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SOME ASPECTS OF THE BIOLOGY OF SQUID *MOROTEUTHIS INGENS* (ONYCHOTEUTHIDAE) FROM NEW ZEALAND WATERS

NIEKTÓRE CECHY BIOLOGICZNE KALMARA *MOROTEUTHIS INGENS* (ONYCHOTEUTHIDAE) Z WÓD NOWEJ ZELANDII

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Abstract. The paper presents length analysis, sexual maturity, and degree of stomach fullness in 201 squid *Moroteuthis ingens* caught in New Zeland waters between May and August, 1981. The length–weight relationship was calculated; it equalled $W = 0.41\ DML^{2.23}$ for males and $W = 0.1\ DML^{2.7}$ for females. Relationship between total length and length of statolith core and DML was also calculated, but the correlation values obtained were low (below 0.75). This may indicate that the age of squid *Moroteuthis ingens* cannot be determined on the basis of growth rings on statoliths, contrary to a conclusion arrived at in earlier papers.

INTRODUCTION

The squid *Moroteuthis ingens* (Smith, 1881) has not been so far a subject of a separate biological study (besides a very specific paper by Clarke, 1975). The biology of this species was usually discussed in studies dealing with zoogeographical and systematic analyses (review: Clarke, 1966). The scarce knowledge of the whole genus *Moroteuthis* is revealed by Clarke's (1980) speculations; he suspects that squid of this genus, caught on New Zealand fishing grounds and found in the stomachs of sperm whales there, may belong to a separate, hitherto undescribed genus. Clarke (1980) believes that *M. ingens (s. str.)* occurs in a very limited area (in the notal part of the Patagonian province).

The goal of this paper is to describe selected biological parameters of squid provisionally determined as *Moroteuthis ingens*. These parameters include length

composition, sexual maturity, degree of stomach fullness, length–weight relationship, and relationship between total statolith length and statolith core length DML. However, the material collected is not sufficient to arrive at taxonomic conclusions.

MATERIAL AND METHOD

The material consisted of 201 squid *Moroteuthis ingens* of both sexes. They were taken from the *Profesor Bogucki* catches made with a commercial bottom trawl with a mesh size in the codend of 110 mm. Samples from 15 tows were taken for analyses. Location of sampling sites is presented in Figure 1.

Most of the materials collected came from the northern slopes of the Chatham Rise, where squid are caught incidentally during fishing operations for *Hoplostethus atlanticus*, carried out from May to July, 1981, at depths of 850–1100 m. The remaining squid were caught in single tows in August on the Campbell Plateau, Pukaki Rise and the southern slope of the Chatham Rise, at depths of 450–500 m.

Biological analyses included length and weight measurements, determination of sexual maturity and degree of stomach fullness, and statolith preparation and measurements.

Squid mantle length (DML) was measured to 1 cm below. The accuracy of weight measurements was 10 g. Sexual maturity was determined on the basis of Lipiński's (1979) scale, and stomach fullness – with the help of a 5–grade scale used in ichythyological investigations.

Statoliths (total length and length of their core) were measured with a measuring microscope with an accuracy of 0.01 mm. The terminology and definitions of Clarke (1978) were used.

RESULTS

LENGTH COMPOSITION AND SEXUAL MATURITY

The length composition of squid *Moroteuthis ingens* from the Chatham Rise area is presented in Figure 2. Throughout the whole study period, sexually mature specimens predominated, with sexual dimorphism well pronounced. Minimum DML for mature males was 26 cm (a maximum of 39 cm), for females – 46 cm (a maximum of 56 cm). In July, one juvenile male was caught on the Chatham Rise with the DML equalling 15 cm; in August, scarce immature males and maturing females (stage IV) were also caught.

On the Campbell Plateau and Pukaki Rise 12 specimens of squid were caught; no sexually mature squid were observed.

Table 1 presents the maturity stage of squid gonads in all study areas together.

It was observed that, when cutting the female's mantle, the pigmentation of the mantle changed in the following way, depending on the gonads' maturity:

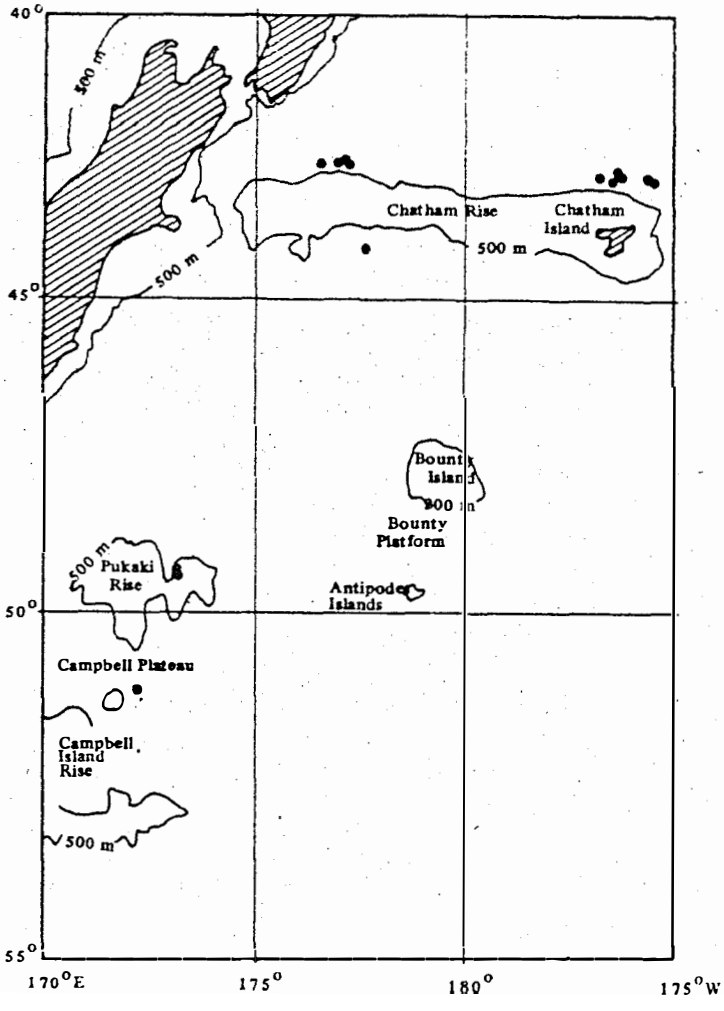

Fig. 1. Sites of squid *Moroteuthis ingens* biological samplings in the New Zealand waters between May and July 1981.

Rys. 1. Miejsce poboru prób biologicznych kalmarów *Moroteuthis ingens* z wód Nowej Zelandii w okresie od maja do lipca 1981 r.

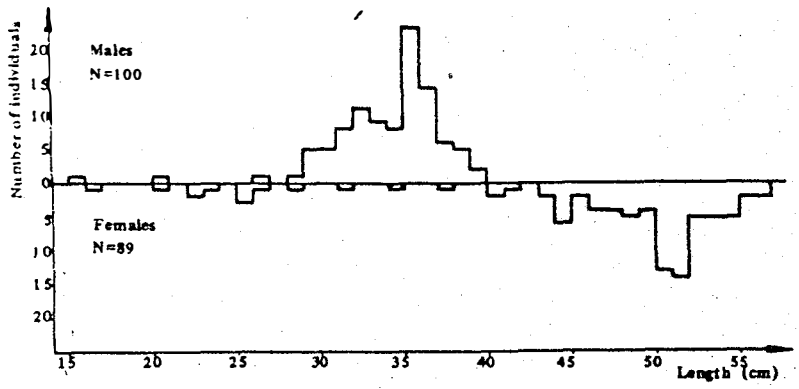

Fig. 2. Length composition of squid *Moroteuthis ingens* on the Chatham Rise.
Rys. 2. Skład długościowy kalmarów *Moroteuthis ingens* w rejonie Chatham Rise.

Table 1. Stage of gonads' maturity in squid *Moroteuthis ingens*.
Tabela 1. Stan dojrzałości gonad *Moroteuthis ingens*

Stage / Month	Males						Females					
	I	II	III	IV	V	VI	I	II	III	IV	V	VI
May	–	1	1	2	56	2	–	1	1	14	35	1
June	–	–	–	–	8	1	–	–	–	3	8	3
July	1	–	–	–	10	1	–	–	–	1	8	1
August	–	1	–	7	13	–	4	10	3	4	–	–
Total	1	2	1	9	87	4	4	11	4	22	51	5
Grand total				104						97		

– stages I–II – white
– stage III – light–pink
– stage IV – pink–violet
– stage V – dark–brown with a violet tint
– stage VI – dark–violet, almost black.

In the literature on the subject written so far, no oceanic squid females at stage VI were observed; it was a hypothetical stage (Lipinski, 1979). That is why we include below the description of stage VI females of *Moroteuthis ingens*:

flaccid and thin mantle with very dark pigmentation, ovary degenerated (its boundaries blurred), single, transparent eggs seen in the formless yellow mass, nidamental glands shrinked.

DEGREE OF STOMACH FULLNESS AND FOOD OF SQUID

It was found that all mature males had empty stomachs while only a few females were feeding; the degree of stomachs fullness may be seen below:

Degree of stomach fullness	0	1	2	3	4
Number of specimens	44	1	6	4	3

The above list covers only mature females (stage V) caught between May and July on the Chatham Rise. Their food consisted of squid, an example of the cannibalism common among *Teuthoidae*.

LENGTH–WEIGHT RELATIONSHIP

Length–weight relationship for squid is presented in Figure 3. It is expressed by the equation $W = a\,DML^b$ and defined by the following parameters:

males:	n = 96;	$R^2 = 0.9800$
	a = 0.4107;	b = 2.2307
females:	n = 85;	$R^2 = 0.9644$
	a = 0.1006;	b = 2.6978

where: W = weight (in g), DML – mantle length (in cm), R – correlation coefficient, a, b = equation coefficients, n = number of specimens weighed.

The length–weight relationship is an excellent illustration of the sexual dimorphism of the species visible in the differences in the weight of males and females in the same length classes. These differences may be observed in a small length interval between 22 and 39 cm DML. Males with these lengths begin development and reach full sexual maturity. Females with the same lengths are immature sexually and begin to develop only to a slight degree. They reach sexual maturity at lengths substantially exceeding the maximum observed length of males, i.e., over 40 cm DML. It may be seen from Figure 3 that the quick increase in the weight of females over 40 cm DML is related to the development of ovaries and eggs; for example, the weight of eggs alone in a mature female (stage V) with a length of 55 cm was 1450 g, approximately the same as the maximum observed weight of males.

STATOLITH LENGTH–MANTLE LENGTH RELATIONSHIP

A diagram of the statolith of squid *Moroteuthis ingens* and the method of its measurement are presented in Figure 4.

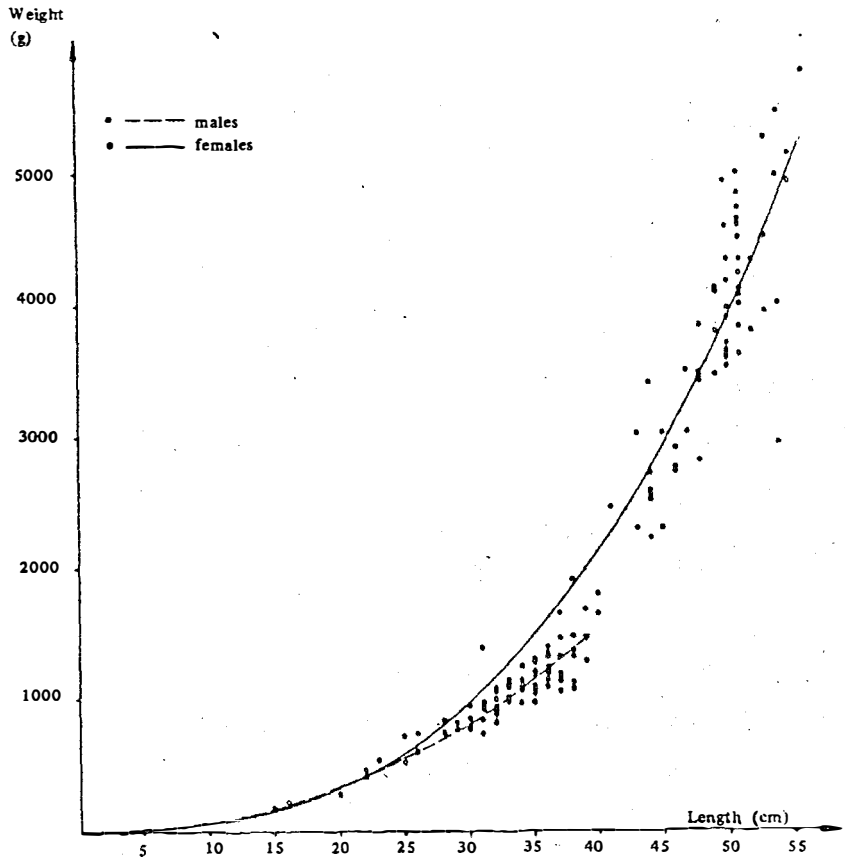

Fig. 3. Weight–length relationship in squid *Moroteuthis ingens*.

Rys. 3. Wykres zależności ciężaru od długości kalmarów *Moroteuthis ingens*

The calculated relationships between total length or statolith core length and total length of squid have the form $y = ax^b$ with the following parameters:

– for the statolith length–DML relationship
  N = 86 $R^2 = 0.2836$ (R = 0.5325)
  a = 0.6195; b = 0.1063
– for the statolith core length–DML relationship
  N = 86; $R^2 = 0.5601$ (R = 0.7484)
  a = 0.2573; b = 0.1984.

These relationships are presented in Figure 5.

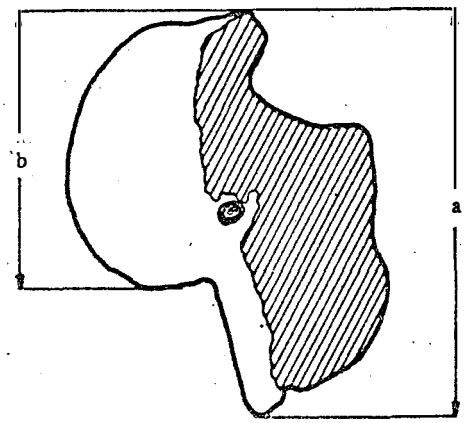

Fig. 4. Drawing of squid *Moroteuthis ingens* statolith and method of measurements: a – length of statotlith, b – length of statolith core.

Rys. 4. Schemat budowy statolitów *Moroteuthis ingens* z zaznaczeniem sposobu pomiarów: a – długość statolitu, b – długość trzonu statolitu.

The analysis of the relationship between statolith lengths and DML showed that the statolith increase only slightly with an increase in the length of the mantle.

DISCUSSION

The results presented here indicate that squid *Moroteuthis ingens* caught on the Chatham Rise and Campbell Plateau, and the Pukaki Rise may belong to two separate stocks, which spawn at different times. The sexual maturity of squid is, according to Kawakami (1976), the commonly accepted criterion of stock separation.

The relationship between statolith length (or statolith core length) and DML, and the low values of the coefficient R point to the allometric increase of the investigated values. It is a different type of growth to the one observed in squid *Illex illecebrosus* (Lipinski, 1981), where the correlation between TLS and DML was R = 0.95. Our results contradict the hypothesis according to which growth rings which might be observed inside statoliths are formed in the equivalent units of time (Lipinski, 1978). The hypothesis may be true with respect to other species of squid but it seems inapplicable to *Moroteuthis ingens*.

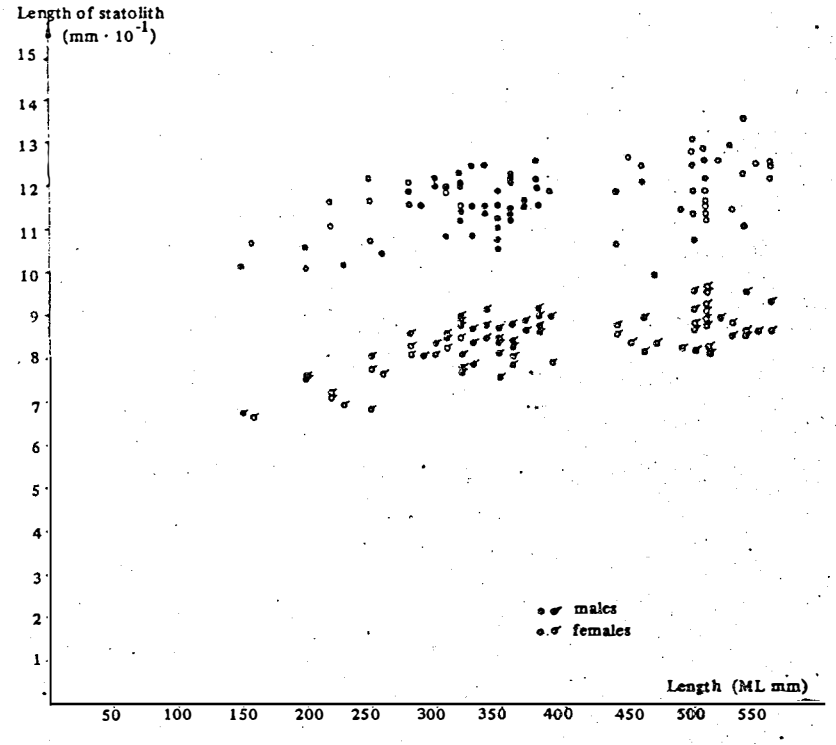

Fig. 5. Relationship between the length of statolith and its core and the length of the squid *Moroteuthis ingens* mantle.

Rys. 5. Zależność długości statolitu i jego trzonu od długości płaszcza kalmarów *Moroteuthis ingens*.

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STRESZCZENIE

Praca obejmuje dane dotyczące wielkości, dojrzałości płciowej, stopnia wypełnienia żołądków i pokarmu kalmarów z gatunku Moroteuthis ingens. *Ponadto przedstawiono zależność długość–ciężar oraz próbowano znaleźć powiązanie dwóch długości statolitów z grzbietową długością płaszcza. Zakres DML badanych samic wynosił 16–56 cm, a samców 15–39 cm. W rejonie Chatham Rise kalmary wykazywały wysoki stopień dojrzałości płciowej (zazwyczaj stadium V), natomiast kalmary z rejonów Campbell Plateau i Pukaki Rise były niedojrzałe płciowo. Wskazuje to na istnienie co najmniej dwóch różnych stad kalmarów* Moroteuthis ingens *w wodach nowozelandzkich.*

Stwierdzono, że w okresie badań samce nie żerowały, natomiast samice żerowały tylko w nieznacznym stopniu. Obliczono zależność pomiędzy długością (DML) i ciężarem ciała samców ($W = 0{,}41\ DML^{2{,}23}$) *oraz samic* ($W = 0{,}1\ DML^{2{,}7}$). *Uzyskane niskie (poniżej 0,75) wartości korelacji między długością całkowitą i długością trzonu statolitu a DML wskazują, że u kalmarów* Moroteuhis ingens *nie można określać wieku na podstawie pierścieni przyrostów widocznych wewnątrz statolitów.*