RESEARCH ARTICLES
ОРИГИНАЛЬНЫЕ СТАТЬИ

CYCLICITY IN ONTOGENY AND AGE DETERMINATION OF *FLEXOPECTEN GLABER* (BIVALVIA, PECTINIDAE) IN THE BLACK SEA

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Received: 22.04.2024. Revised: 26.08.2024. Accepted: 07.09.2024.

Flexopecten glaber is an actively fished species in the Mediterranean Sea and a promising candidate for mariculture in the Black Sea. *Flexopecten glaber* is included in the Red Data Books of the Republic of Crimea and Sevastopol city as a species declining in number (Category 2). In this study, over 1500 specimens sampled near the Crimean Peninsula between 2017 and 2023 were analysed to investigate the ontogeny of *F. glaber* and develop a method for determining individual age, based on the relationship between stages of gonadal development and changes in shell surface morphology. The cyclicity of development was assessed by comparing the cycles of gonad formation with the features of the surface morphology of the shell. A correlation was found between the morphology of the surface of shell valves and the stages of the annual cycle of gonad development. On this basis, a scheme for determining the developmental stages and individual age of *F. glaber* specimens from the morphology of shell valves has been developed. The most prominent mark on the shell surface is formed mainly in winter as a result of the physiological restructuring of the organism before the beginning of the annual cycle of gonad formation. However, to determine the age of *F. glaber*, the spawning marks formed mainly in summer need to be considered. The proposed scheme for determining the developmental stages and age of *F. glaber* individuals is a valuable tool for studying the species and can help resolve a variety of ecological and conservation issues.

Key words: annual cycle, gonads, protected species, scallop, shell morphology

Introduction

Interest in the study of mollusks is constantly increasing due to the need to solve problems related to the rational use of marine biological resources, the assessment of productivity, development of monitoring systems and biotechnology for growing commercial species and protecting vulnerable species (Zolotarev, 1989; Gosling, 2004; Marčeta et al., 2016).

Flexopecten glaber (Linnaeus, 1758) is the subject of active fisheries in the Mediterranean, and one of the most promising mariculture species in this area (Lykakis & Kalathakis, 1991; Marčeta et al., 2016; Berik et al., 2017; Yigitkurt et al., 2022) and in the Black Sea (Bondarev, 2019; Revkov et al., 2021). While *F. glaber* had not been found in the Black Sea shelf zone for over two decades, its population is now showing recovery signs (Bondarev, 2018, 2019; Revkov & Revkova, 2023). Recent discoveries of *F. glaber* on the Romanian shelf (Filimon, 2020; Danilov et al., 2024), in the waters of Bulgaria (Todorova et al., 2022), and on the southwestern shelf of Crimea in the Laspi area, where the species forms a community (Revkov & Boltachova, 2022), confirm this trend. Currently *F. glaber* is protected in accordance with the Red Data Books of the Republic of Crimea (Revkov, 2015) and Sevastopol Region (Revkov, 2018) as a species declining in number (Category 2).

Determining the individual age of mollusks is a crucial aspect of many studies on their biology. The concept of individual age plays a key role in understanding ontogenetic development, morphological and ecological characteristics, and the productivity of species. Accurate information about the age structure of populations is essential for analysing the mechanisms of species-environment interactions, including regulation of abundance, changes in life expectancy, and mortality rates. Although the problem of determining individual age in mollusks is a seemingly narrow topic, it is important to several fields of marine biology. However, it is also one of the least studied characteristics of these organisms, mainly due to the lack of reliable methods for age determination in most marine animals (Zolotarev, 1989).

Sculptural methods form the basis for determining the age of mollusks. These methods identify shell elements formed on the surface of the valve according to daily or seasonal changes in environmental conditions. The growth rings on the external surface of the valve are the most commonly used for this purpose. These external growth rings are sculptural elements formed due to periodic changes in the growth rate of the mollusks. Their morphology is very diverse, and, in some cases, the outer growth rings are accompanied by changes in the colour of the outer surface of the valve (Zolotarev, 1989; Gosling, 2004).

The determination of the age of *Flexopecten glaber* based on the sculptural elements of the shell surface, interpreted as a result of an annual winter slowdown in growth, was carried out on samples from the Black Sea (Bondarev, 2019, 2020; Filimon, 2020; Todorova et al., 2022; Danilov et al., 2024). The maximum age of Black Sea individuals of *F. glaber* was estimated to be seven (Bondarev, 2019) and nine years (Todorova et al., 2022; Danilov et al., 2024). However, during the study of *F. glaber* reared in cages in a shellfish farm, it was found that individual specimens with an age of less than three years exceeded the previously determined maximum sizes of the Black Sea individuals (Revkov et al., 2021). In the Mediterranean Sea, *F. glaber* can reach a maximum size at 2+ years of age (Lykakis & Kalathakis, 1991). These results cast doubt on the reliability of the determination of maximum age and the method of age determination based on the «annual» growth lines of *F. glaber*.

Understanding the rhythmicity of animal growth is a central aspect of growth research (Mina & Klevezal, 1976). In *Flexopecten glaber*, a distinct annual development cycle is observed in the gonads. The reproductive process of *F. glaber* gonads at commercial size in the Adriatic Sea is categorised into six stages within the annual cycle (Marčeta et al., 2016), which had been previously identified on the basis of the various morphological criteria given for other pectinids (Mason, 1958; Reddiah, 1962; Sause et al., 1987).

The aim of this study is to investigate the cyclicity of development in the ontogeny of *Flexopecten glaber* from the Black Sea and to develop a method for determining individual age based on the relationship between stages of gonadal development and changes in shell surface morphology. Our study is based on the idea that the development of mollusk organs is interdependent during ontogeny in accordance with seasonal rhythms.

Material and Methods

Analysis of long-term variations in the Black Sea population of *Flexopecten glaber* allows categorising the Crimean coastal zone as one of the areas with the most favourable environmental conditions for the smooth scallop to inhabit (Revkov & Revkova, 2023). During the study, *F. glaber* specimens were collected manually using diving equipment off the coast of the Crimean Peninsula at depths ranging from 0.5 m to 17.0 m from 2017 to 2023. The salinity of the water in the study area ranges from 17.5‰ to 18.2‰, which corresponds to the average values in the Black Sea. The water temperature at the bottom surface ranged from 7°C in February to 25°C in August.

A total of more than 1500 *Flexopecten glaber* individuals were analysed, ranging in size from 2.0 mm to 65.0 mm in shell length. The majority of the samples (> 1000 specimens) were collected in 2023, covering all seasons by month.

The surfaces of the *Flexopecten glaber* shell valves were thoroughly cleaned of fouling by mechanical and chemical means to allow detailed analysis of their morphological characteristics. Changes in growth patterns on the valve surface were recorded, and the position of marker concentric growth lines and their correspondence to changes in gonadal structure were noted. The main dimensions of the shell, including height (H), length (L), and width (W) of the valve (Fig. 1a,b), as well as the height of the mesoconch (juvenile scallop – Hmc), and position of the concentric structural markings relative to the umbo (apical point) of the individual, were measured using a caliper SC–11–250–0.1 GOST 166–80 to an accuracy of 0.1 mm.

Each individual was opened with a scalpel and dissected. The viscera of the opened individuals were photographed. The valves were numbered, and then the stage of gonad development was compared with the morphological features of the surface of the cleaned valves.

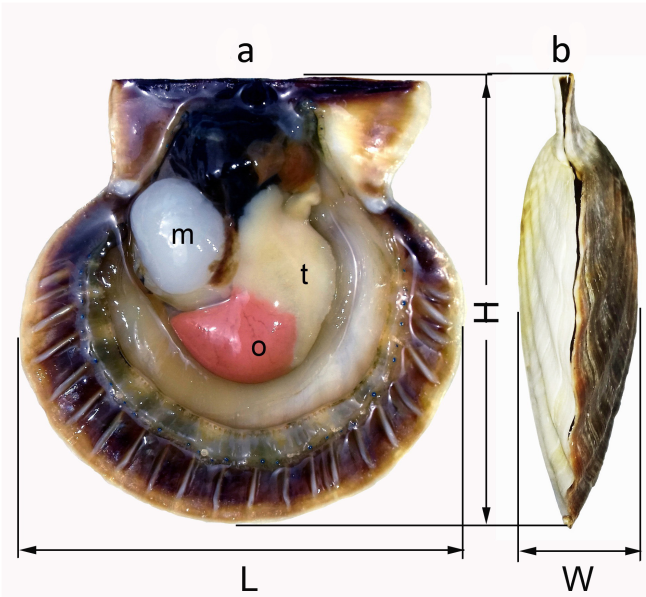

Fig. 1. Main morphological characteristics of the shell and internal organs of *Flexopecten glaber* sampled 08.06.2022 in the Sevastopol Region, Crimea, Russia. Designations: a – upper (left) valve from inside, b – frontal (anterior) view of the shell, where H – height, L – length, W – width, m – adductor muscle, o – female part of the gonads, t – male part of the gonad.

Flexopecten glaber is a synchronous hermaphrodite, with a bipartite gonad, i.e. male and female (Marčeta et al., 2016). The gonad is located closer to the anterior side of the valve, near the adductor muscle, and is connected to it in a small area on the inner side of the distal part. The distal part of the gonad, which is lighter in colour, contains the oocytes (o), while the testicular part (t) occupies the proximal position (Fig. 1a).

As a basis for dividing the cycle of gonadal development into stages, we used a scheme developed on the basis of the results of examination of *Flexopecten glaber* individuals in the Adriatic Sea, which are commercially available. This cycle was divided into six stages as follows: 1) proliferating, 2) developing, 3) mature, 4) spawning, 5) post-spawning, and 6) spent according to Marčeta et al. (2016).

The age of *Flexopecten glaber* individuals was estimated from spawning marks using the method described in this paper. The graphs and calculations in this study were created using the MS Office Excel ver. 10 software.

Results

The morphology of the gonads of *Flexopecten glaber* at various stages of the annual developmental cycle is shown in Fig. 2. Gonad formation begins at the bend of the intestine during the transition from the juvenile stage or at the beginning of the annual cycle (Fig. 2a). Further development leads to the formation and accumulation of germ cells and primary differentiation of the gonad into female and male lobes (Fig. 2b,c). When the gonads reach maturity, the differentiation is complete, and both parts exhibit characteristic colouration (Fig. 2d–k). The female part of the gonad is usually more colourful, with shades ranging from red-orange (Fig. 2h) to pale creamy pink (Fig. 2i) and milky white (Fig. 2m). In the last two variants, the male part of the gonads may even appear slightly darker than the female part.

A gonadal colour spectrum (see Fig. 2) was found in *Flexopecten glaber* individuals from all studied local populations, and it is unrelated to the colour morph of the species, suggesting that these characteristics are independent. While individuals with a brightly coloured female gonadal portion are more common, there are also those with a pale coloured portion. However, in some habitats, individuals with milky white or slightly creamy coloured female gonads (> 50%) predominate. In most *F. glaber* individuals, the male and female proportions of the mature gonads are approximately equal ± 10%. However, in some individuals, either the male (Fig. 2j) or female (Fig. 2k) proportion of the gonads may account for more than 80% of the amount.

In the late stages of spawning, shedding of some of the reproductive products leads to a «loosening» of the gonads in most individuals (Fig. 2l–n). This process results in the formation of residual nuclei of concentrated female and male gametes at the end of spawning (Fig. 3r). Emptying of the male and female parts of the gonads occurs more or less simultaneously (Fig. 2m,n). However, in some cases part of the gonad is emptied at an accelerated rate (Fig. 2o) and may be completely emptied with the remaining of a nearly full part of the opposite sex (Fig. 2p). At the post-spawning stage, the resorption processes dominate, and the size of the gonads decreases considerably (Fig. 2s). In the last stage of the cycle, the gonad is free of reproductive products, and the intestine is visible through the wall of the gonad sac (Fig. 2t).

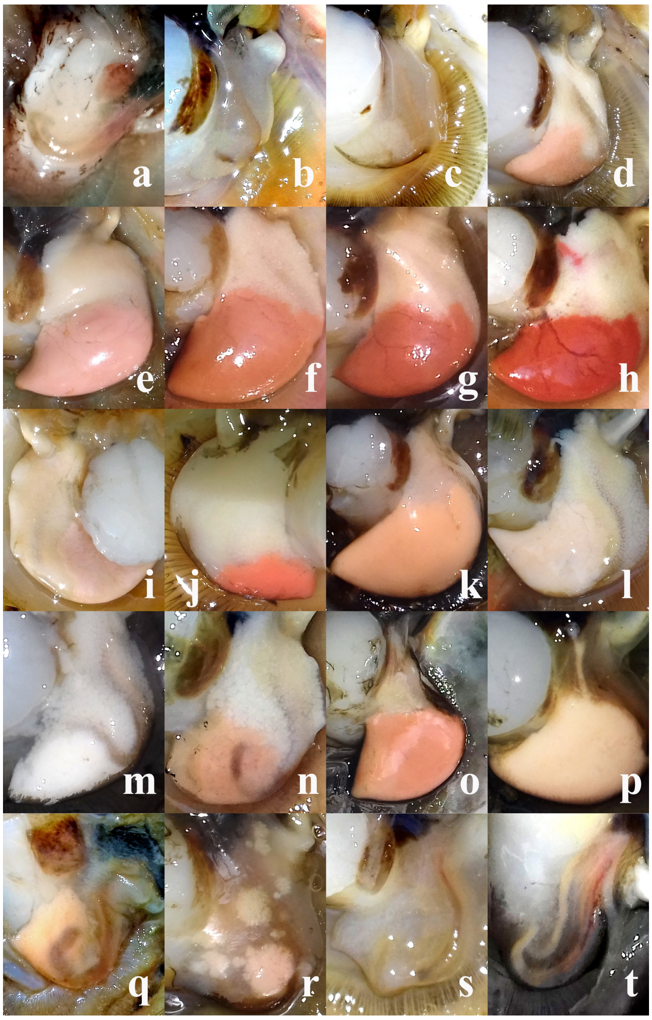

Fig. 2. *Flexopecten glaber* gonad morphology by stages of the annual development cycle. Designations: a – proliferating, b, c – developing, d–k – mature, l–r – spawning, s – post-spawning, t – spent. Not to scale. Specimens sampled from 18.02.2021 to 20.10.2023 in the Crimea, Russia.

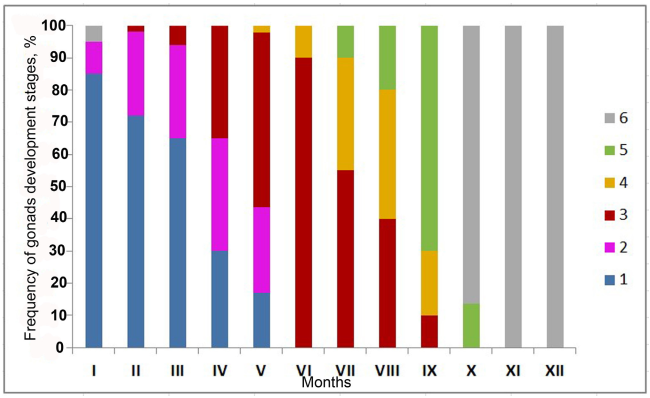

Fig. 3. Frequency plot (%) of gonads development stages of *Flexopecten glaber* sampled in January–December (I–XII) 2023 in the Sevastopol Region, Crimea, Russia. Designations: 1 – proliferating, 2 – developing, 3 – mature, 4 – spawning, 5 – post-spawning, 6 – spent.

The development of the gonads is not synchronous, even in individuals from the same local population. A new annual cycle of gonad development begins mainly in January at a temperature of 8°C, and in mid-February at a temperature of 7°C. Individuals can be found at various stages of development to maturity (Fig. 2a–d, Fig. 3). The gonads in the upper row (see Fig. 2a–d) belong to individuals collected from a local population at a depth of 15–17 m and at a low temperature of 7°C. In May, at a temperature of 12°C, the gonads of more than 50% of the *Flexopecten glaber* individuals were already in the mature stage. The highest number of mature individuals (90%) was recorded in June at a temperature from 17°C to 22°C, when active spawning begins, continuing until September. In October, about 85% of individuals have spent gonads, which remain in this state throughout the entire population from November to December (Fig. 3).

At the end of December to the beginning of January, the organism of most individuals undergoes a changeover, which precedes the beginning of the development cycle of the gonads. This transition results in a severe slowdown or even cessation of shell growth. During this process, a fairly noticeable starting mark forms on the surface of the valve, corresponding to the ventral edge of the shell during growth stoppage (Fig. 4a,b,c,f,h). The shell between the successive start mark is formed over the course of a calendar year. In individuals entering puberty, such a mark delimits the juvenile shell, or mesoconch (Fig. 4). At the mesoconch stage, the gonads of *Flexopecten glaber* are not yet developed, and subsequent formation and maturation of the gonads in individuals within the population do not occur simultaneously.

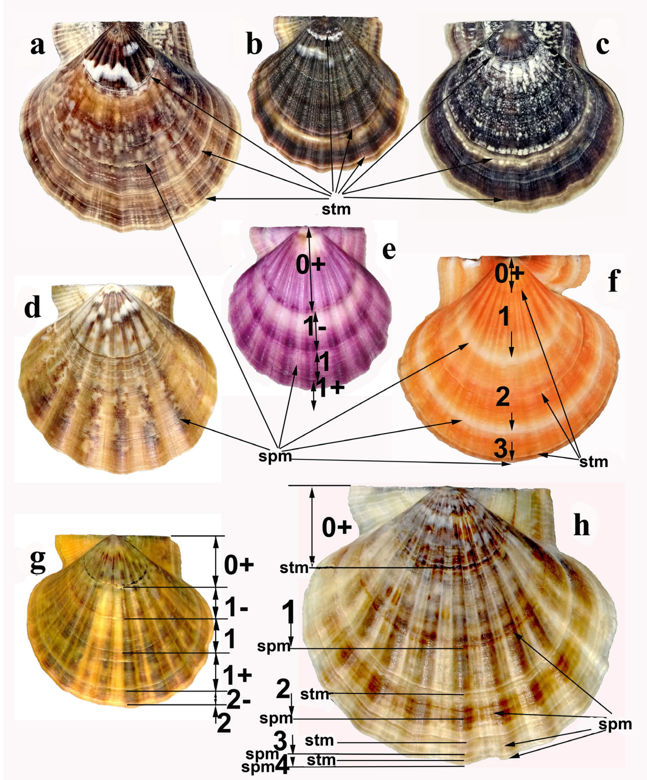

Fig. 4. *Flexopecten glaber* shell valves of various colour morphs, sizes (mm), ages (year) and the development stages. Designations: a: H = 46.2 mm, L = 48.0 mm, Hmc = 15.5 mm, 3-years; b: H = 33.5 mm, L = 34.2 mm, Hmc = 6.1 mm, 3-years; c: H = 43.2 mm, L = 44.5 mm, Hmc = 11.0 mm, 3-years; d: H = 42.5 mm, L = 44.0 mm, Hmc = 19.5 mm, 2-years; e: H = 36.5 mm, L = 36.3 mm, Hmc = 22.2 mm, 1+year; f: H = 43.5 mm, L = 46.8 mm, Hmc = 8.0 mm, 3-years; g: H = 42.7 mm, L = 46.4 mm, Hmc = 15.2 mm, 2 years; h: H = 58.8 mm, L = 65.0 mm, Hmc = 20.5 mm, 4 years; stm – starting mark, spm – spawning mark. All shells are at the same scale. Specimens were sampled from 18.02.2019 to 23.08.2023 in the Crimea, Russia.

The mesoconch often exhibits varying degrees of protective disruptive colouration (Fig. 4a,b,c,d,g,h). Sometimes the dissecting colouration extends into the zone corresponding to the mature stage of the gonads (Fig. 4b), but this is even less common in subsequent zones of the annual cycle (Fig. 4c).

The growth of the shell and the development of the gonads of mollusks are closely related. However, during the maturation of the gonads (stages 1–3), the growth rate of the shell is lower, and the growing layers form a more uneven surface than in the subsequent developmental stages, as can better be seen in Fig. 4d. These layers, which follow the first starting mark, are often lighter in colour than those that follow the subsequent ones (Fig. 4a,b,c,e). In some specimens, the transition from mesoconch to dissoconch (mature shell) is marked by a white zone (Fig. 4b,c), and this colouration may also follow the starting mark of a new cycle in the second year of life, although less frequently (Fig. 4c).

After reaching maturity with distinguishable male and female parts (Fig. 1a), the gonads of the mollusks continue to grow until the spawning begins. This phase is accompanied by a more rapid growth of the valves and more intense colouration of their surface (Fig. 4a,d,e). The transition from terminal maturity to spawning is often characterised by a change in the surface colour of the shell (Fig. 4a) and/or the appearance of a concentric relief mark to varying degrees (Fig. 4b,c,e,g). This stage of spawning is similarly evident on the upper valve (Fig. 4). The end of the active spawning period is often marked by a distinct concentric line that lies slightly below to the relief of the starting mark at the beginning of the gonadal maturation cycle. This mark, which is more often located in the middle (Fig. 4h), and less often at the end (Fig. 4a,d,g) of the spawning zone on the shell surface, is called the spawning mark. Its occurrence corresponds to the exhaustion of the gonads by more than 60–90%. In some specimens of the orange colour morph, a white stripe marks the middle of the spawning phase, which also indicates significant restructuring processes of the body. This marking indicates approximately the end of the regular year of life (Fig. 4f).

In order to determine the growth stages and ages of individual *Flexopecten glaber* from their shells, it is recommended that the annual cycle be divided into three stages, namely pre-spawning, ongoing spawning, and post-spawning. These stages are reflected on the surface of the shell valve in concentric zones of approximately equal width, often highlighted by differences in colour or tone (Fig. 4). In individuals with more uniformly coloured shells, where the corresponding markings are not as pronounced, growth stages can be determined by comparison with specimens with clear signs of the division. However, determining age and growth stages from external signs becomes difficult when there are individuals with different growth rates in the population, resulting in the presence of individuals of the same age but different size (see Fig. 5a).

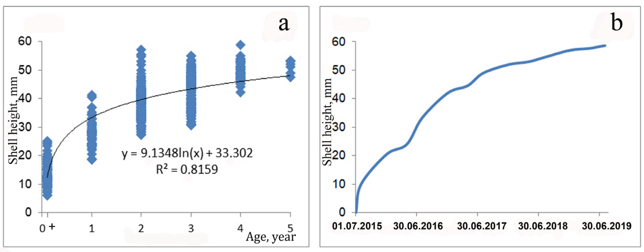

Fig. 5. Graphs of the correspondence between the size and age of *Flexopecten glaber*. Designations: a – growth plot by shell height versus age, N = 600 specimens sampled from 18.02.2023 to 20.10.2023 in Crimea, Russia; b – growth plot of a 4-year-old individual (see Fig. 4h) sampled on 30.06.1019 in Crimea, Russia.

The scheme for determining the growth and age of the shell, as shown on the reference samples, is as follows: mesoconch corresponds to juvenile stage of scallop development and age 0(+) years; stage of dissoconch growth (mature stage of shell development) before spawning, i.e. 1(-) year old; spawning, i.e. 1 year; post-spawning, i.e. 1+ years (Fig. 4e). Dissoconcus formation in subsequent years is similar (Fig. 4g). The growth rate decreases considerably with age (Fig. 4, Fig. 5), and the division into three stages in subsequent years becomes less pronounced, but the spawning mark is more evident (Fig. 4h), remaining less pronounced than the starting mark, though. An alternative version of age estimation can be performed using the spawning marks, the distance on the valve between which quite accurately corresponds to the individual year of the mollusk life (Fig. 4f,g,h).

The growth potential of an individual is largely determined by the size of its mesoconch, which is influenced by the time it takes for a juvenile to reach puberty, especially in the first year of life. In our sample, the maximum value of mesoconch size is 25.0 mm, while the average value is 13.5 mm. The smallest individual of *Flexopecten glaber* with gonads at the developing stage in our sample measured 12.8 mm in height and length (with mesoconch of 10.2 mm), and the smallest individual at the mature stage measured with a height of 16.0 mm and length of 12.9 mm (with mesoconch of 13.8 mm). The minimal mesoconch size observed in the examined *F. glaber* was 6.0 mm, indicating the possibility of sexual maturity in some individuals with a size less than 8–10 mm.

The largest specimen *Flexopecten glaber* we found had a height of 58.7 mm, a length of 65.0 mm, a width of 17.7 mm, and a mesoconch height of 20.5 mm, and it was over 4+ years old (Fig. 4h, Fig. 5b). The growth pattern of this individual (Fig. 5b) is typical for the *F. glaber* populations we studied. During maturation, the growth rate of the shells decreases considerably with age (Fig. 5). The annual periods of decreased growth rates correspond well with the period of gonadal development from the beginning to the mature stage (Fig. 5b).

Plotting the growth of *Flexopecten glaber* by shell height versus age shows a high degree of fit to the logarithmic curve with R^2 value of 0.8159. Using the method developed in the research, the highest age of *F. glaber* found off the Crimean coast was estimated to be 5 years (Fig. 5a).

Discussion

Diagnosing the developmental stages of *Flexopecten glaber* gonads based on morphological characteristics simplifies field and laboratory work with mass material, as compared to histological studies (Fig. 2). However, the phenomenon of various gonad colours at the same developmental stage within the same population, in individuals of the same age and even the same shell colour morph, requires further investigation. Studies on the total carotenoid concentrations (TCC) responsible for gonad colour and intensity in the scallop predator *Rapana venosa* (Valenciennes, 1846), indicate that the colour intensity increases with age due to the TCC accumulation, which are derived from their dietary spectrum (Bondarev & Malakhova, 2016). Unlike the gonads of *R. venosa*, the gonads of *F. glaber* are emptied annually, and pigments do not accumulate with age. The differences in colour and its intensity in the gonads of *F. glaber* within the population might be related to the local and even individual nutritional conditions of the scallops.

In general, the annual development cycle of the gonads of *Flexopecten glaber* in the Black Sea (Fig. 3) is similar to those described for this species in the Adriatic Sea (Marčeta et al., 2016), despite an almost two-fold difference in water salinity. The range of monthly average temperatures in the sampling areas is similar, ranging from 7°C in March to 22°C in September in the Adriatic Sea and from 7°C in February to 25°C in August in the Black Sea. It is noteworthy that the maturation process of *F. glaber* gonads starts in January at low temperatures (about 8°C) before reaching the minimal temperatures in both the Adriatic Sea and the Black Sea. After a brief slowdown, which may lead to a complete stop, shell growth resumes synchronously with gonad development. Therefore, the trigger for the start of gonadal development and the resumption of scallop growth is not, as one might expect, a rise in temperature. The starting mark, which is formed mainly in winter, does not result from a slowdown of life processes under the influence of low temperatures, but as a result of the organism physiological restructuring on the eve of the beginning of the annual cycle of gonad formation.

The start of the first cycle of gonad formation aligns with the ventral edge of the mesoconch, which can often be distinguished from the dissoconch by its colour and patterns (Fig. 4). Protective camouflage colouration of juveniles is a common phenomenon in the animal kingdom. The various colours and patterns of the mesoconch of *Flexopecten glaber* increase the chances of being detected and captured because there are a number of substrates, on which the spat can settle and develop an initially thin-walled shell.

Since in *Flexopecten glaber*, 20 hours after fertilisation of the eggs, a growing shell in the form of a bilobed plate is formed, and all larvae enter the D-veliger stage (prodissoconch I) a day later (Pirkova & Ladygina, 2017), the age of *F. glaber* should be identified either by spawning marks or by areas of the shell surface corresponding to the spawning stage (Fig. 4). The shell surface formed from the apex to the first spawning mark, and further between successive spawning marks, is formed during one year of life of *F. glaber*.

Annual seasonal shell surface marks (starting mark and spawning mark) can often be difficult to distinguish one from another and from other markings caused by various factors such as storm damage, engineering activities, dredging, or predation attempts (Richardson, 2001). In previous studies of *Flexopecten glaber* in the Black Sea (e.g. Bondarev, 2019, 2020), the age estimation was based on starting marks and spawning marks, both annual marks, which resulted in some individuals being overestimated in age by up to two times. Understanding the formation of growth zones and marks on the shell surface can help distinguish regularly from randomly generated marks. Using a zonation scheme based on the established cyclicity of development in ontogenesis to determine the age of mollusks can increase the reliability of the results so that they are as accurate as possible.

The wide range of the size values within a single age group in the population (Fig. 5a) makes it difficult to accurately depict the growth curve for the sample to capture important details of the developmental process in ontogeny. However, this limitation can be overcome by using the individual development graph (Fig. 5b), which reveals the presence of cyclical elements in ontogeny. With a considerable amount of data analysed (> 1500 specimens), the proposed developmental scheme can be applied to study developmental periods and accurately estimate the age of *Flexopecten glaber* individuals with a high degree of confidence.

The maximum age of *Flexopecten glaber* individuals in the Black Sea remains uncertain due to the difficulty of interpreting growth lines on the shell edge in old individuals. The largest recorded individual in the Black Sea, with a height of 58.7 mm and length of 65.0 mm, was estimated to be four years old (Fig. 4h, Fig. 5b), and its size at 2+ years was 49 mm. However, larger 2-year-old individuals with a height of up to 57.1 mm (Fig. 5a) suggest that *F.*

glaber may reach even larger sizes in the Black Sea than previously noted. In the Mediterranean Sea, the age of 85-mm *F. glaber* individual was estimated to be 2+ years, suggesting that this may be the age limit for the species (Lykakis & Kalathakis, 1991). These results support the notion that the largest individuals are often relatively young but have a higher growth rate than those in the main part of the population. Therefore, it is important to recognise the potential error in using the method of calculating the age of individuals in a population based solely on the size and age of the largest individual (Zolotarev, 1989).

Conclusions

By comparing the growth stages and developmental cycles of valves and gonads in the ontogeny of *Flexopecten glaber*, correlations between these processes were discovered. The most prominent mark on the shell surface is formed mainly in winter as a result of the physiological restructuring of the organism before the beginning of the annual cycle of gonad formation. However, to determine the age of *F. glaber*, the spawning marks formed mainly in summer should be considered. The scheme for determining the individual age of *Flexopecten glaber* considered in our study can serve as a model for establishing this important biological indicator in related species of Pectinidae and some other Bivalvia.

The proposed scheme for determining the developmental stages and age of *Flexopecten glaber* individuals based on the morphology of their shell valves is a valuable tool for studying the species and can help resolve a variety of commercial, ecological and conservation issues. Moreover, it has the potential to contribute to the development of the theory of animal ontogeny.

Acknowledgements

The author is grateful to the anonymous reviewers for their comments and recommendations, which improved the quality of the paper. The study was conducted within the framework of the Russian Academy of Sciences research assignment «Biodiversity as the basis for the sustainable functioning of marine ecosystems, criteria and scientific principles for its conservation» (State registration №124022400148-4).

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ЦИКЛИЧНОСТЬ В ОНТОГЕНЕЗЕ И ОПРЕДЕЛЕНИЕ ВОЗРАСТА *FLEXOPECTEN GLABER* (BIVALVIA, PECTINIDAE) В ЧЕРНОМ МОРЕ

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Flexopecten glaber является объектом активного промысла в Средиземном море и перспективным видом для марикультуры в Черном море. *Flexopecten glaber* занесен в Красные книги Республики Крым и города Севастополя как вид, сокращающийся в численности (категория 2). В данном исследовании было проанализировано более 1500 особей, отобранных вблизи Крымского полуострова в период с 2017 по 2023 гг., с целью изучения онтогенеза *F. glaber* и разработки метода определения индивидуального возраста на основе взаимосвязи между стадиями развития гонад и изменениями морфологии поверхности раковины. Цикличность развития оценивали путем сопоставления циклов формирования гонад с особенностями морфологии поверхности раковины. Установлено соответствие между морфологией поверхности створок раковины и стадиями годового цикла развития гонад. На этой основе разработана схема определения стадий развития и индивидуального возраста особей *F. glaber* по морфологии створок раковины. Наиболее выраженная метка на поверхности раковины формируется преимущественно зимой в результате физиологической перестройки организма перед началом годового цикла формирования гонад. Однако для определения возраста особей *F. glaber* необходимо учитывать нерестовые отметины, формирующиеся преимущественно летом. Предложенная схема определения стадий развития и возраста особей *F. glaber* является ценным инструментом для изучения вида и может помочь в решении различных экологических и природоохранных вопросов.

Ключевые слова: годовой цикл, гонады, морской гребешок, морфология раковины, охраняемый вид