Jolanta KOSZTEYN

Sea Fisheries Institute in Gdynia

Oceanologia, 16 (1983)
PL ISSN 0078-3234

MORPHOLOGICAL VARIABILITY AND INDIVIDUAL DEVELOPMENT CYCLE OF *SAGITTA ENFLATA* (GRASSI) 1881 AS COMPARED WITH THE SHELF WATER DYNAMICS OF NORTH-WEST AFRICA

1. INTRODUCTION

Sagitta enflata (Grassi) belongs to the phylum *Chaetognata*. This phylum embraces several dozen species of marine organisms, usually planktonic, rarely demersal. *Sagitta enflata* occurs in all ocean and marine waters of the equatorial, tropical and subtropical zones, and partly in the boreal and antiboreal zones. Generally speaking, it occurs south and north of the equator, to 40° parallel (Alvarino [1]).

Sagitta enflata is the most abundant representative of *Chaetognata* in the shelf waters of N. W. Africa. It constitutes one of the main components of zooplankton in this region (about 23% of all *Chaetognata* found in the samples).

Sagitta is known to react distinctly to all changes taking place in the character of water masses. For this reason, considerable attention has been devoted to the distribution and abundance of *S. enflata*, among other things, in the shelf waters discussed here (for instance, Furnestin [4—6]; Saint-Bon [17]; Alvarino [1]; Ducret [2]; Koszteyn [11]; Köller [10]). On the other hand, its population structure has rarely been dealt with, especially in relation to the variable hydrological character of these waters, the latter depending on he season and geographic latitude.

The present paper aims to present at least a partial explanation of the problems mentioned.

Characteristic of the waters of the part of the N. W. African shelf discussed is the specific hydrologic situation, determined by the noticeable

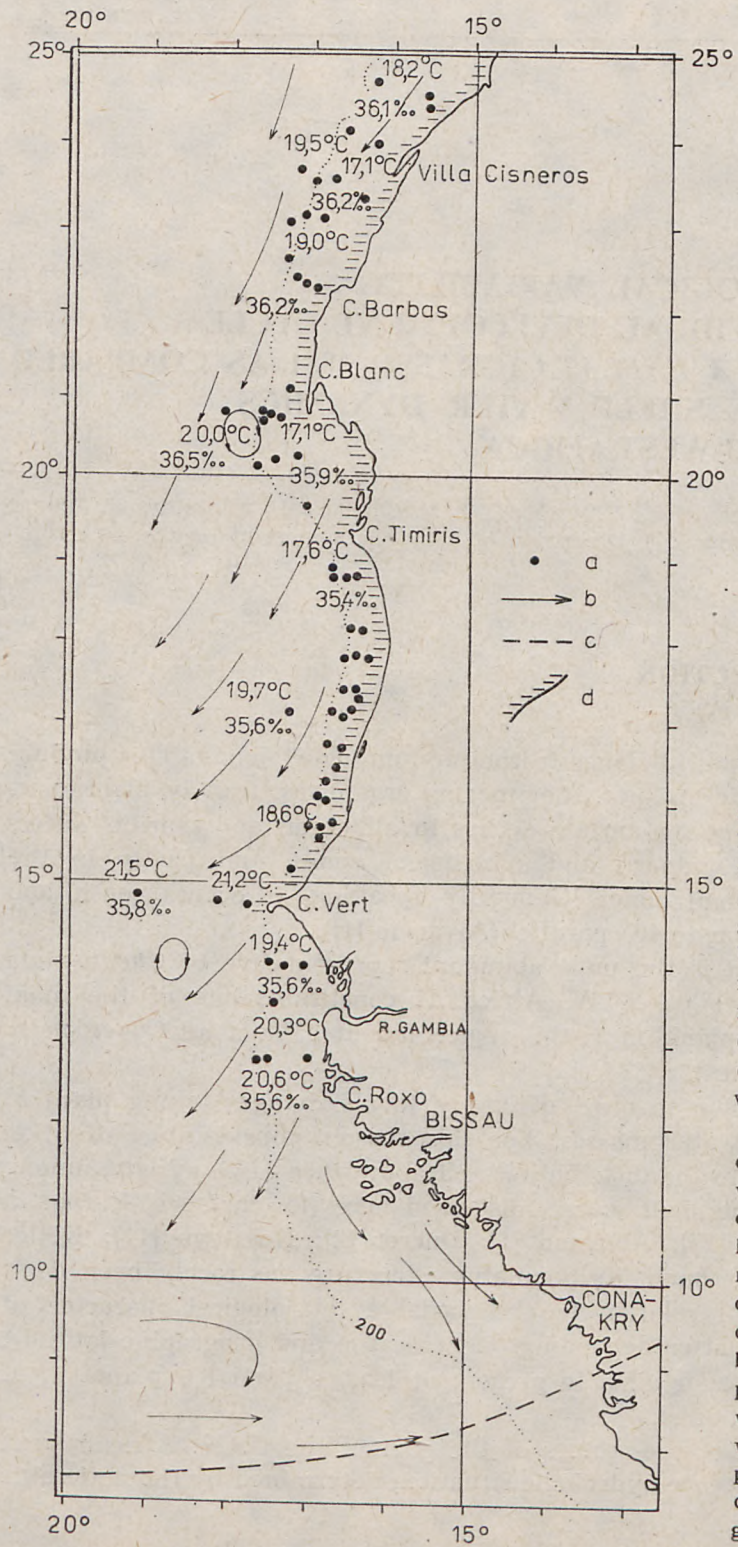


Fig. 1. Hydrological situation in waters of the investigated part of the N. W. African shelf in February and March 1970; *a* — sampling stations, *b* — surface currents, *c* — southern range of N. E. trade winds in March, *d* — shelf section with upwelling

Rys. 1. Sytuacja hydrologiczna w wodach badanego odcinka szelfu Afryki północno-zachodniéj w lutym i marcu 1970 r.; *a* — stacje, na których pobierano próby, *b* — prądy powierzchniowe, *c* — południowa granica zasięgu pasatu N-E, *d* — odcinek szelfu objętego upwellingiem

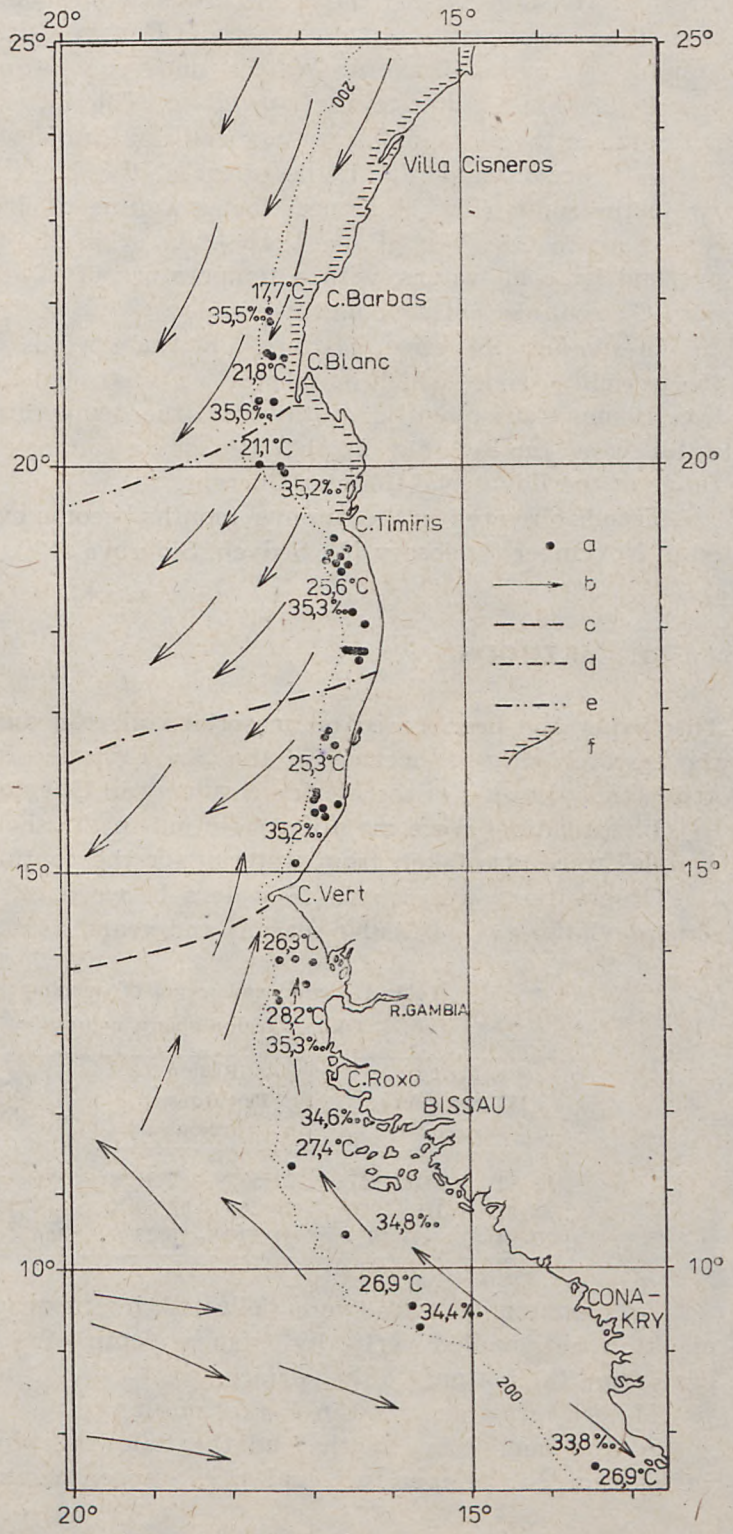


Fig. 2. Hydrological situation in waters of the investigated part of the N. W. African shelf in July and August 1967; *a* — sampling stations, *b* — surface currents, *c* — southern range of N. E. trade winds in June, *d* — southern range of N. E. trade winds in July, *e* — southern range of N. E. trade winds in August, *f* — shelf section with upwelling

Rys. 2. Sytuacja hydrologiczna w wodach badanego odcinka szelfu Afryki północno-zachodniej w czerwcu, lipcu i sierpniu 1967 r.; *a* — stacje na których pobierano próby, *b* — prądy powierzchniowe, *c—e:* południowa granica zasięgu pasatu N-E *c* — w czerwcu, *d* — w lipcu, *e* — w sierpniu, *f* — wycinek szelfu objęty upwellingiem

effect of constant winds: the N. E. trade winds and equatorial winds, as well as the variable range of the cold Canary Current and the warm Equatorial Counter-Current. Waters north of Cap Vert have highly specific dynamics, due to the upwelling. The latter phenomenon was not noted in the more stabile waters south of Cap Vert.

In February and March the effect of the N. E. trade winds shifts far to the south (Fig. 1). Hence, the upwelling of deep waters was observed up to Cap Vert (Cape Verde). As a result of this, the shelf is overlaid by cold waters, with a temperature of 17—18°C, the cold Canary Current also influencing this.

In summer the effect of the N. E. trade winds diminishes, as does the upwelling zone, which is, in practice, restricted to the area north of Cap Blanc. Consequently, southwards, the temperature of the surface waters rises rapidly (Fig. 2), this also being connected with the greater range of the Equatorial Counter-Current.

Trends observed in the summer months become even more pronounced in November (Fedoseev [3]; Sedych, Sidorova [18]).

2. METHODS

This paper has been based on material collected during the cruises of the research ships "Wieczno" of the Sea Fisheries Institute in Gdynia, and "Jan Turlejski" of the Marine Academy in Gdynia.

Investigations were mainly carried out in the shelf waters, but some samples were also taken from waters over the continental slope.

Observations were made in waters between 32° N and 7° N, with some deviations in particular seasons and years, as presented in Table 1.

Table 1. Period and region of sampling

Tab. 1. Okres i region zbioru matreiałów

Period Okres zbioru materiałów	Region Penetrowany rejon	Ship Statek
12 VI – 4 VIII 1967	21°53′N – 7°31′N	„Wieczno"
5 II – 4 III 1970	24°26′N – 12°59′N	
20 XI – 3 XII 1973	31°57′N – 16°23′N	„Jan Turlejski"

Zooplankton samples were collected by means of a Hensen-type plankton net, hauled vertically from a depth of 100 m (in shallower parts from the bottom) to the surface.

Material was preserved in 4% formalin.

At the same time, depths and the following physico-chemical data were recorded: temperature, salinity, oxygen content, and inorganic

phosphate content (in samples from 1973 phosphates were not determined) (*Report from the cruise of m. t. "Wieczno" to N. W. African fishing grounds in 1967; Report from the cruise of m. t. "Wieczno" to N. W. African fishing grounds in 1970).*

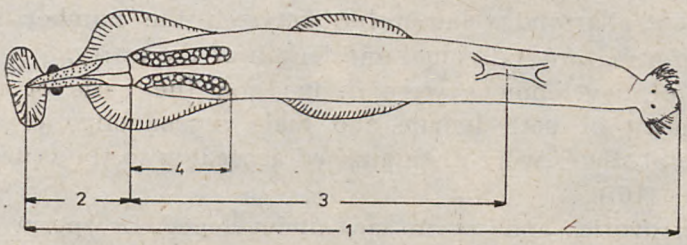


Fig. 3. Method of measuring *S. enflata* individuals; *1* — total length, *2* — length of the caudal segment, *3* — distance between septum and ganglion ventralis, *4* — length of the ovary

Rys. 3. Sposób mierzenia osobników *S. enflata; 1* — długość całkowita, *2* — długość segmentu kaudalnego, *3* — odległość septum (oddzielającego część tułowiową od ogonowej) od ganglion ventralis, *4* — długość jajnika

Altogether 144 samples were collected. They contained 18 540 individuals of *S. enflata*. In view of the large numbers in some samples, only random samples were analysed. These contained about 100 individuals each. In case of less numerous samples, analyses were made of all organisms.

3640 individuals of *S. enflata* were analysed, taking into account their developmental stage and the following features (Fig. 3): 1) total

Table 2. 5-grade scale for the III stage of development of *Sagitta enflata*

Tab. 2. Pięciostopniowa skala ocen dla III stadium dojrzałości osobników *Sagitta enflata*

Feature Cecha	Range of values Zakres wartości	Grade Ocena	Feature Cecha	Range of values Zakres wartości	Grade Ocena
total length (1)	−12,99	1	length of the caudal segment (2)	−2,15	1
	13,00−15,99	2		2,16−2,45	2
	16,00−18,99	2		2,46−2,75	3
	19,00−21,99	4		2,76−3,05	4
	22,00−	5		3,06−	5
distance between septum and ganglion ventralis (3)	− 7,55	1	length of the ovary (4)	−1,45	1
	7,56− 8,55	2		1,46−1,95	2
	8,56− 9,55	3		1,96−2,45	2
	9,56−10,55	4		2,46−2,95	4
	10,56−	5		2,96−	5

length, 2) length of the caudal segment, 3) distance between septum (separating the thorax from the caudal part) and ganglion ventralis, 4) length of the ovary, 5) number of eggs in a mature ovary.

Ratios were calculated between total length and: length of the caudal segment, length of the ovary, distance between septum and ganglion ventralis, and relatnonship between the number of eggs in the ovary of a mature individual and length of the ovary.

Stages of development were defined on the basis of the degree of development of both female and male reproductive organs. Three developmental stages were distinguished according to the criteria applied by Rożańska [16]).

I stage: ovaries and sperm sacs undeveloped, or sperm sacs indistinctly marked and ovaries sometimes in the form of thin "threads".

II stage: ovaries and sperm sacs moderately developed; ovaries thin, eggs undeveloped; empty sperm sacs.

III stage: ovaries and sperm sacs fully developed; ovaries packed with mature, compact eggs; sperm sacs contain spermatozoids; sometimes sperm sacs broken with spermatozoids escaping.

3. MORPHOLOGICAL VARIABILITY OF *SAGITTA ENFLATA* (GRASSI) INDIVIDUALS

The complicated hydrological situation existing in the waters of the part of the N. W. African shelf discussed, results in considerable differentiation in the living conditions of *S. enflata*. This fact affects not only its abundance (Koszteyn [11]), but also some of the morphologicaol features and biology of this species.

In order to establish the morphological differences between the individuals in full, comparisons were made only between organisms at the same stage of development.

First, statistical analysis of the following meristic features was carried out: 1) total length, 2) length of the caudal segment, 3) distance between septum and ganglion ventralis, 4) length of the ovary.

Extreme values and arithmetical mean for the above values were found for each sample containing randomly selected individuals of *S. enflata*. Standard error and standard deviation of the arithmetic mean were also calculated.

These data were among those used for geographic comparison of the mean values of particular local samples with the mean value of the total sample (graphic method of comparison of the shape of the Jentys-Szaferowa 1948—1951 curve) (Fig. 4). Sample numbers presented on the right of the figure are arranged from the highest to the lowest geographic lattitude. The vertical line marked 1 represents a comparat-

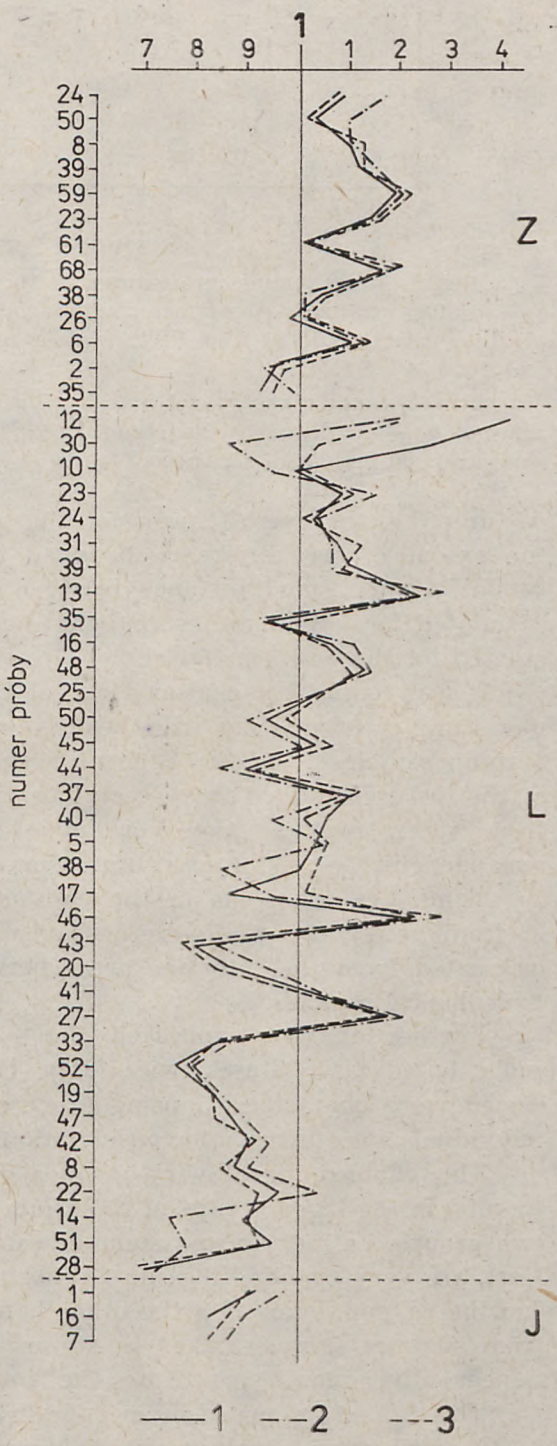


Fig. 4. Graphic presentation of the relation between mean values of the three features in individuals in the III stage of development in local samples (broken line) and the mean values for the whole material (vertical line); *1* — total length, *2* — length of the caudal segment, *3* — distance between septum and ganglion ventralis, *Z* — winter samples, *L* — summer samples, *J* — autumn samples

Rys. 4. Graficzne przedstawienie stosunku średnich wartości trzech cech u osobników III stadium dojrzałości w próbach lokalnych (linia łamana), w odniesieniu do średniej ze wszystkich prób (linia pionowa); *1* — długość całkowita, *2* — długość segmentu kaudalnego, *3* — odległość septum od ganglion ventralis, *Z* — próby pochodzące z pory zimowej, *L* — próby pochodzące z pory letniej, *J* — próby pochodzące z pory jesiennej

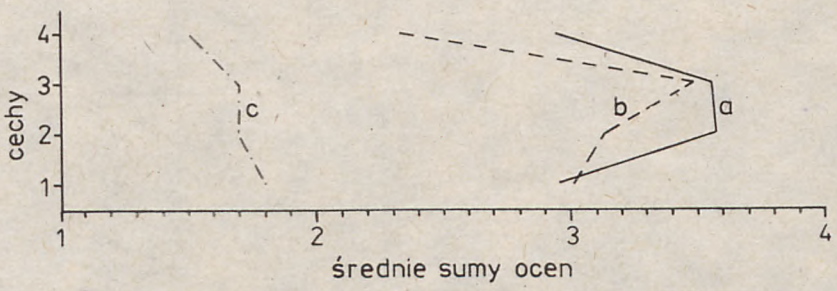


Fig. 5. Mean grades for features in three groups of *S. enflata* individuals; *a* — winter months, *b* — summer months, water north of Cap Vert, *c* — summer months, waters south of Cap Vert; *średnie sumy ocen* — mean grades, *cechy* — features

Rys. 5. Średnie oceny cech trzech grup osobników *S. enflata; a* — miesiące zimowe, *b* — letnie, wody na N od Przylądka Zielonego, *c* — miesiące letnie, wody na S od Przylądka Zielonego

ive unit (i.e. the overall mean for the given stage). Broken lines show the extent of the difference between the total length, length of the caudal segment, and distance between septum and ganglion ventralis calculated for local samples, and the mean values of these features calculated for the whole material.

It was found that characteristic of the groups of *S. enflata* in summer samples originating from waters south of Cap Vert and in some autumn samples from the Senegal River estuary, was the lower value of the features studied than *S. enflata* from summer samples originating from waters north of Cap Vert, and those from winter samples. This was particularly true of adult organisms.

Some deviations (as in the case of summer samples No. 43 and 20 from waters at 15° N) were probably due to the fact that the samples originated from the interface areas between water masses of different hydrological regimes.

Further analyses embraced the so-called Anderson hybridization index (cited after Staszkiewicz [21]). The four meristic features mentioned were characterized using a score method (Table 2). Only adult individuals were taken into consideration in these analyses.

This enabled the drawing up of a graph of the average sum scores (points) in the three groups of *S. enflata* (Fig. 5). It can be seen that the two groups, i.e. winter and summer samples from waters north of Cap Vert, are very similar. It is most probable that they represent the same "northern" population. On the other hand, the third group of organisms from summer samples taken in waters south of Cap Vert, and in the Senegal River mouth, constitutes the "southern" population.

This is also supported by cyclograms drawn up from score estimates. In the cyclograms, each sample is presented as a quadrangle inscribed in a circle. The method of preparing a cyclogram is presented in Fig. 6.

Table 3. Mean values of some features of the „northern" (N) and „southern" (S) populations
Tab. 3. Średnie wartości niektórych cech w populacji „północnej" (N) i „południowej" (S)

Description Wyszczególnienie	Stage of development Stadium dojrzałości			
	III		II	
	Populations – Populacja			
	N	S	N	S
	mm			
Total length – Długość całkowita	17.81	14.00	12.40	11.15
Length of caudal segment – Długość segmentu kaudalnego	2.77	2.35	2.02	1.66
Distance between septum and ganglion ventralis – Odległość septum od ganglion ventralis	9.82	7.68	6.75	6.00

Graphs presented in Fig. 7 show clearly that quadrangles representing the "southern" *Sagitta* population have considerably smaller surface areas than those of the "northern" population. Areas of quadrangles representing the "northern" population are also less differentiated, the only exception being samples Nos. 43 and 20, originating from the interface waters mentioned.

Further studies showed that in the case of the "southern" *Sagitta* population, the average values of the features investigated differed significantly, viz. lower than similar average values calculated for the "northern" population (Table 3). The significance of these differences was tested with the "d" test (Parker [13]).

Characteristic of adults from the "southern" population was a smaller number of eggs in the ovary: there were 17 eggs on average, whereas

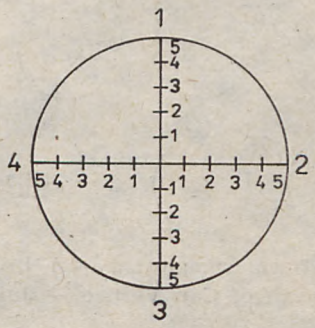


Fig. 6. Method of preparing a cyclogram. Number on the circumference denote particular features; *1* — total length, *2* — length of the caudal segment, *3* — distance between septum and ganglion ventralis, *4* — length of the ovary. Numbers on the radii correspond to the grades presented in Table 2

Rys. 6. Sposób wykreślania cyklogramu. Cyfry na obwodzie okręgu oznaczają cechy: *1* — długość całkowita, *2* — długość segmentu kaudalnego, *3* — odległość septum od ganglion ventralis, *4* — długość jajnika. Cyfry na promieniach odpowiadają ocenom zamieszczonym w tab. 2

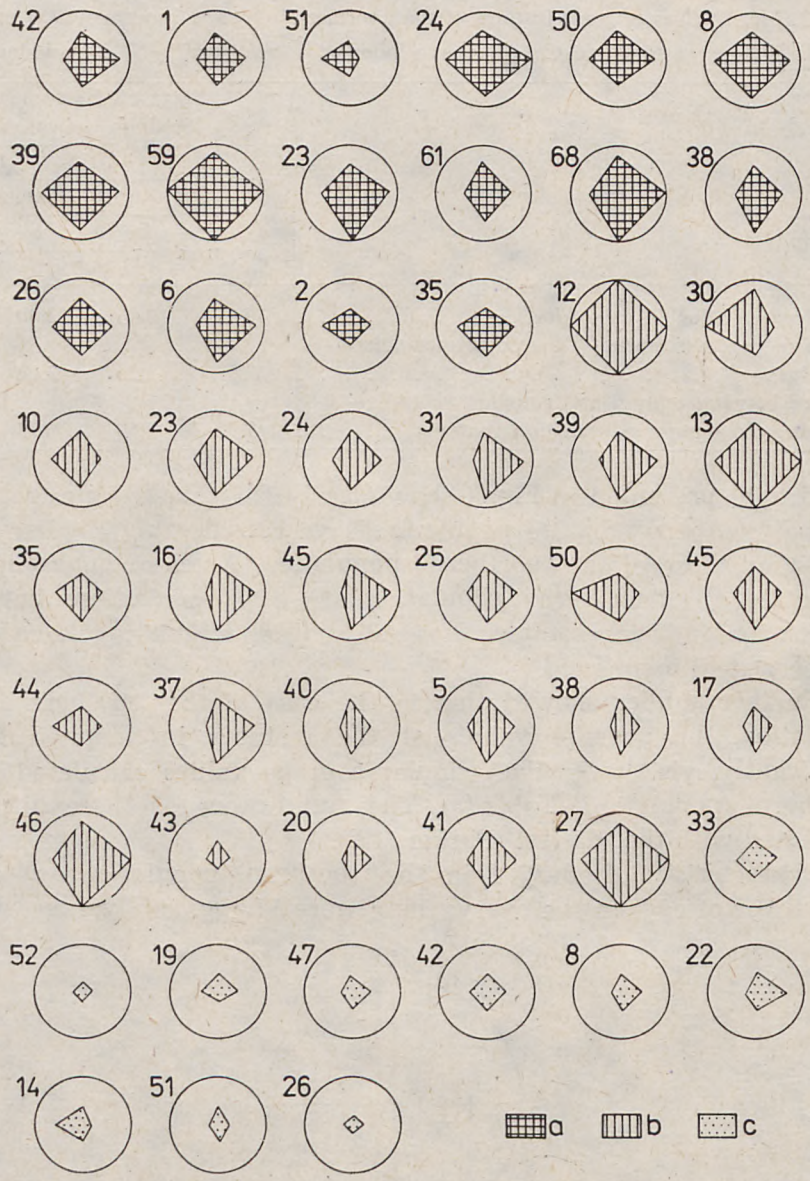


Fig. 7. Cyclograms of local samples; *a* — February, March 1970, *b* — June July, August 1967, waters north of Cap Vert, *c* — June, July, August 1967, waters south of Cap Vert

Rys. 7. Cyklogramy prób lokalnych; *a* — luty i marzec 1970, *b* — czerwiec, lipiec, sierpień 1967, wody na N od Przylądka Zielonego, *c* — czerwiec, lipiec, sierpień 1967, wody na S od Przylądka Zielonego

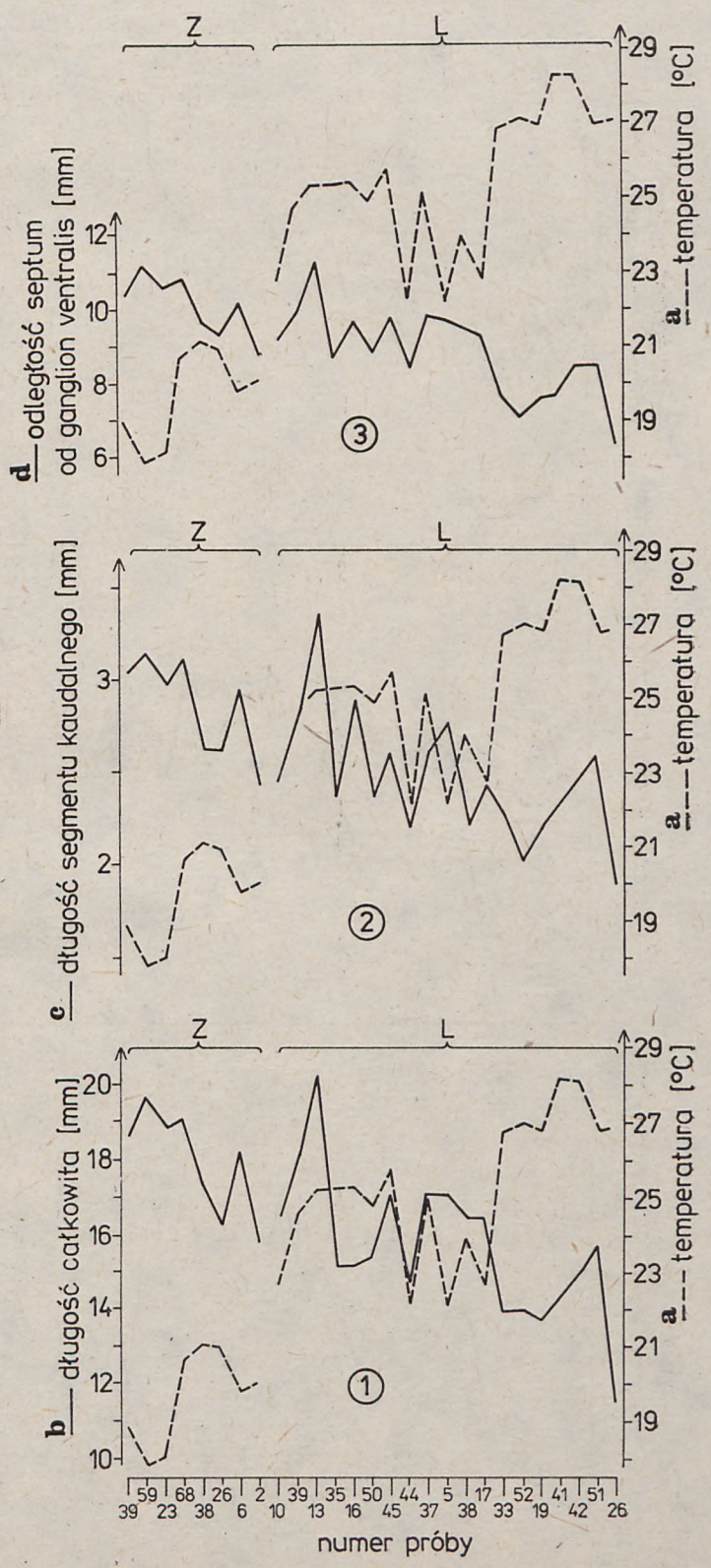
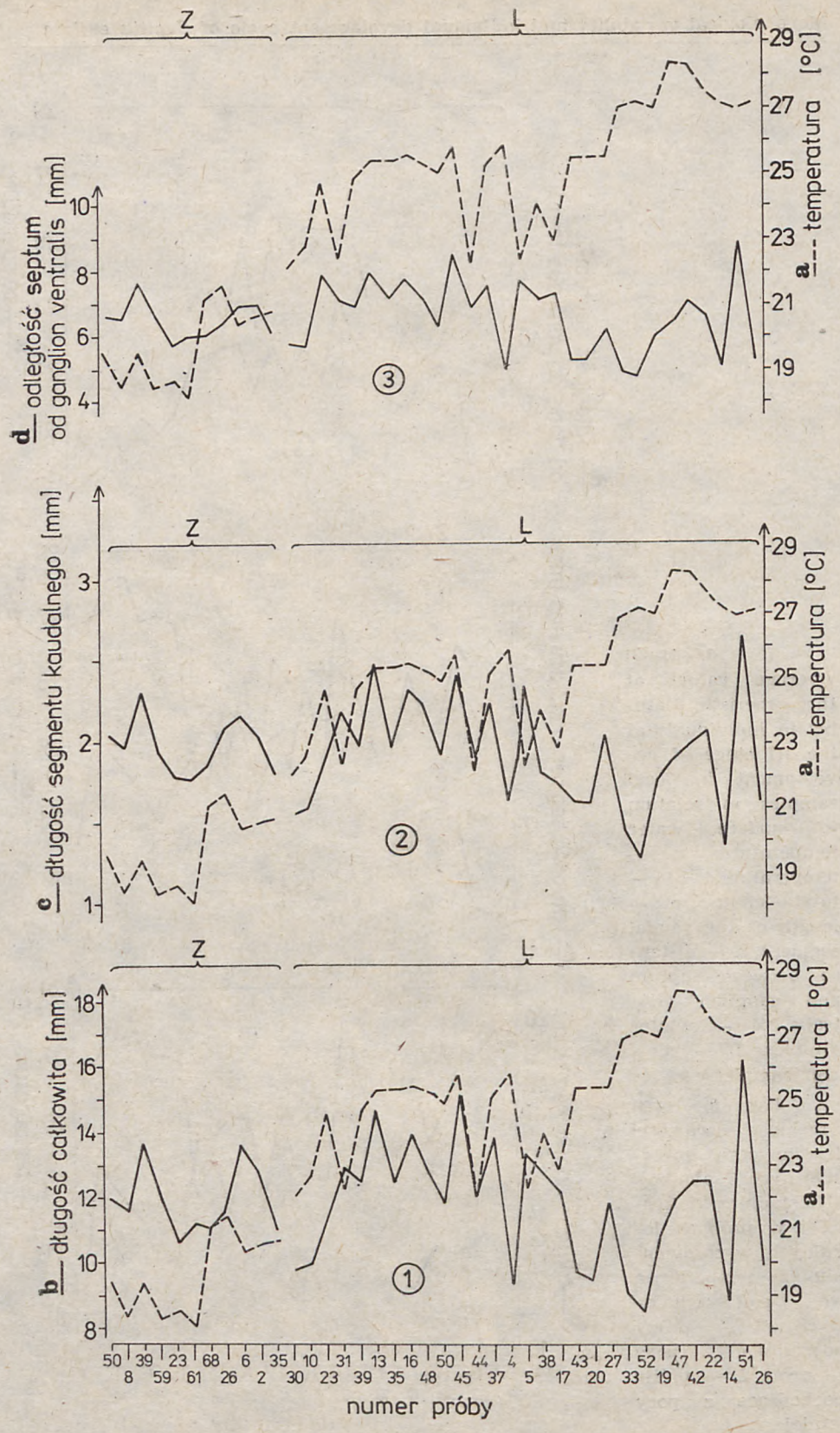


Fig. 8. 1)—3) Average values of three meristic features in individuals at the III stage of development in local samples in relation to surface water temperature; *a* — temperature, *b* — total length, *c* — length of the caudal segment, *d* — distance between septum and ganglion ventralis, *Z* — winter samples, *L* — summer samples

Rys. 8. 1)—3) Średnie wartości trzech cech merystycznych osobników III stadium dojrzałości w próbach lokalnych, w porównaniu z temperaturą wód powierzchniowych; *Z* — próby pochodzące z pory zimowej, *L* — próby pochodzące z pory letniej


Z
L
d odległość septum od ganglion ventralis [mm]
a — temperatura [°C]
③
c długość segmentu kaudalnego [mm]
②
b długość całkowita [mm]
①
50 39 23 68 6 35 10 31 13 16 50 44 4 38 43 27 52 47 22 51
8 59 61 26 2 30 23 39 35 48 45 37 5 17 20 33 19 42 14 26
numer próby

in the "northern" population, ovaries of adults contained an average of 22 eggs.

Both populations were also compared as regards qualitative features. The ratio between the total length and length of the ovary, calculated for mature individuals, showed that *S. enflata* from the "northern" population possessed relatively longer ovaries than *S. enflata* from the "southern" population.

On the other hand, the ratio between the average number of eggs in the ovary and length of the ovary (constituting an index of egg size) was similar in both populations, although the eggs of *S. enflata* were visibly larger in winter than in summer. This most probably resulted from a general regularity, viz. the fact that in lower temperatures organisms develop slower and attain larger sizes than in higher temperatures. The same regularity explains the phenomenon of decreasing body size of *S. enflata* to the south, i.e. with the rising temperature of the water (Figs. 8, 9).

In short, it can be stated that two populations of *S. enflata* were distinguished in the material studied — the "northern" population connected with colder waters, and the "southern" one, inhabiting warmer waters. At the same time: 1) individuals from the "northern" population, as compared with the "southern" one, had a longer body, greater distance between septum and ganglion ventralis, relatively longer ovaries, and greater number of eggs in the ovaries; 2) individuals in both populations had a constant ratio of total length to distance between septum and ganglion ventralis, irrespective of the stage of development (Koszteyn [12]); 3) the ratio between total length and length of the caudal segment showed that in both populations, juvenile individuals possessed a relatively longer caudal part than the adults; 4) the size of eggs did not differ in the two populations.

DEVELOPMENT CYCLE OF *SAGITTA ENFLATA* (GRASSI)

It can be assumed that temperature also affects the rate of development and maturation, and number of development cycles of *S. enflata*.

Although lack of seasonal continuity of the material did not permit

Fig. 9. 1)—3) Mean values of the three meristic features in individuals at the II stage of development in local samples in relation to surface water temperature; *a* — temperature, *b* — total length, *c* — length of the caudal segment, *d* — distance between septum and ganglion ventralis, *Z* — winter samples, *L* — summer samples

Rys. 9. 1)—3) Średnie wartości trzech cech merystycznych osobników II stadium dojrzałości w próbach lokalnych, w porównaniu z temperaturą wód powierzchniowych (objaśnienia, jak na rys. 8)

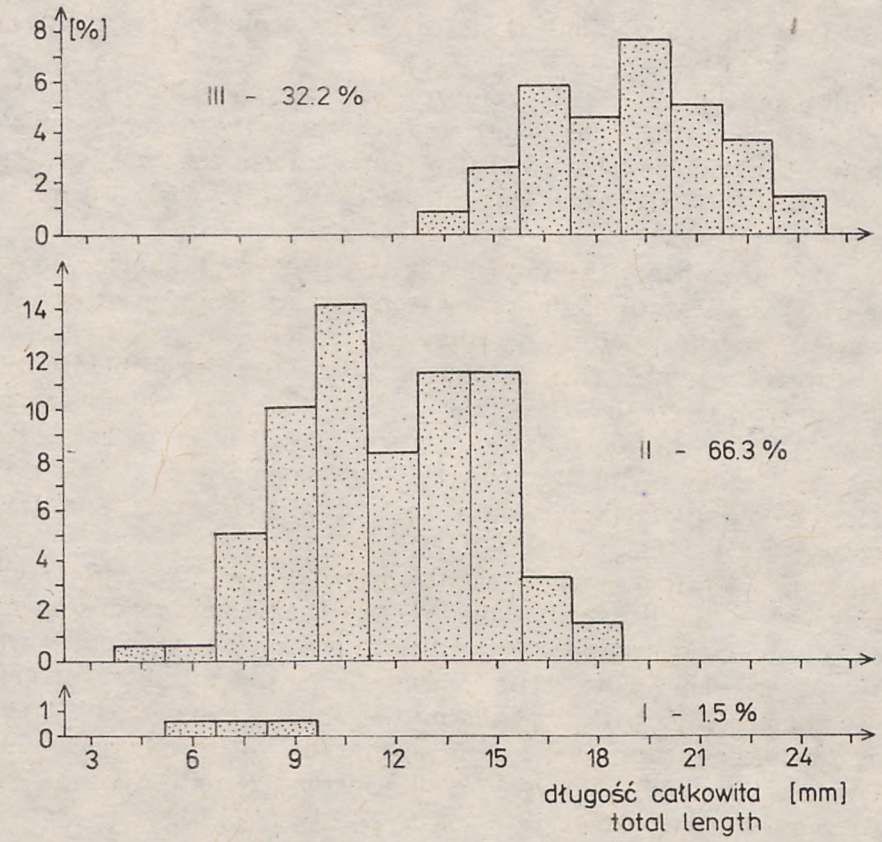


Fig. 10. Percentage of individuals in the I, II and III stages of development in particular total length classes. Waters between the mouth of the Senegal River and Cap Vert, winter 1970

Ryc. 10. Procentowy udział osobników I, II i III stadium dojrzałości w wyróżnionych klasach długości całkowitej. *S. enflata* pochodzi z prób zebranych z wód między ujściem Senegalu a Przylądkiem Zielonym, zimą 1970 r.

a detailed analysis of these problems to be carried out, some regularities can be noted. These were related to either the season or the latitude.

In both seasons more rapid individual development of *S. enflata* was noted in lower geographic latitudes. It was also found that the development of individuals belonging to the "northern" population were slower than that it the "southern" population. Consequently, in the "northern" population only one development cycle was observed within one generation. It was only during the summer that a second maturation of the individuals which had already reproduced (a phenomenon typical of the "southern" population) was noted in waters close to Cap Vert.

The graphs illustrate both these situations: Fig. 10 presents the per-

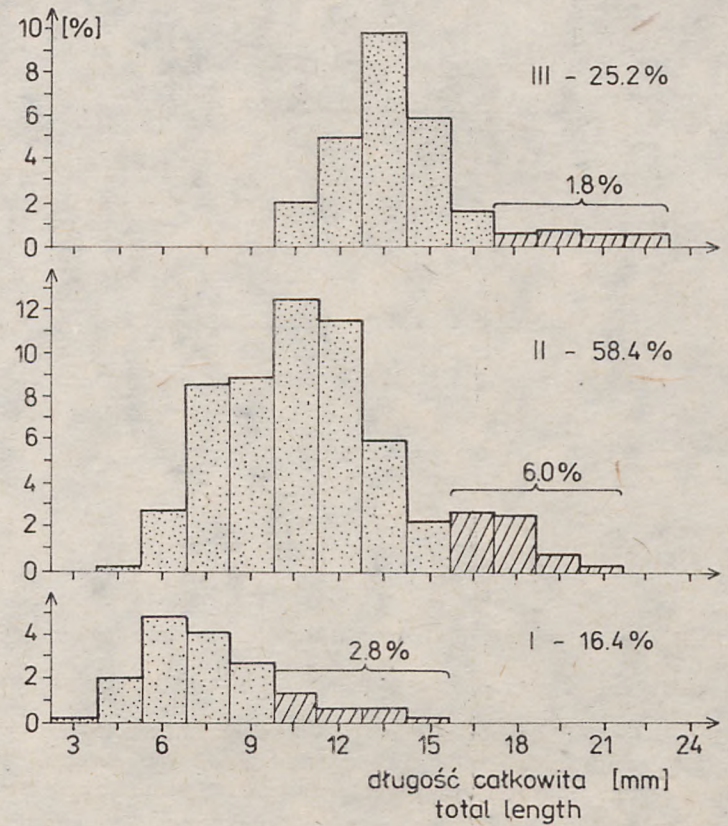


Fig. 11. Percentage of individuals in the I, II and III stages of development in particular total length classes. Waters south of Cap Vert down to Sierra Leone, Summer 1967. Brackets represent the percentage of individuals undergoing maturation for the second time

Rys. 11. Procentowy udział osobników I, II i III stadium dojrzałości w wyróżnionych klasach długości całkowitej. *S. enflata* pochodzi z prób zebranych z wód na południe od Przylądka Zielonego po wybrzeże Sierra Leone, latem 1967 r.

centage of *S. enflata* individuals in the I, II, and III stage of development in particular classes of total body length. This graph embraces winter samples collected from waters in the same latitude as Cape Timiris. The development cycle within one generation can be seen to be well advanced, as shown by the share of individuals in the II and III stages of development. Stage I is represented only by juveniles, among which no really small ones were found, whereas larger individuals were frequent.

Fig. 11 illustrates the situation existing in waters south of Cap Vert in summer. Looking at the unlined part of the figure relations similar to previous ones can be observed, viz. a considerable share of individuals in the II and III stages of development. Stage I is represent-

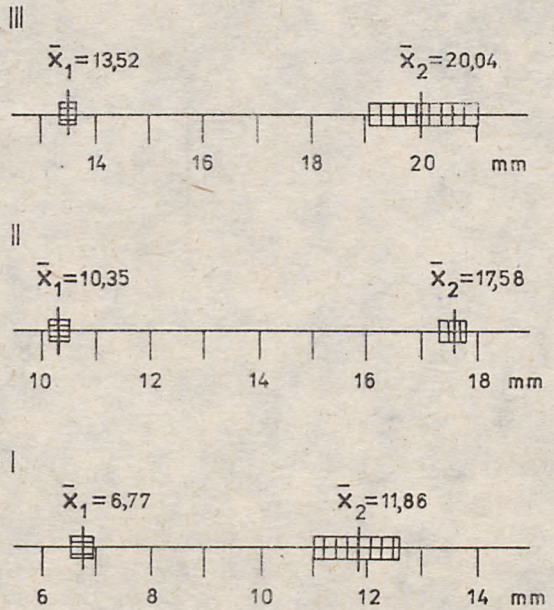


Fig. 12. Mean values of total length together with 95% confidence limits $\left(\bar{x}=\frac{\sigma}{\sqrt{N}}\right)$ in particular stages of development; $\bar{x}_1$ — arithmetic mean with 95% confidence limits for individuals of the first development cycle, $\bar{x}_2$ — arithmetic mean with 95% confidence limits for individuals of the second development. Samples from waters south of Cap Vert, down to Sierra Leone, Summer 1967

Rys. 12. Średnie wartości długości całkowitej wraz z 95% granicami ufności $\left(\bar{x}=\frac{\sigma}{\sqrt{N}}\right)$ w poszczególnych stadiach dojrzałości; $\bar{x}_1$, $\bar{x}_2$ — średnie arytmetyczne z 95% granicami ufności dla osobników pierwszego, drugiego cyklu dojrzewania. *S. enflata* pochodzi z prób z wód na południe od Przylądka Zielonego po wybrzeże Sierra Leone, latem 1967 r.

ed by juveniles with a total length of up to 10 mm, probably originating from eggs deposited by the preceding generation. At the same time, however, there is a substantial group of immature, but large individuals, up to 15 mm long, probably representatives of the currently reproducing generation, viz. representing that part of mature individuals which have already reproduced.

It can be assumed that these individuals undergo the maturation process for a second time since a group of distinctly larger organisms occurs among those in the II and III stage of development.

Differences in the individual size of *Sagitta* maturing for the first time and for the second time are additionally proved by the situation presented in Fig. 12.

The effect of temperature on the development cycle of *S. enflata* is also supported by the percentage of individuals in the I, II and III

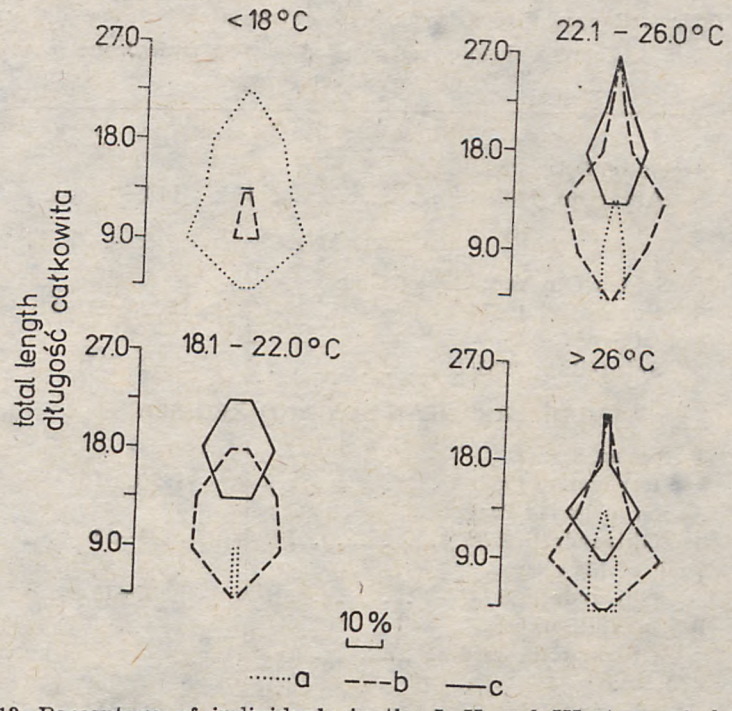


Fig. 13. Percentage of individuals in the I, II and III stage of development in particular total length classes and temperature ranges

Rys. 13. Procentowy udział osobników I, II i III stadium dojrzałości w poszczególnych klasach długości całkowitej, w wyróżnionych zakresach temperatur

stage of development in particular length classes in relation to the water temperature (Fig. 13). This is, in one sense, a theoretical illustration of the stage of development of the *S. enflata* population, which could have been found if water areas of different temperatures had been analysed at the same time. It can be seen quite clearly that the percentage of immature individuals decreases with the rising temperature, whereas the percentage of organisms in the II and III stage of development increases. Individuals undergoing maturation for the second time are found at temperatures above 22°C.

4. DISCUSSION OF THE MOST INPORTANT RESULTS

There are only a few studies on the morphological variability, egg size and number, rate of individual growth and development, or number of development cycles of *S. enflata*. Also, the existing papers are equivocal and usually not supported by adequate statistical analyses. This refers, for instance, to the differences of total individual length noted by many authors, which depend on geographic latitude, as illustrated by Table 4.

Table 4. Ranges of total length of *S. enflata* given by some authors
Tab. 4. Zakresy długości całkowitej *S. enflata* stwierdzone przez niektórych autorów

N-W AMERICA	
Region of Delaware:	
Alvarino, 1965	14.1–18.4
N-E ATLANTIC	
To S from Cap Vert, Bay of Guinea:	
Furnestin, 1957	13; 17; 20; 23–24
Ivory Coast:	
Saint-Bon, 1963	5–24 (37)
MEDITERRANEAN SEA AND RED SEA	
Tyrrhenian Sea:	
Furnestin, 1957	13; 15; 16
Region of Istrian Peninsula:	
Ghirardelli, 1947	3–13
Strait of Messina:	
Ghirardelli, 1947	8–18
Bay of Villefranche:	
Ghirardelli, 1950	9–17
Red Sea:	
Ghirardelli, 1947	7.3–22

It should be stressed that the absolute values presented in this table must be treated as indicatory only, as in most cases they represent only adult organisms. Neverthless, some of these values (the lower ones) suggest that they may refer to juvenile organisms, although the authors did not define the state of gonad development.

These facts resulted in my analysing the variability of body size within particular stages of development. At the same time, several statistical methods were used, these together seeming to confirm the conclusion as to the existance of two different populations of *S. enflata* in the shelf waters of N. W. Africa. These populations inhabit waters of different hydrological regimes, particularly as regards thermal conditions, hence it may be assumed that temperature is responsible for the differences observed in the morphological features and species development cycles of the two populations.

Relatively high temperatures prevailing in waters inhabited by the "southern" population result in the fact that these organisms have a more rapid rate of growth and development than the "northern" population. Individuals belonging to the "southern" population already attain sexual maturity at a body length of about 10 mm, whereas those belonging to the "northern" population — at a length of about 14 mm. The possibility of repeated maturation by individuals belonging to the

same generation explains the apparently contradictory fact of the larger body size of *Sagitta* individuals from the "southern" population. Thus, in the "northern" population there were individuals 22—24 mm long in the III stage of development, whereas in the "southern" population individuals 27 mm long were noted (maximum even 35.3 mm). Similar data for the tropical Atlantic (the Gulf of Guinea) are as follows (after Furnestin [4]): eggs appear in individuals 13 mm long, but there are also mature individuals 26 mm long. Saint-Bon [17] found 8 mm long mature individuals, attainig a maximum length of 37 mm (24 on average). In the Mediterranean, *S. enflata* attains maturity at a length of 15—16 mm (Furnestin [4]).

The significance of temperature as a factor differentiating populations of *S. enflata* with respect to some morphological featuers, development and maturation, is partly supported by the literature.

Many authors (e.g. MacArthur, Jacobs, Kinne) agree that temperature is the main factor affecting seasonal and habitat variability of zooplankton organisms, as also their rate of development (cited after Węglańska [22]). According to Pietiakov, Cremisov, and Burgis (loc. cit.) zooplankton fecundity also depends on temperature. The thermal factor also determines the length of the egg develompent period, viz. the rate of embryonal development (Węglańska [22]).

Numerous authors are of the opinion that physico-chemical parameters do not affect the life-processes of zooplankton so much as the concentration and kind of available food resources. This is supported by experimental work by Papanicolau, Anderson, Richman and others (cit. after Węglańska [22]) which showed that the abundance and availability of food accelerated the development and shortened the maturation process of zooplankton organisms.

So far there have been no papers which have dealt extensively with the food requirements of *S. enflata*. Basing on the papers by Rakusa-Suszczewski [14, 15] or Różańska [16] on *S. sestosa* and *S. elegans*, it can be expected that the food components vary depending on the season, geographic latitude, depth, distance from the shore etc. Considering studies on the distribution and biomass of zooplankton in African waters it semes justified to relate the accelerated development and higher number of development cycles of *S. enflata* in the tropical zone more to the effect of temperature than of food resources (Furnestin [4]; Saint-Bon [17]; Ducret [2]).

Jolanta KOSZTEYN

Morski Instytut Rybacki w Gdyni

ZMIENNOŚĆ MORFOLOGICZNA I CYKL ROZWOJOWY OSOBNIKÓW *SAGITTA ENFLATA* (GRASSI) 1881 W WODACH SZELFOWYCH AFRYKI PÓŁNOCNO-ZACHODNIEJ

Streszczenie

Sagitta enflata (Grassi) jest w wodach szelfowych Afryki północno-zachodniej najliczniejszym przedstawicielem *Chaetognatha*. Ujawnione w drodze analizy statystycznej różnice między wartościami niektórych cech u poszczególnych osobników wskazują na istnienie dwóch populacji: „północnej" i „południowej". Strzałki populacji „południowej", związane z ustabilizowanymi i ciepłymi wodami zalegającymi przede wszystkim na południe od Przylądka Zielonego, cechuje mniejsza długość całkowita, krótszy segment kaudalny, mniejsza odległość *septum* od *ganglion ventralis*, stosunkowo krótszy jajnik i niższa liczba jaj w jajniku osobnika dojrzałego, w porównaniu ze strzałkami populacji „północnej". Ta ostatnia bytuje w wodach chłodniejszych, na którym to obszarze występuje zjawisko upwellingu.

Jednocześnie można z dużym prawdopodobieństwem sądzić, że *Sagitta enflata* populacji „południowej" charakteryzuje się szybszym tempem rozwoju i dojrzewania niż osobniki populacji „północnej".

REFERENCES

1. Alvarino, A., *Chaetognaths*, Oceanogr. Mar. Biol. Ann. Rev. 1965, 3.
2. Ducret, F., *Chaetognathes des camagnes de l'Ombago dans les eaux equatoriales et tropicales Africanes*, Cah. ORSTOM, ser. Oceanogr. 1968, 6, 1.
3. Fedoseev, A., *Geostrofic circulation of surface waters on the shelf of North-West Africa*, Cons. Int. Explor. Mer. 1970, 159.
4. Furnestin, M. L., *Chaetognathes et zooplancton du sectour Atlantique Marocain*, Rev. Traw. Inst. Pêches Marit. 1957, 21.
5. Furnestin, M. L., *Chaetognathes de côtes Africaines. (Compagnes Belges du „Mercator" et du „Noordende III")*, Result. Sc. Exped. Belge, eaux côtieres Africaines de l'Atlantique Sud, 1948, 1949, 1962.
6. Furnestin, M. L., *Chaetographes des eaux Africaines*, Atlant. Rept., 1966, 9.
7. Ghirardelli, R., *Chetognati raccolti nel Mar Rosso e nel l'Oceano Indiano della nave „Cherso"*, Boll. Pesca, Piscic. Idrobiol, 1947, 2.
8. Ghirardelli, R., *Osservationi biologische e sistematische sui Chetognati della Baia di Villefranche sur Mer*, Boll. Pesc. Piscic. Idrobiol. 1950, 5.
9. Jentys-Szaferowa, J., *Graficzna metoda porównywania kształtów roślinnych*, Kosmos A 1948—1951.
10. Köller, S., *Systematik und Ökologie der Chaetognathen im Epipelagial der nordwestafricanischen Auftriebsregion*, [Ph. D. thesis. Wilhelm-Pieck-Universität, Rostock 1977].

11. Koszteyn, J., *The effects of temperature on the occurrence of Sagitta enflata (Grassi) in the waters of the North-West African shelf*, ICES, C. M. 1976/L:12.
12. Koszteyn, J., *Badania nad możliwością stosowania pewnej dodatkowej cechy w identyfikacji Sagitta enflata (Grassi)* [in press].
13. Parker, R. E., *Wprowadzenie do statystyki dla biologów*, Warszawa 1978.
14. Rakusa-Suszczewski, S., *The use of Chaetognath and Copepod population age-structures as an indication of similarity between water masses*, J. Cons. Prm. Int. Explor. Mer., 1967, 31.
15. Rakusa-Suszczewski, S., *The food and feeding habits of Chaetognatha in the seas around the British Isles*, Pol. Arch. Hydrobiol. 1969, 2.
16. Różańska, Z., *Studia nad biologią i ekologią Chaetognatha w Bałtyku*, Olsztyn 1971.
17. Saint-Bon, M. C., *Les Chaetognathes de la Côte l'Ivoire (especes de surface)*, Rev. Trav. Inst. Peches Marit. 1970, 27.
18. Sedych, K. A., W. N. Sidorova, *Gorizontalnaya cirkulacya vod v severovostochnej chasti tropicheskoi Atlantyki v sentabre 1971 — maie 1972 g.*, Trudy AN 68, 1976.
19. *Sprawozdanie z rejsu m.t. „Wieczno" na łowiska północno-zachodniej Afryki (20 V — 20 VIII 1967 r.)*, Gdynia 1967.
20. *Sprawozdanie z rejsu m.t. „Wieczno" na łowiska północno-zachodniej Afryki (24 I — 19 III 1970 r.)*, Gdynia 1970.
21. Staszkiewicz, J., *Badania nad sosną zwyczajną z Europy południowo-wschodniej i Kaukazu oraz jej stosunkiem do sosny z innych obszarów Europy oparte na zmienności morfologicznej szyszek*, Fragm. Flor. et Geobot. 1968, 14.
22. Węglańska, T., *Zagadnienie wpływu temperatury i pokarmu na rozwój, wzrost osobniczy i płodność zooplanktonu*, Wiad. Ekolog. 1970, 1.