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PSAMMOTHIDIUM VERNADSKYI SP. NOV. (*BACILLARIOPHYTA*) FROM THE BLUE LAKE, EAST SIBERIA, RUSSIA

Bacillariophyta species composition from two lakes in East Siberia was investigated. In one of them *Psammothidium vernadskyi* Bukht. et Stanislavskaya sp. nov. was found. The diagnosis, illustrations and other necessary material for the new taxon attributes are provided. Typification of new species and infraspecific taxa of *Bacillariophyta* is discussed.

K e y w o r d s : new species, morphology, taxonomy, nomenclature type, holotipe, paratype, diatom species typification, small lakes, algal-bacterial mats.

Introduction

The algological studies of the water basins in the East Siberia mainly concern large rivers such as Ob' River and its tributaries (Kuksn, 1972; Safonova, 1972; Naumenko, 1995; Bogdanov et al., 2002; Semenova, 2009) and Irtysh River (Yurova, 1974; Naumenko, 1986; Porkhacheva, 1986; Bazhenova, 2005). It is also known several publications on the diatoms (*Bacillariophyta*) of these rivers (Levadnaya, Safonova, 1972; Genkal, Semenova, 1989, 1999; Naumenko, 1995). Much less data exists on the algal flora of numerous small ponds and streams in the East Siberia where only flood-lands and sorovye[1] basins of the large rivers have been investigated so far (Popova, 1964; Levadnaya, Safonova, 1972; Naumenko, 1986, 1988; Porkhacheva, 1986; Belyakov et al., 2001; Stanislavskaya, 2004; Valeeva, 2009).

Recently the geoecological studies of several small lakes in the central part of East Siberia were carried out. These lakes are located on the Tazov peninsula within the Konda River basin – 70 km south-east of city Hanty-Mansiysk (Kuzin, Yakovlev, 2011).

Materials and Methods

Algal composition of the algal-bacterial mats from two lakes with conventional numbers N 29 and N 73 is studied (the data of Stanislavskaya in Kuzin, Yakovlev, 2011). The *algal-bacterial mats* are specific communities of benthic

[1]Sorovye basins are mostly ephemeral flood-land basins that are arisen from spring flood. Sorovye basins play an important role in the river basin ecosystems because they are numerous and some of them remain for whole vegetation period and later on.

algae and bacteria habit on the littoral sand. They create somewhat friable macrocoverings about 1-2 cm thickness olive-green or blue-green in color.

Both lakes have roundish shape with 1.0–1.5 km diameter, 2-3.5 average depth (maximum – 5.0), under spreading bed with feldspar-quartz sands. Because these lakes do not have any artificial sources of pollution their water is naturally clean and colourless, has high transparency and belongs to low salinity type of hydrocarbon-sodium waters (Kuzin, Yakovlev, 2011).

Qualitative samples of the algal-bacterial mats were collected from the littoral sand at the depth 0.3-1.0 in the middle of July 2010. Samples were fixed with 40 % formalin. For diatom identification they were cleaned from an organic matter by standard cold method with concentrate sulfuric acid (Krishtofovich, Proshkina-Lavrenko, 1949). Permanent slides were mounted using high-refractive index resign Naphrax® (R.1. = 1.7). For scanning electron microscopy (SEM) examination cleaned and dried diatom material from the samples were coated with gold on 10 mm diameter stubs a JFC-1100 for 5 min.

Equipment includes light microscope Biolar PZO (Poland) with photo camera T100 Sciencelab 10.0MPi, China; scaning electron microscope JEOL 6060LA, Japan.

Results and Discussion

Preliminary investigation showed low algal species richness in observed lakes: 11 species were found in lake N 29 and only 8 species – in lake N 73 (the data by Stanislavskaya in Kuzin, Yakovlev, 2011). Further study of *Bacillariophyta* revealed in both lakes 37 species together with the new one for science.

Psammothidium vernadskyi sp. nov. Figs *1*, *1a-c* – holotypus, *designed here*; *2–8a* – paratypi, *designed here.*

Diagnosis. Morphometric data: length 26–30 μm, width 10–12 μm, L/W ratio 2.5–2.6; striae density 25–29 in 10 μm.

Frustule is slightly bent to the rapheless valve (RLV), heterovalvaty[2] = 3 (valve curvature, raphe presence/absence, shape of the central hyaline areas). **Valves** linear-elliptical with somewhat narrowed broadly rounded poles (Figs *1, 2, 3-6*), raphe valve (RV) almost flat, RLV slightly concave and the mantles both of them are bent under the right angle (Figs *1c, 2a*). **Central hyaline area on the RV** rectangle or bow-like, asymmetrically placed, almost reachs the mantle (Figs *1c, 3-5*); **on the RLV** – rhombic or round, asymmetrically placed, occupies ½ of valve width (Figs *2, 2a, 6*). **Striae** are weakly radiate without interruption on the mantle. **Areolae** poroid, foramina small, transapically oval (Figs *1a-c, 2a, 8a*). **Velum** of hymen type has two rows of fine round openings (Fig. *8b*, arrow). **Raphe system** situates on diagonal, **on outside surface** consists from two filiform slits that accompanied by grooves and thin ribs (Fig. *1c*), with long curved distal slits turned to the opposite directions on the mantle (Figs *1a, 1b*).

[2] Heterovalvaty – number of features that differs two valves in one frustule (Bukhtiyarova, 2006).

Diagnostic features of *Psammothidium vernadskyi* sp. nov.

Taxon	Diagnostic						
	Length	Width	Length/ width ratio	Striae density in 10 μm	Striae direction	Areolae foramen form	Frustule hetero-valvaty
	μm						
P. vernadskyi	26-30	10-12	2.5-2.6	25-29	radial	trans-apically oval	3
P. helveticum (Hust.) Bukht. et F.E.Round	22-5[(2)] 7-28[(1)] 12-6[(4)]	7-9[(2)] 5-7.5[(1)] 6-8[(4)]	2.7-3.1 (1.4-3.7[(1)])	24-27[(2)] 23-28 [(1)] 24-30[(4)]			
P. bioretii (Germain) Bukht. et F.E.Round	10-30[(1)]	5-10[(1)]	2.0-3.0	22-28[(1)]		round	2
P. atalanta (Carter) Bukht. comb. nov.	12-20[(3)]	5-6[(3)]	2.4-3.3	26[(3)]		UN	2

Empty cage shows that feature meaning is the same as in *P. vernadskyi*. [(1)] – The data according Krammer, Lange-Bertalot, 1991; [(2)] – our calculation from Pl. 220, figs 1-9 – type material, in Simonsen, 1987; [(3)] – Carter, 1966; [(4)] – Potapova, 2010b. UN – unknown feature; S = 21 – sum of the features, involved in comparison, including overlapping morphometric data.

Диагноз. Морфометрические данные: дл. 26–30 мкм, шир. 10–12 мкм, отношение Д/Ш – 2.5–2.6; 25–29 штрихов в 10 мкм.

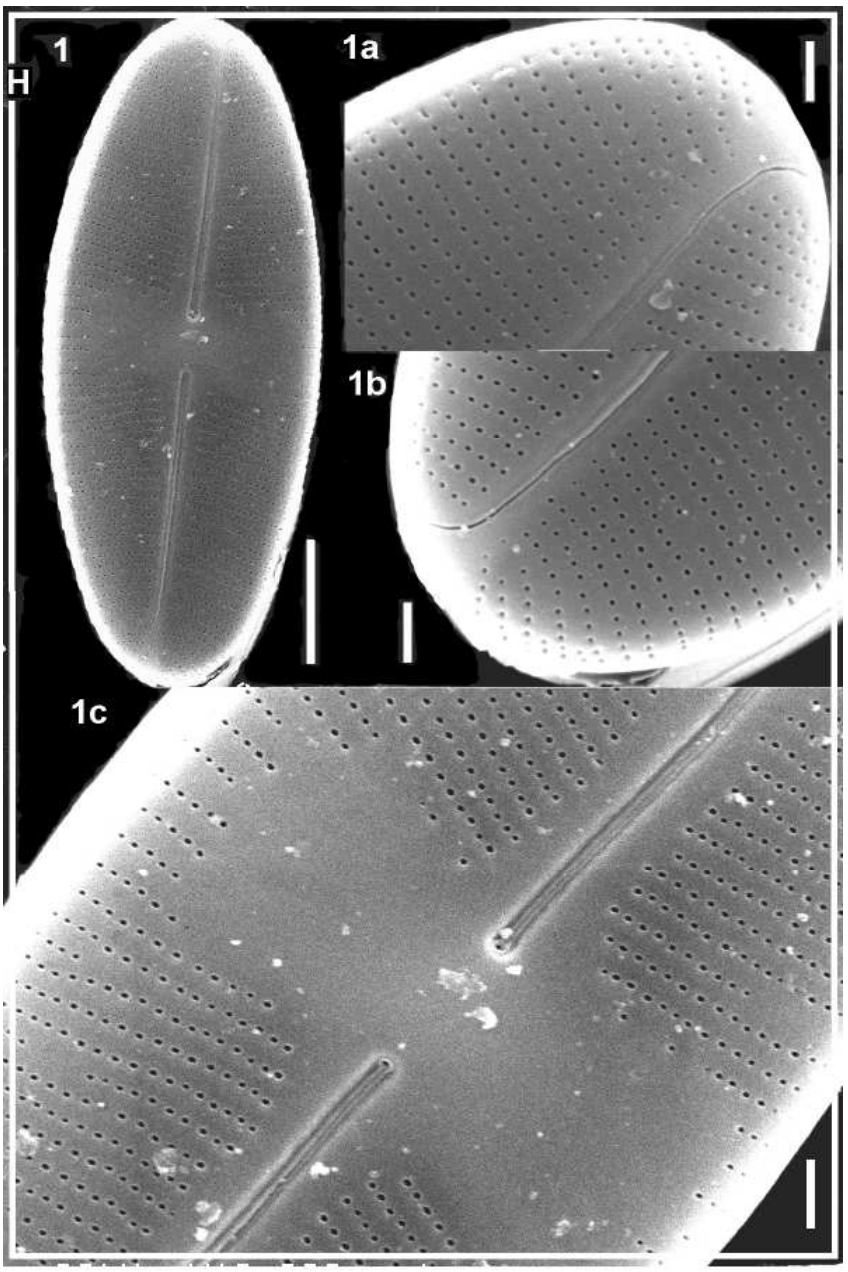
Панцирь слегка согнут к бесшовной створке (RLV), гетеровальварность[3] = 3 (изогнутость створки, присутствие/отсутствие шва, форма центральных гиалиновых полей). **Створки** линейно-эллиптические с несколько суженными широкозакругленными концами (Figs *1, 2, 3–6*),

[3] Гетеровальварность – количество признаков, по которым различаются две створки в одном панцире (Bukhtiyarova, 2006).

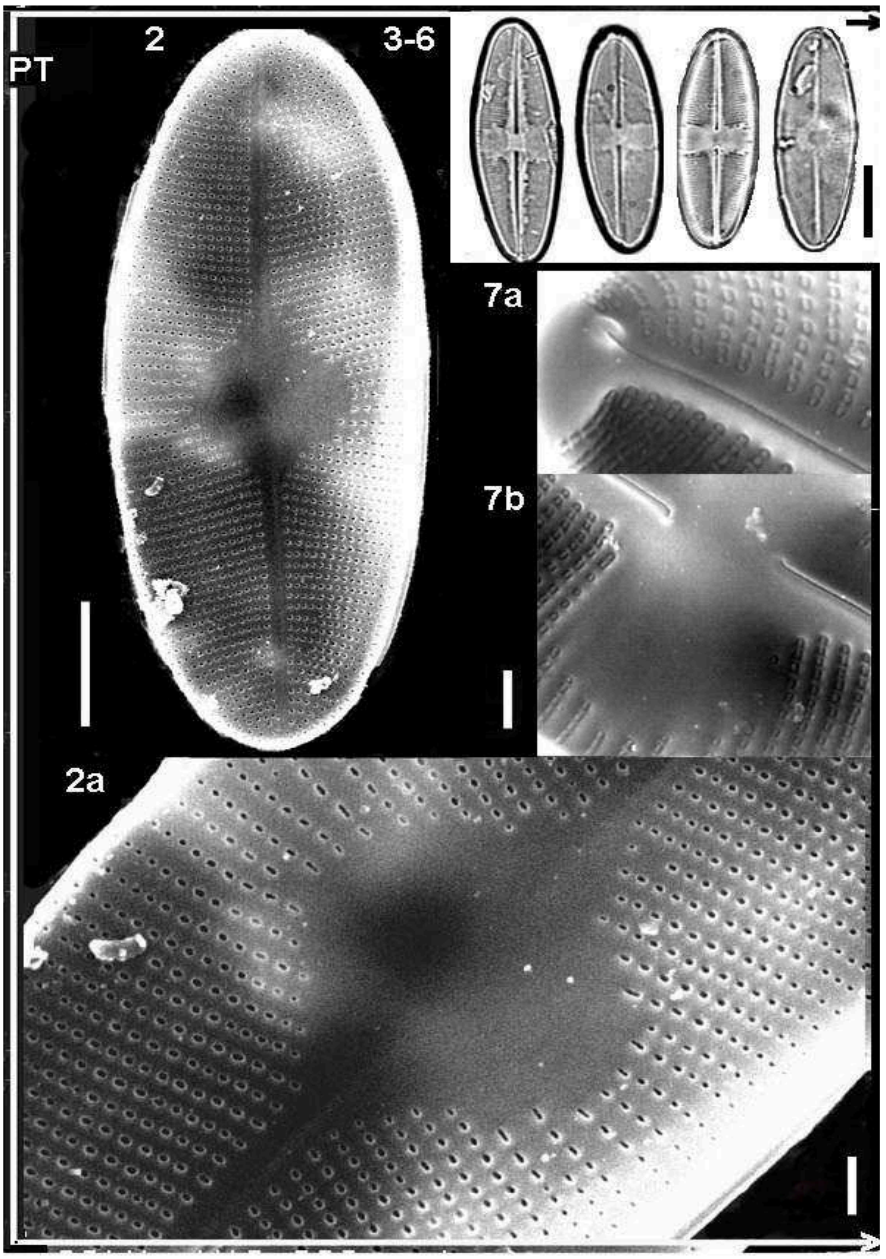
in compare with morphologicaly similar species

features							
Valve outline	RV surface	RV central area	RLV central area	Raphe system on the outside valve surface			N of common features (relative similarity in %)
		form/ size/ position	form/ size/ position	Posi-tion	Raphe-pores	Distal ends	
					ribs around/ distance	form/ position/ curverture	
linear-oval	flat	rectangle bow-like	Rhombic or round	dia-gonal	thin ribs	curved long	S = 21
		almost reachs mantle	1/2 of valve width			mantle	
		asym-metric	asym-metric		6-7 striae	opposite directions	
				axial			16 (76%)
			2/3 valve width				
		axial	axial		5-6 streae		
	undulate		bow-like			drop-like	11 (53%)
		½ valve width	1/3 valve width			mantle margine	
		axial	axial				
	UN	apically oval	apically oval		UN	UN	7 (~37%, with UN till 67%)
		½ valve width	½ valve width			UN	
		axial	axial		UN	UN	

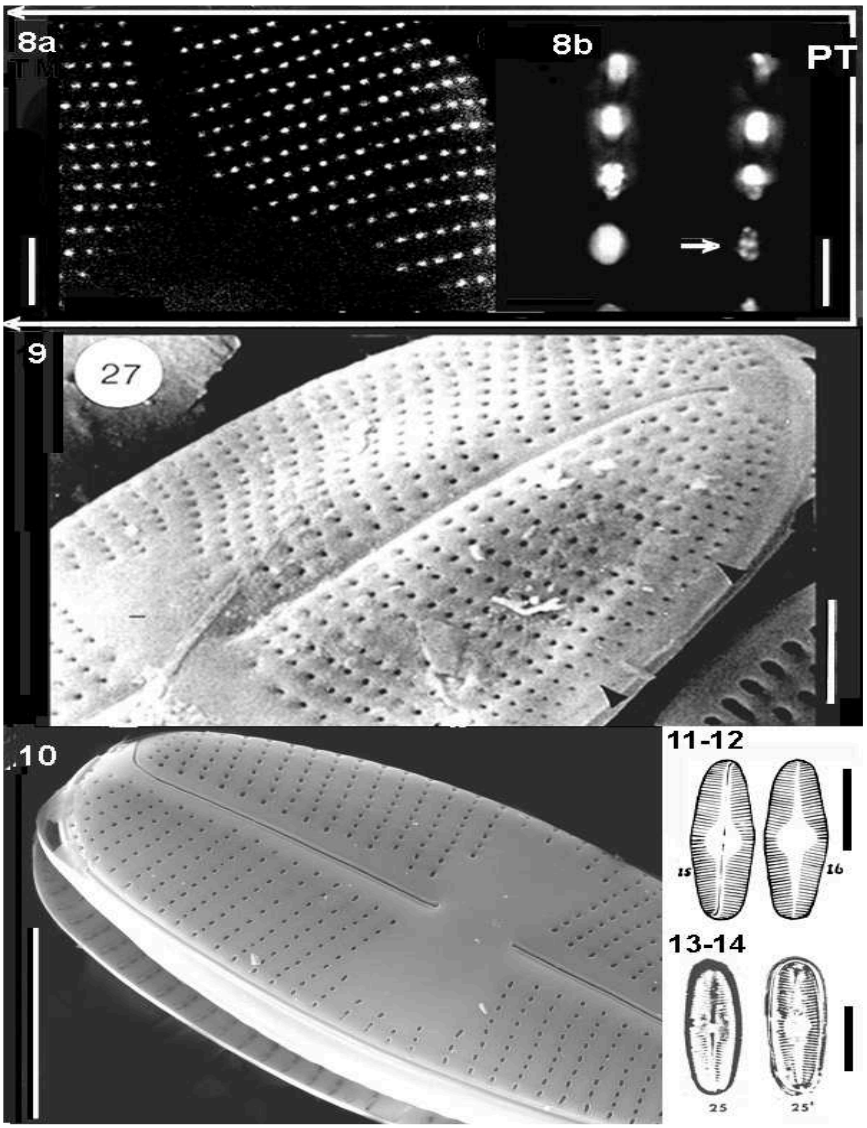
шовная створка (RV) почти плоская, RLV слегка вогнутая, загибы обеих створок согнуты под прямым углом (Figs *1c, 2b*). **Центральное гиалиновое поле RV** прямоугольное или бантиковидное, асимметрично расположено, почти достигает загиба (Figs *1c, 3–5*); **RLV** – ромбовидное или округлое, асимметрично расположено, занимает ½ ширины створки (Figs *2, 2a, 6*). **Штрихи** слегка радиальные, непрерывные на загибе створки. **Ареолы** пороидные, мелкие, с транс-апикально овальными фораменами (Figs *1a–c, 2a, 8a*). **Велум** типа гимен имеет два ряда мелких круглых отверстий (Fig. *8b*). **Шовная система** расположена диагонально, **на внешней поверхности** состоит из двух нитевидных щелей, сопровождающихся тонкими ребрами (Figs *1a–c*); с длинными изогнутыми дистальными щелями, повернутыми в противоположные стороны на загибе (Fig. *1a, b*); центальные поры шва сопровождаются ложбинками и тонкими ребрами, расположены на расстоянии 7–8 штрихов (Fig. *1c*).



Figs *1, 1a-c*. Holotypus *designed here* – a set of the microphotos from single specimen of ***Psammothidium vernadskyi*** Bukht. et Stanislavskaya sp. nov. with its enlarged fragments: *1* – raphe valve, outside view; *1a-c* – the fragments of the same valve. *1a,b* – valve poles with long curved terminal raphe slits, turned to the opposite sides on the mantle; *1c* – asymmetrical rectangular hyaline central area and raphe, accompanied by thin ribs. SEM. Scale: *1* – 5 μm, *1a-c* – 1 μm



Figs *2–7b.* The **paratypi** *designed here* – 7 speciemens of ***Psammothidium vernadskyi*** Bukht. et Stanislavskaya sp. nov. and/or their fragments taken from the type material. *2* – Rapheless valve, outside view; *2a* – the fragment of rapheless valve with rhombic central hyaline area, *3–5* – the raphe valves, *6* – rapheless valve; *7a,b* – the fragments of raphe valve from inside surface, *7a* – raphe end with little helictoglossa, *7b* – central area with central raphe pores, turned to the opposite sides. Figs *2, 2a, 7b* – SEM, *3–6* – LM. Scale: *2* – 5 μm, *3–6* – 10 μm, *2a, 7a,b* – 1 μm



Figs *8a, 8b.* Continuation *for designed here* **paratypi** of ***Psammothidium vernadskyi*** Bukht. et Stanislavskaya sp. nov. from the type material. *8a* – fragment of rapheless valve with transaptcally oval areolea, *8b* – enlarged fragment with hymen velum, completed with two rows of round openings – arrow. **Fig. *9* – *P. bioretii*** (Germain) Bukht. et F.E. Round – half of RV from outside surfafe, scanned picture N 27 from Bukhtiyarova, Round, 1996. **Fig. *10* – *P. helveticum*** (Hust.) Bukht. et F.E. Round – RV from outside surface, 2/3 of Fig. 8 from Potapova (2010b). **Figs *11–14* – *P. atalanta*** (Carter) Bukht. comb. nov. *11, 12* – original scanned pictures of Figs 15, 16 from Carter, 1966; *13, 14* – both valves from single exemplar, type material, scanned pictures of Taf. 19, Figs 25, 25' from Lange-Bertalot, Krammer, 1989. *11, 13* – raphe valves, *12, 14* – rapheless valves. Figs *8a, 8b* – TEM, Figs *9*, *10* – SEM, Figs *11-14* – LM. Scale: *8a* – 1 μm, *8b* – 0,2 μm, *9* – 2 μm, *10* – 4 μm; *11–14* – 10 μm

Діагноз. Морфометричні дані: довж. 26–30 μm, шир. 10–12 μm, відношення Д/Ш = 2.5–2.6; у 10 μm 25–29 рисок.

Панцир злегка зігнутий у бік безшовної стулки (RLV), гетеровальварність дорівнює 3 (зігнутість стулки, наявність/відсутність шва, форма центральних гіалинових полів). **Стулки** лінійно еліптичні з дещо звуженими широко закругленими кінцями (Figs *1, 2, 3–6*), шовна стулка (RV) майже плоска, RLV злегка увігнута, загини обох зігнуті під прямим кутом (Figs *1c, 2a*). **Центральне гіалінове поле RV** прямокутне або бантикоподібне, асиметрично розташоване, майже сягає загину (Figs *1c, 3–5*); **RLV** – ромбоподібне або круглясте, асиметрично розташоване, займає ½ ширини стулки (Figs *2, 2a, 6*). **Риски** злегка радіальні, безперервні на загині стулки. **Ареоли** пороїдні, малі, з трансапікально овальними фораменами (Figs *1a-c, 2a, 8a*). **Велум** гімен типу має два ряди малих круглих отворів (Fig *8a, b*). **Шовна система** розташована діагонально, **на зовнішній поверхні** складається із двох ниткоподібних щілин, супроводжується ринвочками і тонкими ребрами (Fig *1a–c*), з довгими зігнутими дистальними щілинами, поверненими у протилежні боки на загині стулки (Fig *1a, b*); центральні пори шва супроводжуються тонкими ребрами, розташовані на відстані 7–8 рисок (Fig *1c*).

Type locality and biotope. Longitude: 66°42'02", Latitude: 77°01'48". Russia, East Siberia, Khanty-Mansiyskiy region, Sogom-Endyrskiy district, Tazov peninsula within the R. Konda basin –70 km south-east of city Hanty-Mansiysk, Blue Lake N 29, algae-bacterial mats.

Type material: T-Bukht-3, collected by I.L. Kuzin, includes 2 permanent slides and preserved sample in collection of L. Bukhtiyarova; **T-EStanislav-1** – permanent slide and rude material in Collection of E. Stanislavskaya; permanent slide N **ZU8/67** in Friedrich Hustedt Collection. Alfred-Wegener-Institute für Polar- und Meeresforschung, Bremerhaven, Germany.

Etymology. The species is named in honor of an Academician V.I. Vernadsky who elaborated the concept of the biosphere and its ecological architecture and believed that the diatoms having siliceous cell shalls is one of the most important component of the Earth Life.

Ecology and distribution. *P. vernadskyi* is only known from type locality that characterized by naturally clean, colorless fresh water with high transparency and belonging to the low salinity type of hydrocarbon-sodium waters. In type locality new species amounts about 1 % within diatom community.

Observation and comparison with morphologically similar species. The thin hymens in most areolae were destroyed, probably, for the samples treatment. Nevertheless, a few areolae have kept velum (Fig. *8b*, arrow) that consists two rows of fine round openings.

Several species are similar with *P. vernadskyi* in valve outline and size range, striae arrangement and raphe construction on the outside valve surface that is shown in the comparable Table. More than half morphological features coincide with well investigated *Psammothidium bioretii* (Germain) Bukht. et F.E. Round and *Psammothidium helveticum* (Hust.) Bukht. et F.E. Round. *Psammothidium atalanta* (Carter) Bukht. comb. nov. was not yet investigated

with EM therefore uncompleted data on its fine morphology does not allow to make a proper conclusion on its similarity with new species. ***Psammothidium vernadskyi*** **distinguishes from** ***P. helveticum*** (Taf. 220, Figs 1-9 in Simonsen (1987); Fig. 20 in Bukhtiyarova and Round (1996); Fig. 8 (here Fig. *10* – 2/3 part) in Potapova (2010b) – in size and position of central hyaline area on RLV, in position of central hyaline area on RV; diagonal raphe position; **from** ***P. bioretii*** (Fig. 27 (here Fig. *9*) in Bukhtiyarova, Round (1996), fig. 9 in Potapova (2010a) on heterovalvaty is 3, flat RV, shape and size of central hyaline areas on both valves, transapically oval areolae foramina, long raphe distal ends curved on the mantle; **from** ***P. atalanta*** (Figs 15, 16 (here Figs *11, 12*), 19–20 in Carter, 1966; Taf. 19, 21–24, Taf. 19, Figs 25, 25' (here Figs *13, 14*) in Lange-Bertalot, Krammer, 1989) – on heterovalvaty is 3, shape, size and position of central hyaline areas on the both valves.

The arrangement of illustrations for our new species is based on the principle definition of the **nomenclature type** that is a herbarium exemplar of species *or detailed picture of plant* on the base of which new species was described and to which species name is connected. In case of *Bacillariophyta* that are *microalgae* and cannot be visible without microscopic equipment, the **Art. 37.5.** of ICBN (McNeill et al., 2006) acts and it tells: " ... the type of a name of a new species or infraspecific taxon of microscopic algae ... may be an effectively published illustration if there are technical difficulties of preservation or if it is impossible to preserve a specimen that would show the features attributed to the taxon by the author of the name" (our underlining). Today techniques for the diatoms investigation do not allow to extract from or keep on SEM stub single exemplar of species that served for description of taxonomically valuable features included to the protolog. In the same time, an effectively published *microphotos* have themselves a high documenting and preservation.

For definite and fast orientation in represented illustrations we also follow to earlier suggestion about putting of holotype microphoto together with all its enlarged fragments on the framed table with letter **T=H**, that means **Holotypus** (Bukhtiyarova, 2000, 2001, 2004). Because our new species has heterovalvate frustule, RLV has different structure and view in the microscope, than chosen as holotype RV, and is not a *dublcate* (or copy) of RV structure. The same logic concerns the microphotos of LM, the inside surface fragments and TEM microphotos. Therefore we named all those microphotos as *paratypes*, not as *isotypes* that represent the dublcates of species from type material. Then, **species type (=holotype)** *here designed* as framed plate, marked **H**, with SEM microphotos of a single valve and its engaged fragments. Similarly, we *designed here* a set of other necessary illustrations, served for species diagnose, on framed plate marked by letters **PT** that means **Paratypi** and that those pictures were gotten from several exemplars of type material. Thus, our chose of holotype and paratipes for the new species *Psammothidium vernadskyi* is in complete agreement both with general concept of the type and its applying for microalgae according ICBN.

Psammothidium atalanta (Carter) Bukht. **comb. nov.**

Basionym: *Achnanthes atalanta* Carter, 1966: 444, Figs 15, 16, 19, 20.

Carter J.R. Some fresh water diatoms of Tristan da Cunha and Gough island. Report on material collected by Royal Society expedition to Tristan da Cunha 1962 and the Gough island scientific survey 1956. Nova Hedw. 1966. **11**(N 1–4), P. 443–483.

Lange-Bertalot, Krammer, 1989: Taf. 19, Figs 21-24, Figs 25, 25' (here Figs *13, 14*) – from the type material.

For present *A. atalanta* is included to the synonyms of *A. helvetica* (Hust.) Lange-Bert. (Krammer, Lange-Bertalot, 1991) sin. of *Psammothidium helveticum* (Hust.) Bukht. et F.E. Round. However, *A. atalanta* differs from later taxon by: a) heterovalvaty is 2 (valve curvature, raphe presence/absence); b) uniform apically oval central hyaline areas on the both valves that occupy ½ of the valve width. Those features prove the status of independent species we renew to this taxon.

Conclusions

The description of the new species *Psammothidium vernadskyi* within the genus *Psammothidium* Bukht. et F.E. Round is based on a set of its ultramorphological features *of the genus rank* according Bukhtiyarova and Round (1996), Bukhtiyarova (2007): frustule curvature towards rapheless valve, lenth-breadth ratio – 2,5; uniserial with uniform density striae, poroid areolae with hymen velum and the most common for the monorafid diatoms filiform *raphe system on inside valve surface* – with raphe pores at central nodule, bent to the opposite directions (Fig. *7b*), and small helictoglossa (Fig. *7a*). The new species, like the other *Psammothidium* species, occurs in the fresh waters. A set of distinct ultramorphological *features of species rank* clear separate *Psammothidium vernadskyi* from morphologically similar *P. atalanta, P. bioretii* and *P. helveticum*.

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PSAMMOTHIDIUM VERNADSKYI SP. NOV. (*BACILLARIOPHYTA*) ИЗ ГОЛУБОГО ОЗЕРА, ЗАПАДНАЯ СИБИРЬ, РОССИЯ

Исследован видовой состав *Bacillariophyta* двух малых озер Западной Сибири. В одном из них обнаружен новый для науки вид *Psammothidium vernadskyi* Bukht. et Stanislavskaya sp. nov. Представлен диагноз, иллюстрации и другие необходимые данные, сопровождащие описание нового вида. Обсуждается видовая и внутривидовая типификации *Bacillariophyta.*

Ключевые слова: новый вид, морфология, таксономия, номенклатурный тип, голотип, паратип, типификация видов *Bacillariophyta*, малые озера, альгобактериальные маты.