Age Determination of Polynoidae Polychaetes Based on Growth Lines on the Jaws*

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Jaw structure was examined in six species of polynoid polychaetes from temperate waters of the northern hemisphere. In all species periodic lines or rings are found on the jaws. The number of lines varied from one to eight. Comparison of growth lines on the jaws of *H. imbricata* with the size structure of the population and age as determined by duration of exposure of mussel collectors showed it was possible to use growth lines as age₁markers. The first growth line is formed in the first year of life. Formation of the growth lines occurs in the fall-winter period. Maximum duration of growth in *H. imbricata* off the coast of Crimea is at least two years. It is believed that periodic growth lines on the jaws of polynoid polychaetes can be used to estimate age.

Key words: Age determination, Polynoidae polychaetes, growth lines on the jaws

Age determination of animals is one of the most important tasks of population ecology. Knowing the age makes it possible to calculate growth rates, recruitment, production, mortality, and other population parameters. In recent years, advances have been made in developing methods for age determination of marine organisms with hard skeletal structures: mollusks, sea urchins, corals, and barnacles (Rhoads and Lutz, 1980; Zolotarev, 1988). For other marine animals, in particular, polychaetes, methods of age determination are poorly developed. In some cases, attempts at age estimation have been successful based on analysis of the population size or weight structure (Gibbs, 1968; Hutchings, 1973). However, use of these methods is limited; in particular, they are not suitable for species with protracted or continuous egg deposition as well as uneven growth. In addition, even in species with seasonal nonprotracted egg deposition, but which live long, it is possible, as a rule, to separate only the first two size–age classes, while the subsequent classes fuse because of the unevenness of growth. The attempt to determine age in terebellid polychaetes based on the size of the setae and number of uncinus-type setae is of interest (Duchene and Bhaud, 1988).

We found promising the use of periodic growth lines or rings on the jaws in determining the age of polychaetes with hard jaw elements. This technique was first proposed by Kirkegaard

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Table 1

Species	Sample size, spms.	Body width, mm	h, Number of an- nual growth lines on jaws	
Harmothos impricata	120	06.24	0.2	
narmothoe intericata	120	0,6-2,4	02	
H. derjugini	8	4,2-4,5	48	
Halosydna nebulosa	6	3,5-4,6	4-8	
Hermilepidonotus robustus	2	5,2-7,0	6-8	
Lepidonotus squamatus	3	2,3-2,6	4	
Eunoe aff. depressa	1	8,6	7-8	

Characteristics of Polynoid Polychaetes

Table 2

Harmothoe imbricata: Collection Date, Duration of Exposure of Collectors; Sample Size, Relative Abundance and Size (body width) of Individuals with Different Numbers of Growth Lines on the Jaw

Number of growth lines	19 XII 1987, ex- posure of 7–8 mos.; sample of 24 spms.		17 XI 1987, ex- posure of 12 mos.; sample of 55 spms.		9 II 1988, ex- posure of 21 mos.; sample of 36 spms.	
	Abun- dance, %	Width, mm	Abun- dance, %	Width, mm	Abun- dance, %	Width, mm
0 1 2	48.5 50.0 4.2	0.9 ± 0.3 1.5 ± 0.2 1.9	27.2 36.4 36.4	1.0 ± 0.3 1.5 ± 0.2 2.1 ± 0.3	11.1 41.7 47.2	0.9 ± 0.2 1.4 ± 0.2 1.9 ± 0.3

(1970) for Nephtyidae polychaetes. Later, growth lines were found in certain other families of polychaetes, including the polynoids *Harmothoe imbricata*, *Halosydna brevisetosa*, *Lipidonotus clava*, *Eunoe oerstedii* (Olive, 1980) and *Arctonoe vittata* (Britayev, 1988). However, the possibility of using growth lines as age markers is proved only for the Nephtyidae (Kirkegaard, 1970, 1978).

In order to assess the growth lines for polynoids, we investigated the structure of the jaws of six species of polychaetes of five genera. In addition, we compared the number of growth lines on the jaws of *Harmothoe imbricata* found on mussel collectors with the size structure of the population and approximate age of polychaetes as determined by the time since the collectors had been set out.

Materials and Methods

We investigated six species of polynoid polychaetes (Table 1). *H. imbricata* was collected in the Black Sea near Sudak from structures used to culture mussels in fall and winter of 1987 and 1988 (Table 2). Because the time of exposure of the collectors is known, and, assuming that they are settled exclusively or primarily by larvae settling from the plankton, we can date the age of *H. imbricata*. The abyssal species *H. derjugini* from the Japan Sea was kindly made available by R.Ya. Levenshteyn (IOAN RAN). Other species were collected by T.A. Britayev in different years in the upper sublittoral of Vostok Bay on the Japan Sea. To study the jaws, we prepared glycerin and dry specimens. The pharynx, as a rule, had to be cut out, and the jaws detached and cleaned of tissue. Body width was measured between the bases of the parapodia at the level of segments 10– 15. To assess the condition of the gonads, the polychaetes were dissected ventrally and a piece of the gonad or drop of coelomic fluid was taken and examined under a microscope.

Results

Growth Lines on Jaws of Polynoid Polychaetes

The jaw structure of most polynoids is represented by two pairs of large chitinous hooks, dorsal, and ventral, situated on the distal part of the pharynx when everted. Each hook (jaw) consists of an extended narrow "base" and triangular "crown," the apical end of which projects above the surface of the pharynx. The crown, in turn, consists of a large buccal and small labial plates (Olive, 1980) which are fused to the upper part of the base on both sides (Fig. 1).

Transverse lines (rings) were found on their surface in all investigated species. Thin lines that are barely distinguishable occur with more distinct ones that are easily discerned at low magnification (Fig. 1). They are entirely comparable to the annual growth lines found on the jaws of the Nephtyidae. Along the outer edge of the buccal plate of the crown, darker slender bands alternate with lighter ones. Moving toward the apical part of the jaws, the width of the light bands may increase. We tentatively consider these lines to be annual marks. The results from counting these "annual" lines are presented in Table 1. The growth of the jaw occurs in the basal part of the "crown" and "base"; therefore, the increase in the concentration of the growth lines along the outer margin of the buccal plate shown in Fig. 1 may possibly be associated with a slowing in the growth of the jaw.

The growth lines are more pronounced on jaws of the larger species such as, for example, *Eunoe* aff. *depressa* Moore, 1905, or *Lepidonotus robustus* (Moore, 1905). Counts of the lines in the latter species are best performed on the base of the jaw. In other species, the growth lines are best defined on the buccal plate of the crown. In particular, we note the presence of periodic growth lines on the jaws of *Harmothoe derjugini* Annenkova, 1937—a deepwater species occurring at fairly constant temperature and salinity.

In the smaller species *H. imbricata* (L., 1767), the growth lines are not as well defined, but by changing the direction of the light beam, it is possible to obtain a good estimate of their number. *H. imbricata* is of special interest for us. Its biology is well studied (McIntosh, 1900; Daly,

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Fig. 1. Jaws of polychaete *Eunoe* aff. *depressa*: (A) Jaw, view from pharyngeal cavity;
(B) same, external view (b.p.—buccal plate of crown; c—crown; g.l.c.—growth lines on buccal plate of crown; g.l.b.—growth lines at base of jaws). Bar = 1 mm.

1972; Daly et al., 1972), and the maximum age of individuals that we have is dated by the time of exposure of the mussel collectors. Knowing the exposure time of the collectors and the time of egg deposition, we can determine the approximate age of a particular size class of individuals.

Reproduction in Harmothoe imbricata

Without a thorough study of the reproductive biology of this species, we wanted to determine the approximate time of egg deposition. For this, we examined two small samples of polychaetes collected in fall and winter 1987–1988. In the fall months, the gonads are weakly developed, and sex is difficult to determine. The active processes of production and growth of gametes occur in winter, and in February we found females brooding young beneath the elytra. Their relative abundance at this time is not great, only 13 percent of the total abundance in the sample. In the body cavity of these females, second generation oocytes were found 70–90 μ m in diameter. Thus the main features of the reproductive biology of *H. imbricata* (presence of two contiguous generations of oocytes, brooding of young beneath the elytra, period of egg deposition) off the east coast



Fig. 2. Size distribution of *Harmothoe imbricata* from mussel collectors: (0) Individuals without growth lines on the jaws; (1) with one growth line; (2) with two growth lines. The increase in abundance of individuals with one and two growth lines can be seen as exposure of the collectors increases: (A) 19 XI 1987, 7–8 months since settlement on mussels, n = 24 specimens; (B) 17 XI 1987, 18 months since settlement on mussels, n = 55 specimens; (C) 9 II 1988, 21 months since settlement on mussels, n = 36 specimens. Vertical axis—frequency of occurrence (percent), horizontal—body width (mm).

of Crimea and off the coast of England coincide. This makes it possible to extrapolate the conclusion of Daly (1972) about the short spring settling period of larvae in April-May to the Crimean population.

Estimating Age of *H. imbricata* Based on Exposure of Collectors, Size Structure of Settling Sites, and Growth Lines on Jaws

Taking the data on period of settling, size structure of settling sites, and exposure time of mussel collectors, we can rather precisely estimate age; this makes it possible to compare the number of periodic growth lines on the jaws with age.

The size distribution of individuals in the first November sample (exposure of 7–8 months) was unimodal with the mode being 1.35–1.60 mm (Fig. 2 (A)). Because the collectors are suspended in the water column, and the probability of their massive settlement by drifting adult poly-chaetes is not great, and because settling occurs in April–May, it may be concluded that the age of most or even all individuals in this sample was 6–7 months. The relative abundance of individuals with a different number of growth lines on the jaws is presented in Table 2. Individuals with one line and without lines on the jaws are represented in about equal numbers. Together they account for 95.8 percent of the sample. Only the largest polychaete in the sample had two growth lines. It is possible that this individual came from the preceding year and made it to the collector as an adult from the ground or from another collector by wave action of the near-bottom water layer.

In the histogram of the size composition of the second sample taken at the same time but from a collector that had been exposed for 18 months (that is, encompassing two periods of settlement), a second mode appears (Fig. 2 (B)). If the first mode corresponds roughly to the single mode on the preceding histogram and is formed by young of the year, then the second mode is formed by individuals from the preceding year aged 18–19 months. The appearance in the sample of individuals from 1986 is accompanied by a significant increase in the abundance of polychaetes with two growth lines on the jaws, and, clearly, it is these individuals that represent this generation.

In the winter sample (February 1988, 21-month exposure), there is only one modal group, 1.20–1.45 mm (Fig. 2 (C)), although this sample included individuals from the 1987 and 1986 generations. The disappearance of the second mode may be associated with high mortality in the older age group (for example, with increased mortality associated with reproduction) and with the considerable unevenness in growth rates of individuals. The relative abundance of individuals without growth lines on the jaws in this sample was reduced even more while that for individuals with one and two lines increased proportionately (Table 2).

Discussion

With the increase in age of polychaetes, the number of growth lines on their jaws increases, indicating that these lines are age markers. The first growth line is deposited in *H. imbricata* in the first year of life, and not the second as is the case for Nephtyidae (Olive, 1980). Because the process of depositing the growth lines is protected, errors not exceeding one year are possible in age determination of individuals, but the probability depends on the season. Thus, in *H. imbricata* in November, about 46 percent of individuals from that year (age 6-7 months) did not have a growth line, and 50 percent have one line. In February, in individuals of the same generation (age 9-10 months), abundance of individuals without growth lines drops to 11 percent.

These data testify to the formation of growth lines in the period from November through February, that is, in winter. Therefore, the most distinct separation of age groups of *H. imbricata* is possible in the spring-summer months since by this time formation of the growth lines in each age group is evidently completed. In this period, the number of growth lines on the jaws of polychaetes corresponds to their age in years.

All investigated species of polynoids occur in temperate waters of the northern hemisphere, that is, in waters subject to seasonal climatic variations. Extrapolating the results obtained for *H. imbricata* to other investigated species, we may postulate that formation of periodic growth lines on the jaws is a consequence of seasonal changes in the nature of growth and that the lines them-selves may be used as age markers. The presence of growth lines in the deepwater species, *H. der-jugini*, occurring under stable hydrological conditions, is especially interesting. Most likely, this is related to seasonal changes in plankton production in the surface layers and the corresponding changes in trophic conditions below.

Use of the growth lines as an age marker should be made with caution since differences in the nature of the formation of growth lines may occur in different species. It also cannot be ruled out that various traumas or extreme conditions (abrupt temporary changes in salinity, storms, etc.) influence formation of the growth lines. Therefore, in studying age structure of an population, it is desirable to check data obtained by counting growth lines against analysis of the size (weight) structure of the population.

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