari Dala Kazakhstan".

Identification of snails proved to be somewhat difficult due to the fact that there are at least three differing versions of a determination key allowing to distinguish *L. likharevi* and *L. saridalensis* [Lazareva, 1967; Starobogatov *et al*., 2004; Kruglov, 2005]. These three versions employ different characters (Table 2) and therefore results of their use are ambiguous. Species identification strongly depended on key used, and a single sample may be divided into species in different ways. Usually, less than one-third of individuals may be determined unequivocally when the three keys are applied in parallel (Table 3). Besides, using the keys provided by Lazareva [1967] and Kruglov [2005] revealed 'intermediate' individuals that fell into hiatus between the two species as they are determined by the authors of the keys (see Table 3). It is practically impossible to decide which key is 'better', therefore in the course of my work I used the criteria for species delineation provided by Lazareva since she is the author of the revision where *L. likharevi* and *L. saridalensis* were for the first time compared [Lazareva, 1967].

The shells were measured in a standard way [Kruglov, 2005; Andreyeva *et al*., 2010] using calipers and the ocular-micrometer of the stereoscopic microscope with precision to the nearest 0.1 mm. Only shells of adult, full-grown individuals were measured. In total, seven basic measurements were taken from each shell: **SH** – shell height, **SW** – shell width, **SpH** – spire height, **BWH** – body whorl height, **BWW** – body whorl width measured above the aperture; **AH** – aperture height, **AW** – aperture width. Statistical analyses of the morphometric data were performed in the software package STATISTICA for WINDOWS 6.0 (StatSoft Inc., USA). These include non-parametrical correlation analysis (by means of the Spearman's rank correlation coefficient, r_S) and canonical analysis.

305 specimens of *L. likharevi* and *L. saridalensis* from seven localitites were dissected (see Table 1) following the standard protocol [Kruglov, 2005]. The 'index of the copulatory apparatus' (**ICA**, hereafter) was recommended for distinguishing between the two species [Lazareva, 1967; Kruglov, 2005], and the study of its variation became an important part of this work. **ICA** is the ratio between lengths of the praeputium and the penis sheath that constitute two main parts of the copulatory apparatus. Its general properties as a taxonomically useful character were discussed in my earlier work [Vinarski, 2011].

Table 3. Results of identification of individuals from the samples studied by using different versions of the diagnostic key.

Табл. 3. Результаты видовой идентификации особей из изученных выборок при использовании альтернативных диагностических ключей.

Habitat (see Table 1)	Species	Author(s) of key			% of snails determined similarly by means of all three keys
		Lazareva [1967]	Kruglov [2005]	Starobogatov *et al*. [2004]	
Fadikha	*likharevi*	6	13	24	**28.1**
	intermediate	21	4	–	
	saridalensis	5	15	8	
Kargat	*likharevi*	2	9	25	**22.5**
	intermediate	19	1	–	
	saridalensis	19	30	15	
Kabankul'	*likharevi*	26	6	103	**22.7**
	intermediate	152	51	–	
	saridalensis	122	243	197	
Murzinka	*likharevi*	8	16	27	**33.3**
	intermediate	12	–	–	
	saridalensis	7	11	1	
Omsk	*likharevi*	2	5	50	**34.6**
	intermediate	18	1	–	
	saridalensis	58	72	28	
Trauly	*likharevi*	3	17	43	**8.1**
	intermediate	14	1	–	
	saridalensis	20	36	11	
Vylposl	*likharevi*	1	4	30	**9.4**
	intermediate	7	–	–	
	saridalensis	24	28	2	

Results

1**. Intrapopulation variation of shell characters**. Shell variation in any sufficiently large syntopic sample of *L. likharevi – L. saridalensis* is visibly very high. Typically, shells of snails collected even from a few square meters of bottom differ from each other by relative spire height, shell width and size of the body whorl (Fig. 1). Despite this, the extreme forms of variation that correspond to 'typical' *L. likharevi* and *L. saridalensis* may be found (Fig. 2). The word 'typical' means that the animals are most similar to *L. likharevi* or *L. saridalensis* sensu Lazareva [1967] and Kruglov and Starobogatov [1986]. The statistical analyses, however, revealed that all individuals from such conchologically heterogenous samples belong to the same general totality since distributions of all diagnostic shell characters do not differ significantly from the normal one (Fig. 3). There is no distinct hiatus between *L. likharevi* and *L. saridalensis* by any conchological character, including diagnostic ones. It explains the fact that a large portion of individuals from studied samples cannot be identified unambiguously (see Table 3). The species are, thus, non-diagnosable on the basis of their shell features and constitute a continuum of variation where individuals of both taxa form a large and entire 'cloud' of points in the multivariate space (Fig. 4) with no distinct 'subclouds' that would correspond to separate morphological entitites.

The type series of *L. likharevi* (Fig. 5) is not an exception since it contains rather different shells, and some of the paratypes may be identified as *L. saridalensis* sensu Kruglov et Starobogatov (compare shells labeled as C and J on Fig. 5). The paratypes belong to the same 'cloud' of points in the multivariate space that other specimens of *L. likharevi* and *L. saridalensis* from studied samples (Fig. 6).

2. **Intrapopulation variation in the copulatory organs.** The structure of the reproductive system is generally the same in both species (see Fig. 2), and interspecific differences, according to the

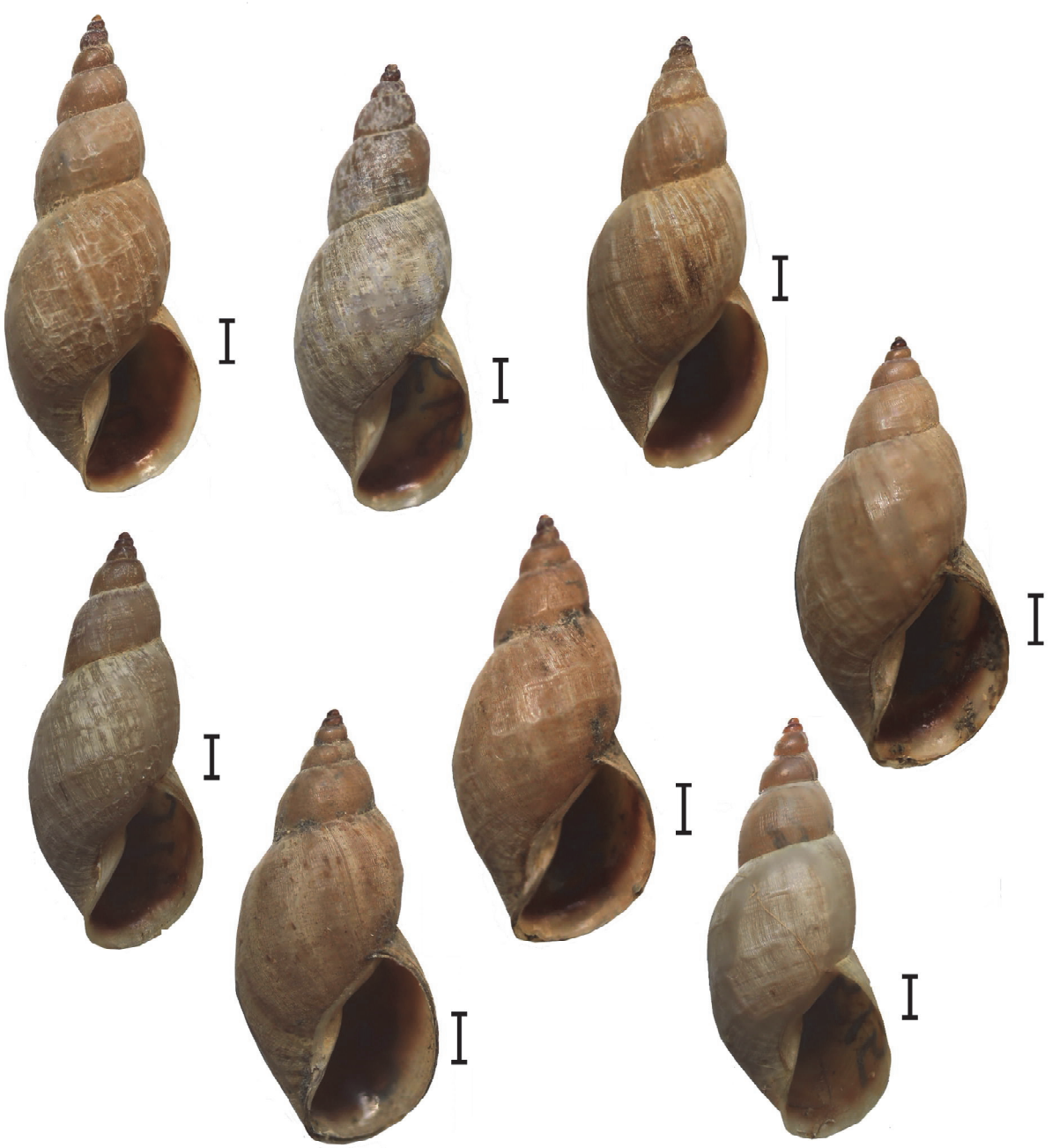

FIG. 1. Shell variation in a mixed syntopic sample of *L. likharevi* and *L. saridalensis* (Kabankul' Lake, Omsk Region). All specimens were dissected and their taxonomic identification was confirmed by study of the anatomical traits. Scale bars 2 mm.

РИС. 1. Изменчивость раковины в смешанной синтопической выборке *L. likharevi* и *L. saridalensis* (Омская обл., оз. Кабанкуль). Все особи были вскрыты и их видовая идентификация проведена с учетом анатомических данных. Масштабные линейки 2 мм.

Russian authors [Lazareva, 1967; Kruglov, 2005], are quantitative, i.e. the two species differ from each other by ICA values (see Table 2). Unfortunately, the using of this index does not allow to distinguish unequivocally *L. likharevi* and *L. saridalensis* since there is no clear hiatus in the continuous distribution of its values within a single population (Fig. 7, A). A good deal of individuals had ICA values between 0.16 and 0.20 that, according to Kruglov [2005], forced us to place them to the 'intermediate' category. The absence of hiatus was found also when all dissected specimens from all samples were pooled into a single sample (see Fig. 7, B). There is no significant correlation between ICA and shell height (a proxy for the snail age): r_S=0.03 (p=0.59). The mean intrapopulation values of ICA vary from 0.12 to 0.18 (Table 4).

3. Study of the type specimens. Mozley [1934:

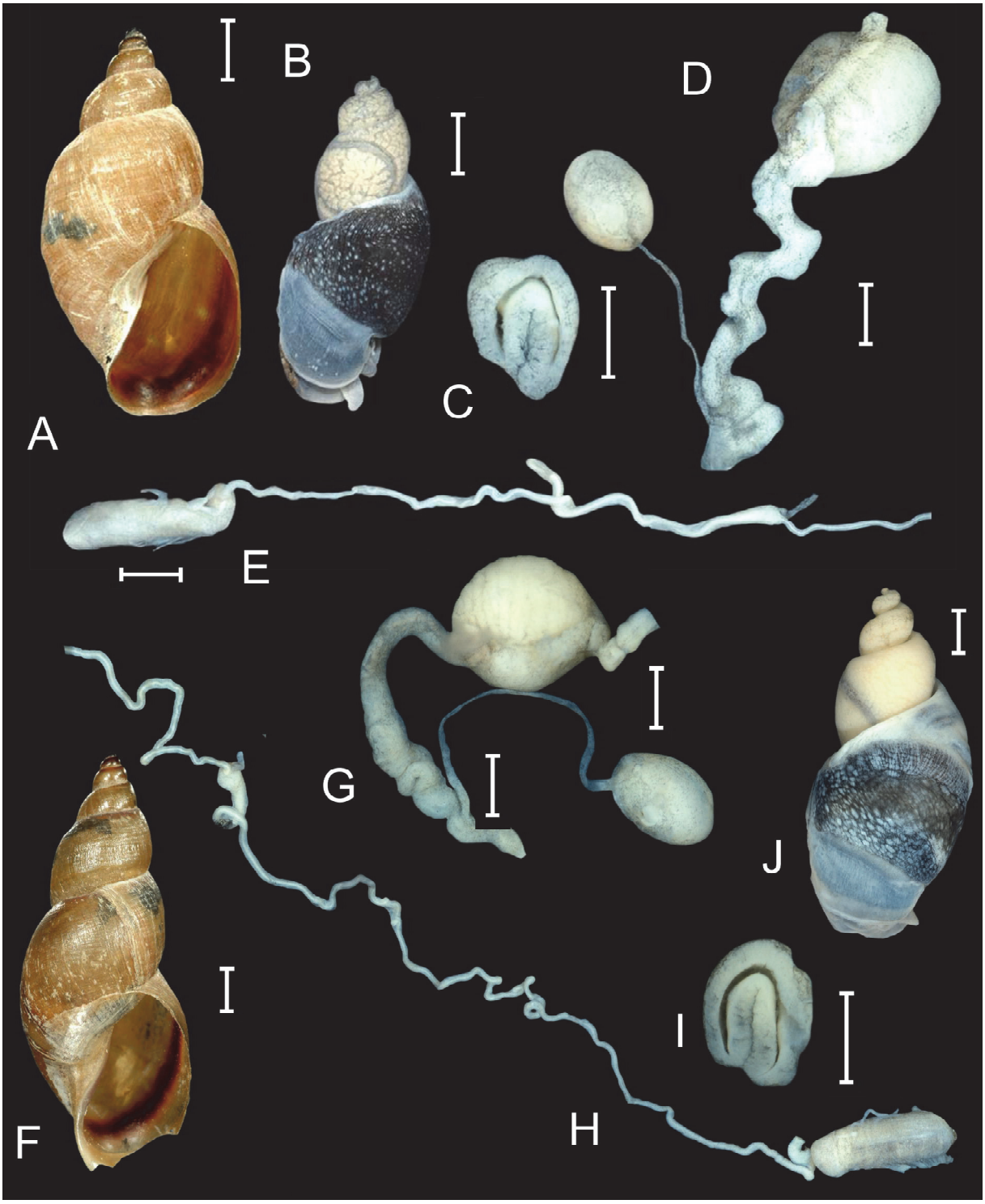

FIG. 2. Shells and some anatomical structures of 'typical' individuals of *L. likharevi* (A-E) and *L. saridalensis* (F-J). A, F – shell; B, J – soft body; C, I – internal section of the prostate; D, G – parts of the female reproductive tract; E, H – copulatory organs. Scale bars 1 mm. Photos by P. Glöer.

РИС. 2. Раковины и фрагменты строения мягкого тела "типичных" особей *L. likharevi* (A-E) и *L. saridalensis* (F-J). A, F – раковина; B, J – внешний вид мягкого тела; C, I – поперечный разрез простаты; D, G – фрагменты женской половой системы; E, H – копулятивные органы. Масштабные линейки 1 мм. Фотографии: P. Glöer.

2] describes shell of *L. saridalensis* as elongate and "much narrower in proportion to the length than in the usual forms of *palustris*". The syntype shell (see Fig. 5, A) fits this description very well though usually shells of *L. saridalensis* are not so extremely narrow (compare Fig. 5 A and Fig. 2 F). Very slender shells of *L. saridalensis* with many whorls that more or less resemble the syntype shell some-

Table 4. ICA variation in mixed samples of *L. likharevi* and *L. saridalensis* from the Western Siberian waterbodies

Табл. 4. Значения индекса копулятивного аппарата в смешанных выборках *L. likharevi* и *L. saridalensis* из водоемов Западной Сибири

Locality	Limits of ICA variation	Mean ICA ± σ
Fadikha Lake*	0.12 – 0.24	0.17 ± 0.03
Floodplain of the Kargat River	0.08 – 0.18	0.12 ± 0.03
Trauly Lake	0.09 – 0.22	0.12 ± 0.03
Floodplain of the Irtysh River, Omsk City	0.10 – 0.24	0.14 ± 0.02
Kabankul' Lake	0.10 – 0.23	0.16 ± 0.03
Murzinka Station	0.11 – 0.24	0.18 ± 0.04
A lake near Vylposl channel	0.10 – 0.19	0.14 ± 0.02

*See Table 1 for information on localities.

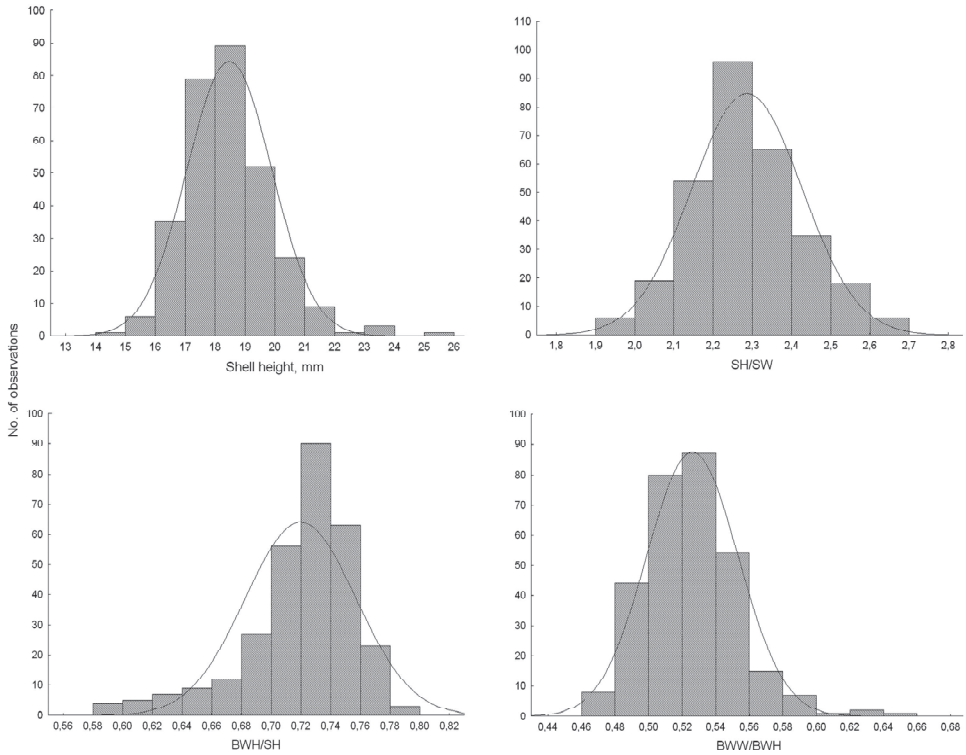

FIG. 3. Distribution of values of shell height and three diagnostic indices in a mixed syntopic sample of *L. likharevi* and *L. saridalensis* (Kabankul' Lake, Omsk Region). Associated normal-distribution curves are given for each graph.

РИС. 3. Распределение значений высоты раковины и трех диагностических индексов в смешанной синтопической выборке *L. likharevi* и *L. saridalensis* (Омская обл., оз. Кабанкуль). Приведены кривые нормального распределения.

times occur in lakes of Western Siberia (see Fig. 5, L), but portion of such individuals is typically low.

Another species of stagnicoline snails described by Mozley [1934] from Western Siberia, *L. draverti*, is characterized by turriculate shell with convex and gently rounded whorls (see Fig. 5 B), and the syntype of this species differs from the syntype of *L. saridalensis* by its external appearance. It is almost impossible to judge on the taxonomic identity of this specimen without knowledge of its anatomical structure, and the true identity of *L. draverti* remains obscure. Some authors used this binomen for designation of a stagnicoline species inhabiting Siberia [Faizova, 1981; Gundrizer, 1984], but later Kruglov and Starobogatov [1986] proposed to synonymize *L. draverti* with *L. saridalensis*. Given its convex whorls, I would guess that the syntype belong rather to *L. taurica kazakensis* Mozley, 1934 than to any species of *Stagnicola*. My attempts to find living specimens (topotypes) of the

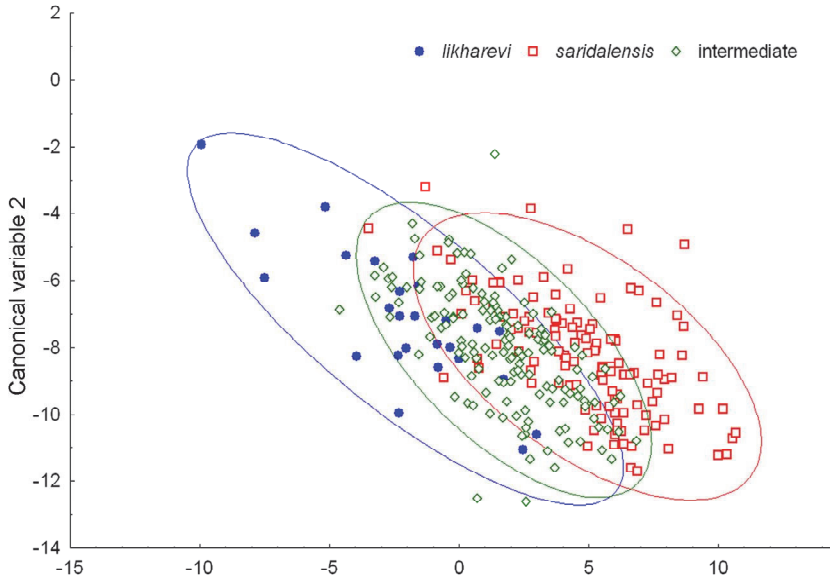

FIG. 4. Results of the canonical analysis of shell variation of the sample from the Kabankul' Lake.

РИС. 4. Результаты канонического анализа изменчивости раковины в выборке из оз. Кабанкуль.

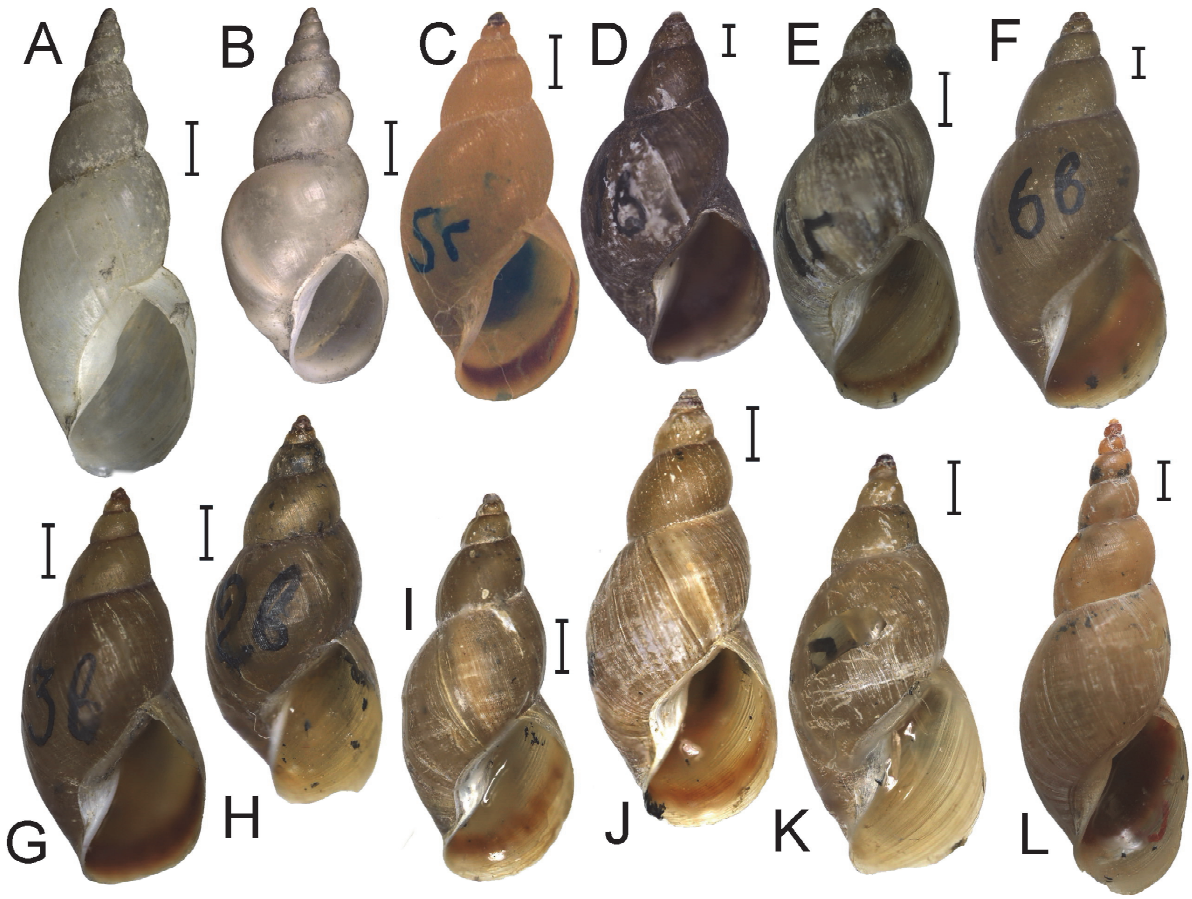

FIG. 5. A. One of the syntypes of *Lymnaea saridalensis* (USNM). B. One of the syntypes of *Lymnaea draverti* (USNM). C. The holotype of *L. likharevi* (ZIN). D–E. The paratypes of *L. likharevi* (Kazakhstan, Akmola Region, Borovoye Lake; ZIN). F–H. The paratypes of *L. likharevi* (Kazakhstan, Kustanay Region, a swamp in the Novonezhinsky collective farm; ZIN). I–K. The paratypes of *L. likharevi* (Kazakhstan, Akmola Region, Borovoye Lake, Golubaya Bay; ZIN). L. *L. saridalensis*. Omsk Region, Trauly Lake (MSAM). Scale bars 2 mm.

РИС. 5. Один из синтипов *Lymnaea saridalensis* (USNM). B. Один из синтипов *Lymnaea draverti* (USNM). C. Голотип *L. likharevi* (ZIN). D–E. Паратипы *L. likharevi* (Казахстан, Акмолинская обл., оз. Боровое; ZIN). F–H. Паратипы *L. likharevi* (Казахстан, Кустанайская обл., заболоченное озеро в Новонежинском совхозе; ZIN). I–K. Паратипы *L. likharevi* (Казахстан, Акмолинская обл., оз. Боровое, бухта Голубая; ZIN IN). L. *L. saridalensis*. Омская обл., оз. Траулы (MSAM). Масштабные линейки 2 мм.

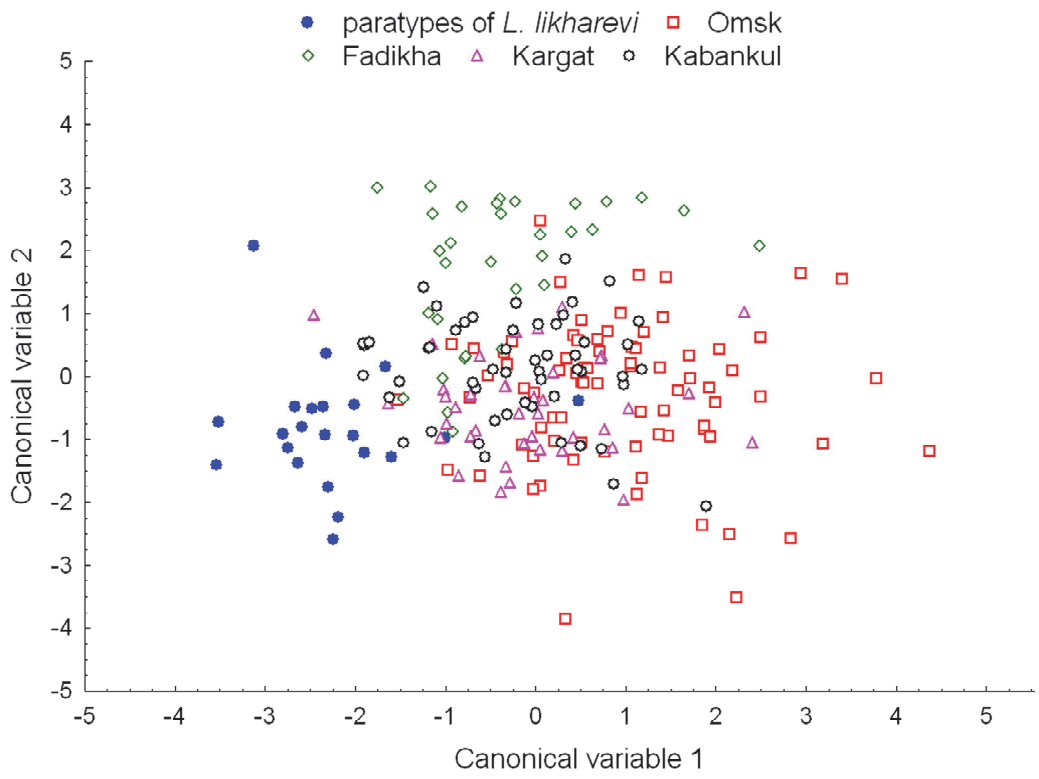

FIG. 6. Results of the canonical analysis of shell variation of several samples of *L. saridalensis* s.lato (including *L. likharevi* and intermediates) and the paratypes of *L. likharevi*.

РИС. 6. Результаты канонического анализа изменчивости раковин из нескольких выборок *L. saridalensis* s.lato (включая *L. likharevi* и «промежуточные» особи) и паратипов *L. likharevi*.

latter in its type locality (Om River near Omsk) were unsuccessful therefore this guess remains speculative.

Discussion

The results provided above show the absence of clear hiatuses in distribution of all studied diagnostic traits, both conchological and anatomical, proposed to separate *L. likharevi* from *L. saridalensis*. Thus the two species are virtually non-diagnosable under condition of syntopy that may be considered as the 'empirical' evidence for their conspecifity [Vinarski, Andreyeva, 2007]. The logic of such conclusion is based on the biological species concept in its classical version [Mayr, 1963]. The true 'biological species' are nothing but 'protected gene pools', and, "in sympatry, all the criteria showing a marked discontinuity between both groups can be used to indicate that two separate gene pools do exists" [Dubois, 1988: 76]. In our case, however, only full continuity in all morphological traits can be observed. The presence of rather numerous 'intermediate' individuals which taxonomic position cannot be determined unambiguously, is a good albeit indirect evidence that 'pure' *L. likharevi* and *L. saridalensis* represent only opposite parts of a single continuum of morphological variation.

The absence of a morphological hiatus between *L. likharevi* and *L. saridalensis* implies that one has no possibility to develop an effective key for unequivocal taxonomic identification of the species. All such keys proposed to the date failed to become an adequate tool for species diagnostics. Though it has been stated that hiatus does not represent a prerequisite to delineate animal species [Zagorodniuk, 2004], in most cases of sympatric species not separated by a 'full' hiatus the bimodal distribution of morphological (or genetical) characters is observed [Jiggins, Mallet, 2000; Vinarski, 2011]. This type of distribution is typically presented by a 'two-humped' curve corresponding to two distinct clusters of individuals (= two distinct gene pools) separated only by a narrow zone filled by rare 'intermediates'. In the case of *L. likharevi* and *L. saridalensis* one could find the unimodal distribution of all morphological traits (see Figs. 3, 7).

In my opinion, all the facts presented above indicate that *Lymnaea likharevi* should be regarded as a junior synonym of *L. saridalensis*.

L. saridalensis s.lato is distributed thoughout Western Siberia (including Northern Kazakhstan)

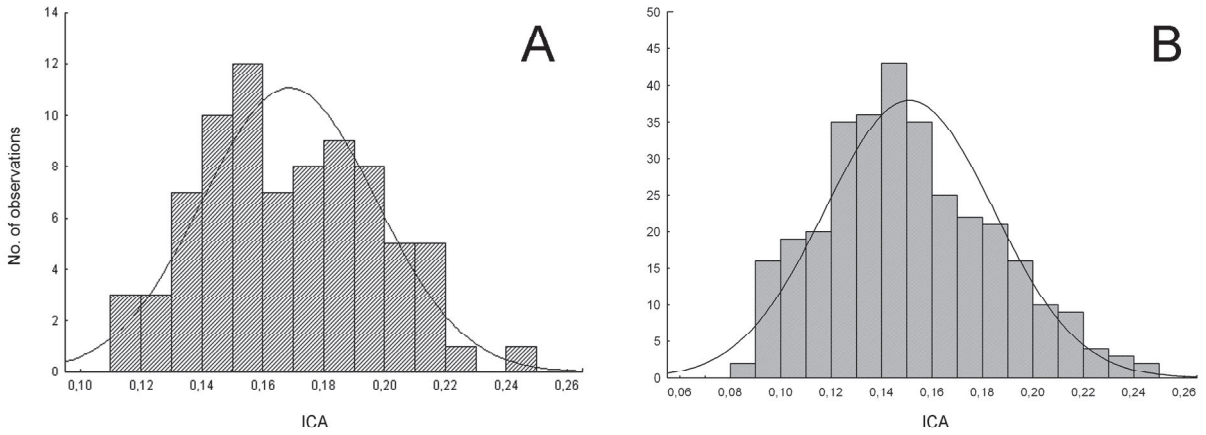

FIG. 7. A. Distribution of the ICA values in a mixed sample of *L. likharevi* and *L. saridalensis* (Omsk City, floodplain of the Irtysh River, n=80). B. Distribution of the ICA values in the combined sample of all dissected specimens of *L. likharevi* and *L. saridalensis* (n=305). Associated normal-distribution curves are given for each graph.

РИС. 7. А. Распределение значений индекса копулятивного аппарата в смешанной синтопической выборке *L. likharevi* и *L. saridalensis* (г. Омск, заболоченный водоем в пойме р. Иртыш, n=80). В. Распределение значений индекса копулятивного аппарата в объединенной выборке, включающей всех вскрытых особей *L. likharevi* и *L. saridalensis* (n=305). Приведены кривые нормального распределения.

and in some parts of Central and Southern Kazakhstan [Lazareva, 1967; Andreyeva *et al*., 2010]. It is also common in the Uralian waterbodies [Khokhutkin *et al*., 2009]. The westernmost finding of *L. saridalensis* was made in the eastern part of European Russia: Lipetsk Region, a pool in the floodplain of the Dryazgavka River [Kruglov, Starobogatov, 1986]. Possibly, the overall range of this species covers the easternmost part of Europe, whole Western Siberia and Kazakhstan. Its taxonomic relations to the European species *L. turricula* sensu Jackiewicz characterized by similar proportions of the copulatory apparatus still need to be resolved.

Acknowledgements

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Lymnaea likharevi Lazareva, 1967 – младший синоним *Lymnaea saridalensis* Mozley, 1934 (Gastropoda: Pulmonata: Lymnaeidae)

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РЕЗЮМЕ. *Lymnaea* (*Stagnicola*) *likharevi* Lazareva, 1967 и *Lymnaea* (*Stagnicola*) *saridalensis* Mozley, 1934 – два близкородственных вида прудовиков, населяющих Западную Сибирь и во многих случаях обитающих совместно в одном водоеме. Детальное исследование изменчивости конхологических и анатомических признаков этих видов из синтопических выборок показало, что в условиях совместного обитания они не диагностируемы ввиду отсутствия морфологического хиатуса между ними. Предложена новая синонимия: *L. likharevi* рассматривается как младший синоним *L. saridalensis.* Приведены данные о типовых сериях указанных видов, а также о типовой серии вида *Lymnaea draveri* Mozley, 1934, также описанного из водоемов Западной Сибири.