

Further considerations on growth of Cephalopods

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In the recent volumes "Cephalopod life cycles" (part I and II) edited by BOYLE, contributors reviewed what is known about cephalopod growth from both laboratory and field studies. The authors again stressed that cephalopods are short-lived and fast-growing animals. As in the previous work by MANGOLD (1983) they reported a number of quite different growth curves for various species. Most of the reviewed articles are based on laboratory research: the authors in fact agreed on the unreliability of the field studies because of the bias in the samples and the lack of population structure analysis techniques (BOYLE, 1983; WORMS, 1983; FORSYTHE and VAN HEUKELEM, 1987; see also BOYLE and KNOBLOCH, 1982). These reviews incite to a critical discussion on this aspect of the cephalopod biology not yet completely defined and described. Problems arise from the proposed life spans. In some cases ideal curves and observations based on a poor sample or on a single specimen reared under aquarium conditions have been used to support that the life of the considered species spans one year or less. For instance, the observed laboratory growth of *Eledone cirrhosa* (FORSYTHE and VAN HEUKELEM, 1987) is considered only on the basis of the exponential "ideal curve of maximum growth" computed by BOYLE and KNOBLOCH (1982) on the basis of a 315 days life, ignoring the typical sigmoid shape of the growth observed by the same authors on individual animals under artificial conditions. On the other hand, BOYLE himself (1983) proposed a composite model of the life cycle of *E. cirrhosa* based on a life span of two years. The general opinion that the field data are not sufficient to investigate growth in cephalopods is supported by the subjective weight given by the authors to some negative factors. Besides an equal number of negative factors affects the laboratory results, mainly the reduced number of specimens involved in the experiment and the general aquarium conditions (shape, colour, size, chemistry of the tanks; feeding, activity etc.). Nevertheless these factors seem to be accepted, while the statistical and mathematical techniques which can improve the field results seem to be neglected. Sampling optimization and frequency distribution decomposition methods have been described and successfully used (SCHWEIGERT and SIBERT, 1983; AKAMINE, 1985; MATRICARDI et al., 1987) also for species with a long recruitment and with a consequent overlap of age classes. Although many authors in Boyle's reviews devote a large part of their work to discuss quite different mathematical models in the cephalopod growth, the problem is not yet defined. Asymptotic equation is recognized to be inadequate (SAVILLE, 1987), but the significance of the parameters of this model is often misunderstood (PRUITT et al., 1979) and the equation sometimes is inappropriately forced on an incomplete data set (WORMS, 1983). This model was found inadequate to describe the growth during early stages and the cyclic trends in the cephalopod life. About this latter aspect PAULY (1985) introduced a modification in the model to improve its fitting which must yet be applied and thus confirmed or rejected. Some aspects of the other mathematical models proposed for various cephalopod species need further discussion: i.e. the confidence limits of the linear and exponential growth obtained by a regression on few data (TURK et al., 1986) or the attempt to employ two equations (exponential and logarithmic) to describe a growth curve which is clearly sigmoid. The arguments are inciting enough to continue along this line.

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Feeding of *Sepietta oweniana* (d'Orbigny 1839) along the slope of the Ligurian Sea : a preliminary note

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In a random stratified sampling effected in spring and summer in the range 0-700 m (Research programme on trawl fisheries "Evaluation of demersal resources", Ministero della Marina Mercantile, Italy, 1985-87) *S. oweniana* was sporadically captured on the shelf, while the most important concentrations were observed in summer between 400 and 500 m depth. This Sepiolid apparently alternates reproductive migrations in circalittoral waters where the eggs are laid (Mangold Wirz 1963) with trophic migrations along the slope. These brief notes describe the diet in this latter environment.

As the sampling design was based on day-time hauls, each lasting one hour, it was possible to analyse the stomach content of specimens caught at different times. Additional sampling was carried out in autumn and winter, so that all seasons would be represented. A very large number of animals had to be examined before a total of one hundred stomachs with food remains (table 1) could be assembled; similar ratios probably due to quick digestion were observed in many species of Cephalopods (Nixon 1987). Feeding however did occur at different times (tab. 1). An average of about 1.5 food items per animal was obtained, which shows a definite preference for a few specific prey types (Mangold 1983). As the categories "vegetable remains" and "Cephalopods" - as explained later - seem to be "false" food, the percentage composition of total stomach content was: Crustacea 65.4%, Osteichthyes 28.3%, other organisms 6.3%.

Crustacea Decapoda and mainly the pelagic eurybathic *Pasiphaea sivado* are the most important prey, both in terms of size and energy value. The importance of *P. sivado* may be even greater considering that a fraction of unidentified Decapods probably belongs to it. Crustacea Peracarida were also frequently recorded, with a marked preference for the benthic isopod *Cyrolana borealis*; however, in terms of size, they have a lesser role. Osteichthyes formed the most frequent food item, but their occurrence was in most cases limited to skin and scales or fragments of fins. Lenses, vertebrae or other very small bones were found only in a few cases. Are these simply discarded after the soft tissue has been eaten, as has been seen in squids (Nixon 1987)? In view of the feeding habits observed in captivity (Bergström 1983a, b) this seems not to be the case. Remains of Cephalopods belong invariably to Sepiidae. There have been cases of an entire club and an arm tip of *S. oweniana*, freshly ingested (in the net or perhaps on the deck when the animal was dying), a fragmented, partially digested segment of an arm and isolated suckers (6 records of 1 or 2). Probably *S. oweniana* fights for food or is somewhat clumsy in pulling the prey to its mouth. Vegetables are mainly fragments of wood or leaves of terrestrial plants (only one instance of weed).

Considering table 1 in more detail, blocks A and B compare morning and afternoon records in a deep environment: among similar numbers of prey, a tendency to rest on the bottom in the afternoon (cf. Boletzky et al. 1971) is indicated by the reduction of the ratio pelagic to benthic crustaceans. Blocks C,D,E,F compare different seasons: the scarcity of Decapods in winter and spring, only in small part balanced by

Table 1. Feeding of *S. oweniana* on bathyal bottoms.

	Predators examined	<i>Pasiphaea sivado</i>	other Decapods	<i>Meganyctiphanes norvegica</i>	Crustacea Peracarida	unidentified Crustacea	Osteichthyes	<i>Leptometra</i> sp.	unidentified organisms	vegetable remains	Cephalopoda	Total food items
A -450 m summer 7-8.30	30	13	7	1	5	2	9		1	2	3	43
B -450 m summer 15.30-17	30	9	2		10	6	10		1		3	41
C -250 m summer 11.30-13	10	2	3		1		6		1		1	14
D -250 m autumn 11.30-13	10	5	1		2	1	6		2	1	1	19
E -250 m winter 11.30-13	10	1	1	1	1	4	1	2	1	6	1	19
F -250 m spring 11.30-13	10	1		1	2	1	4			1		10
Numbers of <i>S. oweniana</i>	100	31	14	3	21	14	36	2	6	10	9	146

Meganyctiphanes norvegica, seems to force *S. oweniana* to eat benthic prey such as *Leptometra* sp. or directly vegetable remains settled on the bottom; the latter however appear undigested.

An important feature of this preliminary diet analysis is, in our opinion, the central role of *Pasiphaea sivado* in the feeding of bathyal benthic organisms. Analogous records were obtained in the analysis of stomach contents of Selachians, Anacanthini, red shrimps and in *Geryon longipes* of the Ligurian Sea. On the other hand, the natural foraging of *S. oweniana* was studied in animals trawled in Gullmar Fjord, mostly at 90-100 m (Bergström 1983). In this case Euphasiids were 56.7% of the prey. Mediterranean *S. oweniana*, although it utilizes to some extent *M. norvegica*, seems to be a specialized hunter of *Pasiphaea sivado*; also the summer concentrations of *S. oweniana* on the edge of mesobathyal levels could be explained in relation to the vertical movements of this prey (Franqueville 1971).

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