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TAXONOMIC STATUS
OF *FLEXOPECTEN GLABER PONTICUS* (BUCQUOY, DAUTZENBERG & DOLLFUS, 1889) –
THE BLACK SEA *FLEXOPECTEN GLABER* (LINNAEUS, 1758) (BIVALVIA: PECTINIDAE)

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The name *Flexopecten glaber ponticus* (Bucquoy, Dautzenberg & Dollfus, 1889) is generally used for the only Pectinidae representative inhabiting the Black Sea. It is registered in the Red Book of the Republic of Crimea as endemic subspecies reducing in amount. *F. glaber ponticus* is listed in WoRMS MolluscaBase as the only accepted subspecies of *Flexopecten glaber* (Linnaeus, 1758). In the past its taxonomic status has been changed from a geographic variety to valid species. The purpose of this study is to establish its correct taxonomic status. The study is based on a comparative analysis of conchological features of *Flexopecten glaber* and *F. glaber ponticus* in relation with the brief natural history of population in the Black Sea. Sampling was performed by snorkel equipment in Kazach'ya Bay (Black Sea, Crimea, Sevastopol) at 2–6 m depths. A total of 100 scallop specimens were sampled in September 2017. To assure a better understanding in a broader context those results are compared with the previously published morphological data based on the analysis of a large amount of material from the Black Sea and the Mediterranean Sea – Marmara Sea regions. Comparative analysis of conchological features of *F. glaber ponticus* from the Black Sea with *F. glaber* from the Mediterranean region has not revealed any distinct differences between them. Thus, there are no evidenced data for the diagnosis of *F. glaber ponticus* as a subspecies. Species *F. glaber* appeared in the Black Sea not earlier than 7,000 years ago and formed a well developed population less than 3,000 years ago. We have to conclude that the specified divergence period is not long enough to form a subspecies. As a result of the present survey the subspecific status of *F. glaber ponticus* is not retained and the name is placed in synonymy of the parent species *Flexopecten glaber*.

Keywords: morphology, life history, taxon, synonymy, population, Pectinidae

The “Smooth Scallop” *Flexopecten glaber* (Linnaeus, 1758) is an edible bivalve which is widely distributed in the Mediterranean Sea. It inhabits muddy and sandy bottom substrates with shell debris between 5 and 900 m depth, occasionally even down to 1600 m [10]. Widely different environmental conditions create a basis for a high intraspecific variability inherent for *F. glaber*. Its variability reflected in the extensive synonymy of 20 names listed by WoRMS [7].

The species is also present in the Black Sea up to 2 to 40 m depth [9], mostly being limited by 30 m isobaths [14]. Certain geographic isolation and some contemplated morphological features allowed to describe *Pecten glaber* var. *pontica* Bucquoy, Dautzenberg et Dollfus, 1889 for the Black Sea Smooth Scallop [5]. In the first Russian monograph on mollusks of the Black Sea and the Sea of Azov [8] this variety became elevated to a species status *Pecten ponticus* (Bucquoy, Dautzenberg et Dollfus, 1889). At the same time K. O. Milachewitch noted that many researchers consider the Black Sea specimens as completely identical to the parent taxon [8]. Meanwhile, the species status have been supported for a long time and modified

to *Flexopecten ponticus* (B., D. et D., 1889) [14]. However, taking into consideration the fact that morphological differences between the Black Sea and Mediterranean specimens are not very distinct and the time of geographical separation is not long enough for new species formation, L. A. Neveeskaya adopted the subspecies status as *Chlamys (Flexopecten) glabra pontica* (B., D. et D., 1889) [9]. *Flexopecten glaber ponticus* (Bucquoy, Dautzenberg & Dollfus, 1889) is now listed in WoRMS as the only accepted subspecies of *Flexopecten glaber* [7].

The Black Sea fauna is a derivative from the Mediterranean – Atlantic one, however in terms of taxonomic composition, it is depleted. In particular, Bivalves amount make up to 30 % approximately of the diversity of Mediterranean one and represented mostly by euryhaline species introduced in the Holocene salinity increasing process. *F. glaber* have appeared in the Black Sea Holocene sediments in the Kalamitian period. In fact, their greatest development has been dated since the Dzhemetin stage when the salinity reached the recent level [9].

At the beginning of the XX century the Smooth Scallop as a mass species was an object of fishing and it was exposed on the market as well as oysters [15]. In the middle of the XX century *F. glaber* was a leading species for the *Chlamys – Ostrea* biocenosis, along with the typical form for a number of the bivalve mollusks biocenosis at the Black Sea [9].

Obviously, that recent significant depopulation of the Smooth Scallop was connected with the complex of factors that led to the disappearance of oysters in the Black Sea, and the regional ecological crisis of the 1990s influenced also. It is assumed the local smooth scallops, as well as some other coenosis-forming species of the Black Sea's bivalve mollusks, pass through the population waves that are the consequence of oceanological oscillations caused by planetary processes [2, 3, 4]. In this context *Flexopecten glaber ponticus* (Bucquoy, Dautzenberg & Dollfus, 1889) is now registered in the Red Book of the Republic of Crimea as endemic subspecies reducing in amount [12].

The aim of our work is to determine the correct taxonomical status of the Smooth Scallop, the only reliably evidenced Pectinid living in the Black Sea, on the basis of conchological features and the life history of the regional allopatric population. Revision of the current taxonomic status of *Flexopecten glaber ponticus* subspecies was based both on the own materials and published data.

MATERIAL AND METHODS

Sampling of *F. glaber* has been performed by the author in snorkel equipment in the Kazach'ya Bay (Black Sea, Crimea, Sevastopol vicinity) at depths between 2 and 6 m. In the studied area *F. glaber* inhabits the sandy with shell debris bottom covered with *Zostera* beds with *Chamelea – Polititapes* biocenosis. A total of 100 *F. glaber* specimens were conchologically analyzed in September 2017. Among them 70 scallop specimens were returned to the biotope after the measurements, the rest ones were cleaned and photographed. The quantity of *F. glaber* was limited due to its status (“reducing in amount”) in the Red Book of the Republic of Crimea [12].

To control the author's own results and to scope them in a broader context, those data were compared with the previously published morphological features based on the analysis of a large amount of material from the Black Sea (BS) and the Mediterranean Sea (MS) – Marmara Sea (MarS) regions [8, 9].

The basic morphological characteristics: shell height (H), length (L), each valve convexity (Wv) and the length of the right valve front part (lf) – were measured using a caliper with 0.1 mm precision. L – the distance from anterior to posterior edge of shell; H – distance from the top of umbo to the bottom edge (from dorsal to ventral sides) of the shell; Wv – valve width, the distance from the point of maximum convexity of the valve to the partition plane of the shell valves (l – left, r – right); lf – distance from the umbo center to the anterior edge of the shell (Fig. 1). Average values (M) and standard deviation (σ) were calculated using Excel.

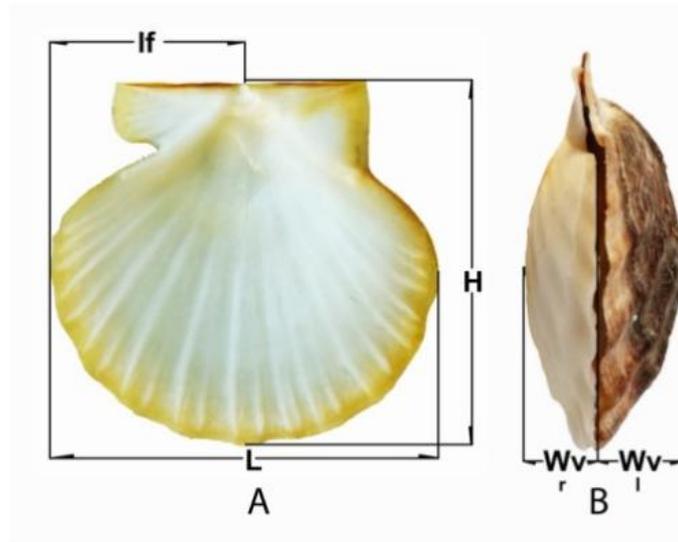


Fig. 1. *F. glaber* shell basic morphological measurements: A – right valve, inner view; B – the shell anterior view

Рис. 1. Основные морфологические характеристики раковин *F. glaber*: А — правая створка, вид изнутри, В — вид раковины спереди

RESULTS AND DISCUSSION

F. glaber specimens collected in Kazach'ya Bay are sized (H–L) from 28.8–29.5 mm to 48.5–55.0 mm for the left valve (Table 1, Fig. 2). The size of left valve is slightly larger and more convex than the size of right valve (Fig. 1B, Fig. 2, Table 1). The shell valves are usually longer than high in accordance with the description [8] and are occasionally equal in H–L dimensions, or rarely higher than long as noted [9].

Table 1. Morphological characteristic of the Late Quaternary (Q4) and Recent *Flexopecten glaber* shells from different regions (data sources: 1 – [8]; 2 – [9]; 3 – own results)

Таблица 1. Морфологические характеристики раковин позднечетвертичных (Q4) и современных *Flexopecten glaber* из различных регионов (источники данных: 1 — [8]; 2 — [9]; 3 — авторские результаты)

Source – region	Max. H, mm		Max. L, mm		Wv/H		lf/L
	left valve	right valve	left valve	right valve	left valve	right valve	
					min – max (M, σ)	min – max (M, σ)	min – max (M, σ)
1 – BS, Sevastopol	50.0	–	55.0	–	0.3*	–	0.48**
2 – BS (Q4)	47.5	44.5	50.0	46.0	0.18–0.34 (0.24, 0.04)	0.09–0.15 (0.13, 0.022)	0.42–0.52 (0.46, 0.032)
2 – BS, Karadag	43.0	41.0	43.0	42.0	0.22–0.29 (0.24, 0.04)	0.10–0.18 (0.13, 0.022)	0.41–0.53 (0.46, 0.032)
2 – MS + MarS	54.6	52.9	56.5	55.0	0.17–0.22 (0.20, 0.07)	0.16–0.17 (0.16, 0.01)	(0.48, –)
3 – BS, Sevastopol	48.5	46.5	55.0	54.0	0.17–0.25 (0.21, 0.022)	0.10–0.17 (0.15, 0.025)	0.41–0.51 (0.48, 0.02)

Note: * – calculated of original data of Wv and H; ** – calculated by original picture [8]

Примечание: * — вычислено по оригинальным данным Wv и H; ** — вычислено по оригинальному изображению [8]

The valves outer surfaces have 10 main radial ribs and only occasionally 1–4 additional ones. The ribs are sharper near the umbo and they gradually transform into smooth folds toward the lower periphery of the shell. Sometimes there are more or less distinct radial thin ribs and concentric lines which occasionally

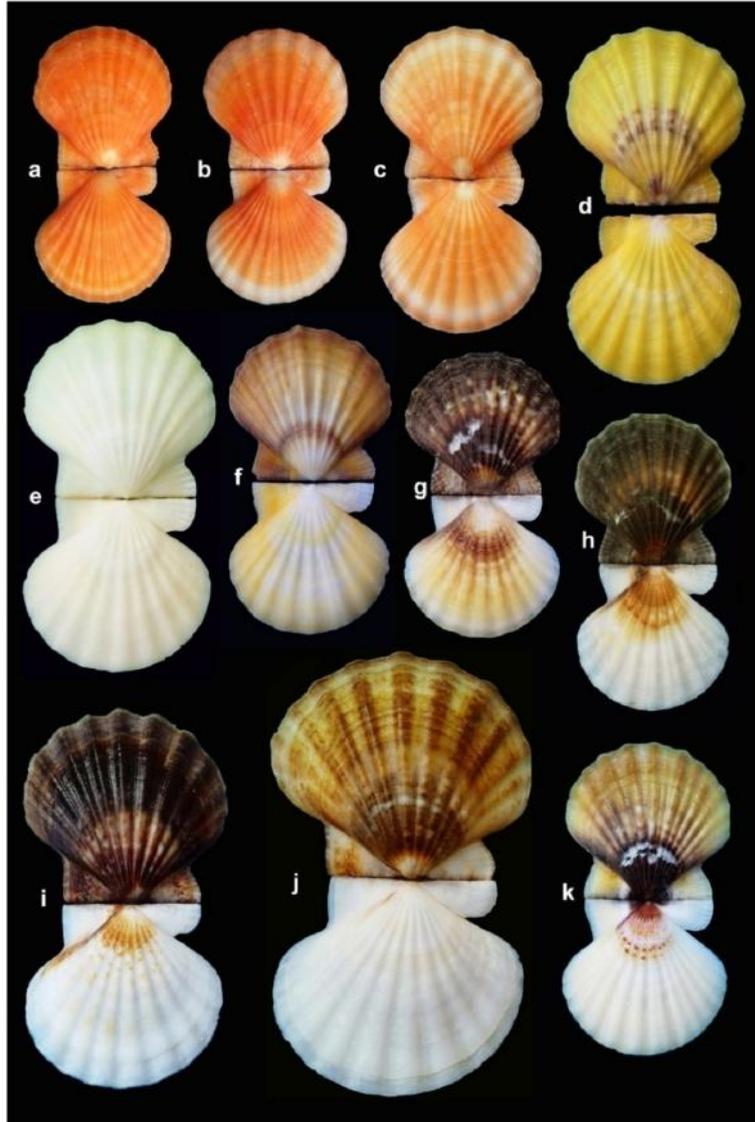


Fig. 2. *F. glaber* shells sampled in Kazach'ya Bay (Sevastopol region, the Black Sea), depth 2–6 m, sand bottom. Dimensions (H–L) given in mm for left (upper) valves: a – 31.0–29.0; b – 30.7–31.2; c – 33.9–34.5; d – 39.0–39.0; e – 39.0–41.2; f – 35.0–36.0; g – 31.3–34.0; h – 34.5–35.1; i – 42.0–43.1; j – 48.5–55.0; k – 34.4–35.5

Рис. 2. Раковины *F. glaber*, собранные в б. Казачья (окрестности г. Севастополя), Чёрное море, глубина 2–6 м, песчаное дно. Размеры (H – L) даны в мм для левой (верхней) створки: а — 31,0–29,0; б — 30,7–31,2; в — 33,9–34,5; д — 39,0–39,0; е — 39,0–41,2; ф — 35,0–36,0; г — 31,3–34,0; h — 34,5–35,1; и — 42,0–43,1; j — 48,5–55,0; k — 34,4–35,5

form growing steps. The umbo is small and located almost centrally. The left valves' auricles are subequal, the front (anterior) auricle of the right valve is slightly longer than the back (posterior) one and has a byssal notch (Figs 1, 2).

There is wide variability of shells color: sometimes orange (Fig. 2a–c), rarely yellow (Fig. 2d) or white (Fig. 2e) but mostly with different shadows of brown (Fig. 2f–k). Left (upper) valves are colored more intensively than right ones which are in most cases only off-white. The Black Sea shells' color coincides with the coloration of a typical *F. glaber* and the form which was suggested earlier as a species of full value *F. unicolor* (Lamarck, 1819) [13].

Although the shell characters mentioned above show no distinct differences between the Black Sea *F. glaber* specimens and the Mediterranean ones [6, 9, 10, 11, 13], the correct cancellation of *F. glaber ponticus* subspecies status requires more detailed discussion.

The results of shells' dimensions of the BS specimens (Table 1) showed that maximal L (55.0 mm) for our sample is somewhat bigger than given in [9] and the same as in [8]. The shell maximal size (H = 54.6; L = 56.5) from the MS and MarS [9] is slightly larger but satisfactory to the correct comparison between the samples. Actually, about 30 % of size dimensions of the Black Sea mollusks are smaller than of the parent Mediterranean ones [9].

Sometimes the difference can be noted in the main ribs quantity (10 vs 12) for *F. glaber* and *F. ponticus* respectively [13]. By our data and others sources [8, 9] normally the BS specimens also have 10 main ribs and only occasionally its have 1–4 more ones. The number of the main ribs (5–6) was the main taxonomic feature for establishing the species status for *F. proteus* (Dillwyn, 1817) [13] or subspecies status [10]. The status of the well distinct form is now accepted as a synonym of *F. glaber* [7] after the analysis of the mitochondrial DNA 16S rRNA gene [6, 11]. Thus, the parameter of ribs quantity cannot be used for taxonomic separation among *F. glaber* forms.

Another suggestive feature of *F. ponticus* is the less developed secondary ribbing on the outer surface of the valves, especially on the right valve [9]. By our observation the secondary ribs are the subject of strong variation and its can be more or less expressed even in one population's specimens.

Most conchological features of *F. ponticus* revealed any differences with the Mediterranean *F. glaber*, except for a more flattened right valve and somewhat more expressed asymmetry that was noted in original description [5]. The asymmetry is estimated by the ratio of the length of the front part to the total length of the right valve (lf/L). The valve convexity degree is indicated by Wv/H ratio [9].

The lf/L ratio was recognized as one of the most important characteristics for the *F. ponticus* diagnosis [8, 9, 14]. It was estimated by [9] as 0.42–0.52 for BS Q4 and 0.41–0.53 for BS Recent samples with common M = 0.46, whereas for the MS *F. glaber* the lf/L mean value was 0.48. The same lf/L = 0.48 was calculated by data from [8] and by our data for Sevastopol Bay population (BS). The range of lf/L values for our BS samples and those available from MS does not show any distinct difference (Table 1). Hence, the differences based on lf/L ratio between *F. glaber* and *F. ponticus* do not exist in reality.

The left valve convexity ratio (Wv-l/H) of the BS Q4 specimens is 0.18–0.34 (M = 0.24; σ = 0.04). The BS Recent specimens' Wv-l/H varied from 0.22 to 0.29 (M = 0.24; σ = 0.04) for Karadag samples [9], from 0.17 to 0.25 (M = 0.21; σ = 0.022) for our samples, and reached 0.3 for the typical specimen represented in [8]. Mediterranean *F. glaber* has a Wv-l/H ratio 0.17–0.22 (M = 0.20; σ = 0.07). Thus, the BS specimens have higher variability and have a higher maximal Wv-l/H ratio whereas MS specimens' indices are close to our data and fall within the range of variation in the parameters of BS specimens (Table 1).

The right valves' convexity of the Black Sea Q4 specimens (Wv-r/H varies from 0.09 to 0.15) is the least of all samples under discussion but M = 0.13 and σ = 0.022 are the same for the Recent Karadag specimens with Wv-r/H 0.10–0.18 (Table 1). Our Wv-r/H data for Sevastopol Bay (0.10–0.17; M = 0.15; σ = 0.025) are close to data for the Karadag, BS ones. The MS – MarS *F. glaber* right valves has Wv/H the least variable values (0.16–0.17; M = 0.16; σ = 0.01) which fall within the range for the BS samples (Table 1).

The more flattened right valve is considered as main *F. ponticus* characteristics [8, 9]. This assumption is true by comparing *F. ponticus* with a "typical" *F. glaber*, meanwhile the MS form *F. unicolor* has "right valve rather flat" [13]. *F. glaber* f. *proteus* also has distinctly more flat bottom (right) valve. Thus flattened right valve is not a characteristic of *F. ponticus* only. K. O. Milachewitch noted that the difference in the convexity of *F. ponticus* valves can be expressed in different degrees and usually increases with age, in young individuals it is barely noticeable [8]. Moreover, among our samples from the Sevastopol Bay population, along with specimens with a flattened right valve, there are mature specimens with a convex one (Fig. 1B). Thereby, it can be assumed that the *F. ponticus* right shell relative flatness varies in a wide range even in one population and, as a result, cannot be used as a subspecies distinctive characteristic.

Concept of the specific morphological features of the *F. ponticus* in comparison with those of the parent *F. glaber* was based on some exaggeration of the differences and partly on incompleteness and inaccurate interpretation of the data. Our research completes the comprehension of the variability of morphological

features and allows to make more precise interpretation of the available information. Analysis of the Smooth Scallop shell morphology, based on comparison of own and published data, gives the basis for confirmation the identity of *F. ponticus* to the parent *F. glaber*.

A subspecies formation happens in conditions of sufficiently long-time geographical isolation. The Black Sea is relatively isolated from the other seas of the Mediterranean region, that allowed the most euryhaline fauna to colonize and spread in the Black Sea with increasing salinity to a level close to the Recent one. The Kalamitian period, when the introduction of *F. glaber* started, dates back to 7,000 years ago and the Smooth Scallop population development covered the Dzhemetin stage which began less than 3,000 years ago [1]. Obviously, this time interval is not sufficient for subspecies' generation in the Black Sea that is confirmed by the absence of any other recognized endemic bivalve mollusk subspecies there. Actually, Late Quaternary (Q4) Black Sea *F. glaber* specimens do not have any significant morphological differences as compared with Recent ones (Table 1). Thus, one of the most variable Pectinidae – *F. glaber* – did not have any natural historical conditions for a subspecies generation in the Black Sea.

Conclusion. The shell morphology data of the Smooth Scallop shows no distinct differences between populations from the Black Sea and Mediterranean basin. Morphological and brief life history analyses gives basis for confirming the identity of *F. ponticus* to the parent *F. glaber*. Thus, *F. glaber ponticus* (Bucquoy, Dautzenberg & Dollfus, 1889) has to be accepted as a synonym of *Flexopecten glaber* (L., 1758).

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ТАКСОНОМИЧЕСКИЙ СТАТУС

FLEXOPECTEN GLABER PONTICUS (BUCQUOY, DAUTZENBERG & DOLLFUS, 1889) — *FLEXOPECTEN GLABER* (LINNAEUS, 1758) (BIVALVIA: PECTINIDAE) ИЗ ЧЁРНОГО МОРЯ

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Название *Flexopecten glaber ponticus* (Bucquoy, Dautzenberg & Dollfus, 1889) обычно используется для единственного представителя семейства Pectinidae, обитающего в Чёрном море. Он зарегистрирован в Красной книге Крыма как эндемичный подвид, сокращающийся в численности. В Базе данных по моллюскам WoRMS *F. glaber ponticus* приведён как единственный признанный подвид *Flexopecten glaber* (Linnaeus, 1758). Ранее его таксономический статус изменялся от географического варианта до полноценного вида. Цель данной работы — установление его правильного таксономического статуса. Основой для исследования служит сравнительный анализ конхологических характеристик *Flexopecten glaber* и *F. glaber ponticus*, наряду с анализом краткой естественной истории формирования популяции в Чёрном море. Отбор проб осуществлён в снаряжении для подводного плавания в бухте Казачья (Крым, Севастополь) Чёрного моря на глубине от 2 до 6 м. В сентябре 2017 г. отобрано 100 экземпляров гребешка. Для большей достоверности и изучения в широком контексте эти результаты сопоставлены с ранее опубликованными морфологическими данными, основанными на анализе большого количества материалов из районов Чёрного и Средиземного — Мраморного морей. В результате сравнения конхологических характеристик раковин *F. glaber ponticus* из Чёрного моря и *F. glaber* из Средиземноморья не выявлено каких-либо различий между ними. Таким образом, нет доказательных данных для определения *F. glaber ponticus* в качестве подвида. *F. glaber* появился в Чёрном море не ранее 7000 лет назад и сформировал хорошо развитую популяцию, очевидно, менее 3000 лет назад. В настоящей работе сделан вывод о том, что время дивергенции черноморской популяции является недостаточным для образования подвида. В результате данного исследования подвидовой статус *F. glaber ponticus* не сохраняется; это название отнесено к синонимам исходного вида *Flexopecten glaber*.

Ключевые слова: морфология, история формирования, таксон, синонимия, популяция, Pectinidae