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Cagnetta P., Sublimi A.

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Productive performance of the common octopus (*Octopus vulgaris* C.) when fed on a monodiet

P. Cagnetta and A. Sublimi
Dipartimento di Produzione Animale, Università di Bari, Via G. Amendola 165/A, 70126 Bari, Italy

SUMMARY – As things are at the moment, the feeding regime of the *Octopus vulgaris* in rearing conditions is based on a varied diet while the use of dehydrated foods still appears unfeasible. Consequently, the study was carried out in a controlled environment with the aim of providing preliminary information about the production responses of the octopus when fed exclusively and alternatively with the prey species which make up the basis of its natural diet: crustaceans, molluscs and fish. The trial lasted 35 days. Three experimental groups were established, and given a monodiet respectively of crab (*Carcinus mediterraneus*: Group C), tattler (*Illex coindetii*: Group T) and fish (*Mugil cephalus* and *Sardine pilchardus*: Group F) "*ad libitum*", 3 times a week. The data sets regarded 3 pairs of octopuses for each experimental group. Crab was captured in markedly greater quantities than fish and tattler and the subjects fed on this food displayed the best pattern, reaching a higher final weight, corresponding to a significantly greater increase than that found in Group F (126.1 ± 11.5 g vs 71.4 ± 11.5 g; $P < 0.01$). The superiority of crab mainly seems to depend on the fact that food intake is higher than for tattler and fish ($P < 0.01$). However, all the foods used during the trial were well accepted by the octopuses.

Key words: New species, *Octopus vulgaris*, monodiet, productive responses, feeding behaviour.

RESUME – *"Résultats productifs du poulpe commun (*Octopus vulgaris *C.) en régime monoalimentaire". Actuellement le régime alimentaire de* Octopus vulgaris *en élevage se base sur l'utilisation d'une diète variée tandis que la possibilité d'employer des aliments commerciaux déshydratés reste encore impraticable. L'étude a été conduite en milieu contrôlé dans le but de fournir des indications préliminaires sur les résultats productifs du poulpe alimenté exclusivement et alternativement avec des espèces qui constituent le fondement de son régime naturel : crustacés, mollusques et poissons. L'essai expérimental a eu une durée de 35 jours. Dans ce but ont été constitués 3 groupes expérimentaux alimentés respectivement avec écrevisse (*Carcinus mediterraneus *: Groupe C), calmar (*Illex coindetii *: Groupe T) et poisson (*Mugil cephalus *and* Sardine pilchardus *: Groupe F) fournis "*ad libitum*" 3 fois par semaine. Les relevés expérimentaux ont concerné 3 couples de poulpes pour chaque groupe. L'écrevisse a été capturée en quantités sensiblement supérieures en comparaison avec le poisson et le calmar. Les sujets du Groupe C ont présenté les meilleurs résultats productifs en rejoignant un poids final plus élevé correspondant à un accroissement significativement supérieur en comparaison au Groupe F (126,1 ± 11,5 g vs 71,4 ± 11,5 g ; $P < 0,01$). La supériorité de l'écrevisse semble due principalement à la plus grande consommation alimentaire, notablement élevée en comparaison avec les autres deux aliments ($P < 0,01$). Toutefois on doit préciser que tous les régimes utilisés pendant l'expérimentation ont été bien acceptés par le poulpe.*

Mots-clés : *Nouvelles espèces,* Octopus vulgaris*, régime monoalimentaire, résultats productifs, conduite alimentaire.*

Introduction

Numerous studies have been carried out on the common octopus in its natural state, and these have greatly furthered our knowledge of its life cycle and biology even if several important problem areas remain not fully understood or even unresolved. Among these we must certainly include its diet at the various stages of ontogenetic development; the reason for this is the difficulty of reconciling the information collected in the natural state with the studies conducted in a controlled environment (Mangold and Boletzky, 1973; Mangold, 1983).

The common octopus usually spends its first 5-12 weeks of life actively preying on plankton. The passage to the next benthic phase is a gradual process (Boletzky, 1974, 1977), and even when its descents to the sea bottom become longer and more frequent, the common octopus continues to feed mainly halfway down without exhibiting a radical change in its feeding habits; in an aquarium it seems that Palaemon larvae represent a necessary completion of the crab-based diet at this stage, for

several days after the beginning of the benthic stage. When its descent becomes final, however, the octopus exhibits behaviour perfectly comparable to that of the adult stage: "it lies on the bottom of the sea and extends a tentacle to catch its prey, feeding mostly at night" (Itamy *et al.*, 1963).

In the sea it consumes mostly crustaceans, molluscs and fish; in Catalonia the stomach contents of this species were found to consist of 80% crustaceans, 12% fish and 8% other cephalopod species (Guerra, 1978); in north-western Africa the proportions were 61.5% crustaceans, 29.5% fish, and the rest of molluscs (Nigmatullin and Ostapenko, 1976). According to Hatanaka (1979), on the other hand, the most important preys are gastropods and bivalves (45-60%), while fish, crustaceans and cephalopods constitute respectively 19-34%, 7-16%, and 4-13%.

The evidence of cannibalism in the common octopus, shown by analysis of the stomach contents, has also been observed in the laboratory; in nature, however, such a food supply seems only a relative contribution to its diet. However, when a choice is offered in the laboratory between live crustaceans (mostly crabs), bivalves, gastropods and fish, the common octopus in Catalonia always prefers crabs, and ignores the other species. If crabs are not offered, the octopus also accepts fish and molluscs, but only after days or weeks without eating (Mangold, 1983). The diet of the octopus, moreover, varies perceptibly due to the geographical area considered, the season and the availability of prey, and also according to the time of day or the depth at which the subjects examined were captured.

Temperature has a great influence on feeding; a high temperature increases the amount of food ingested, even if it increases the metabolic costs; the average rate of food assumed varies in fact from 4.2 to 6.6% at 20°C, from 2.3 to 4.5% at 15°C and from 1.4 to 1.7% at 10°C (Mangold and Boletzky, 1973). Moreover, it should be noted that the relative rate of food ingested decreases with increase in size (Nixon, 1966; Mangold and Boletzky, 1973).

About 50% (from 20 to 80%) of the crabmeat ingested, in terms of wet weight is used for growth, 45% serves for maintenance, while 5% is not absorbed (Mangold, 1983). The food conversion index, moreover, does not depend on the temperature and does not seem to be linked to the size of the animals either; this important productive parameter however, besides being influenced by the types of diet used, also seems subject to great individual variability (Mangold and Boletzky, 1973). Smale and Buchan (1981) discovered that food conversion is improved when molluscs and crustaceans are given as feed rather than just molluscs; this is true for both males (42.1% vs 23.5%) and females (40.3% vs 23.7%), and demonstrates that a more varied diet is more effective than a monodiet. Consequently the nutritional choice carried out in some recent studies (Iglesias *et al.*, 1997; Rama-Villar *et al.*, 1997; Cagnetta *et al.*, 1998) is more than justified; these studies aimed to evaluate growth rates of the common octopus in different rearing conditions, with a diet intended, in various ways, to simulate that of the octopus in its natural state.

In relation to the marked interest which this is arousing because of its possible permanent inclusion among the "new" species for rearing, it would be very opportune to set out valid points of reference for the future development of the feeding techniques for this species; in this context it is of fundamental importance to improve knowledge about the use of single foods.

The study was carried out in a controlled environment with the aim of providing preliminary information about the production responses of the common octopus when fed exclusively and alternatively with the prey species which make up the basis of its natural diet.

Materials and methods

The trial was conducted in the aquaculture sector of the Department of Animal Production of Bari during the months of October and November 1998. The subjects were taken directly from the sea and were first of all allowed a suitable period of acclimatisation (10 days) in the experimental tanks which were provided with a closed water recirculation system (salinity 33‰); however, a partial water change (30%) was programmed weekly.

The water temperature was not conditioned, while the level of dissolved oxygen was kept constantly above 80% of the saturation level.

In the acclimatisation stage the octopuses were kept in stable pairs and fed with the same diet as that intended for the experimental phase. The trial lasted 35 days and it was planned to exclude all pairs in which there were instances of cannibalism. Two suitable earthenware pots were placed in each tank to provide nests for the octopus being tested.

Therefore 3 experimental groups were established and given a monodiet:

Group C: feed on crab (*Carcinus mediterraneus*)
Group T: feed on tattler (*Illex coindetii*)
Group F: feed on fish (mullet: *Mugil cephalus*; sardine: *Sardine pilchardus*)

Feeding was intended to be "*ad libitum*", consisting of thawed prey, either whole or in suitable pieces, which was distributed once a day (h 8.00 a.m.), 3 times a week.

The data sets regarded 3 pairs of octopuses for each experimental group.

Both productive and behavioural traits for each octopus were observed:

(i) The weekly weight of the subjects.

(ii) The weight of prey captured during each distribution.

(iii) The residual quantity of food after each expulsion.

(iv) The time spent capturing food.

(v) The time spent on food retention.

(vi) The time of chromatic variation during capture.

The data obtained were submitted to analysis of variance using the general linear model program of the Statistical Analysis System.

The individual daily growth rate (%) of octopuses was calculated as:

$(\ln Wf - \ln Wi)/n*100$

were Wf = final weight; Wi = initial weight; n = number of days.

Results

The water temperature in the tanks varied from 22 to 18°C, within the optimum range of the species.

The subjects fed on crab display the best pattern, reaching a final weight of 281.9 ± 24.8 g (Fig. 1), corresponding to a significantly greater increase (Fig. 2) than that found in the experimental group fed on fish (126.1 ± 11.5 g vs 71.4 ± 11.5 g; $P < 0.01$).

Figure 3 shows that daily growth rates of octopuses fed on crab or tattler present quite similar values, higher than those fed on fish ($P < 0.01$).

Also the food conversion index (Fig. 4) presented significant differences between Group F, compared with Groups C and T ($P < 0.05$).

Table 1 shows some traits linked to feeding behaviour of the octopus.

In general it is possible to affirm that behavioural traits show correspondences with what has already emerged from analysing the productive results.

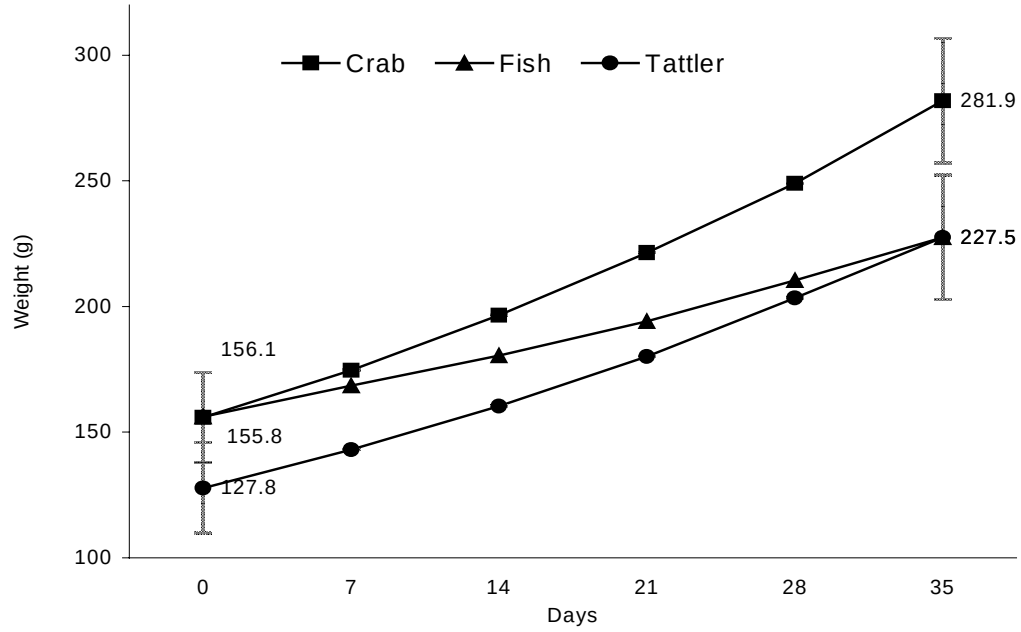

Fig. 1. Weight evolution.

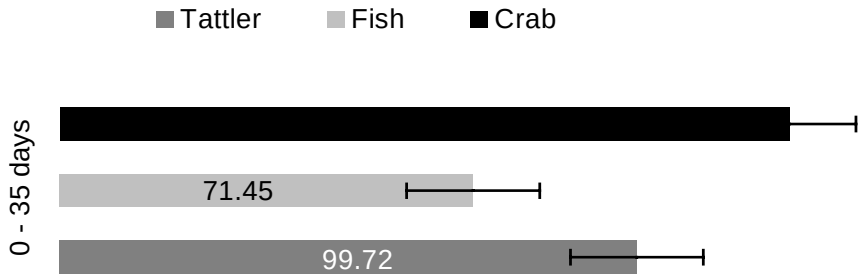

Fig. 2. Total increase (g).

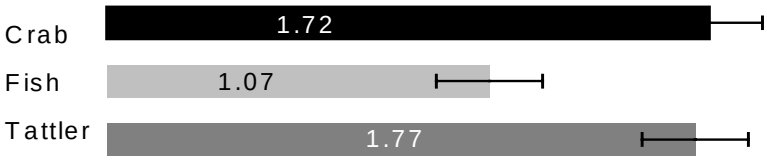

Fig. 3. Daily average growth rate (%).

In order to determine the acceptance of food it was sometimes necessary to intervene and stimulate the octopus (6.8% of cases); the average of total refusal of food was, however, very small (1.4%) and the 3 foods did not show any noticeable differences when compared in this respect.

Crab was captured in markedly greater quantities than fish and tattler ($P < 0.01$). The superiority of crab seems to depend mainly on the fact that the octopus prefers it; the food intake, in fact, is higher ($P < 0.01$) than for tattler and even greater when compared with fish.

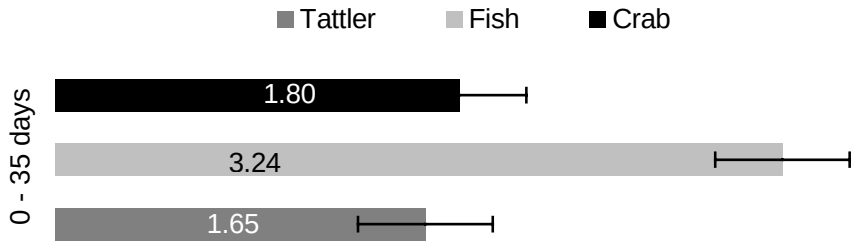

Fig. 4. Food conversion index.

Table 1. Feeding behaviour

	Crab			Fish			Tattler		
	No.	$\bar{x}$	± s.e.	No.	$\bar{x}$	± s.e.	No.	$\bar{x}$	± s.e.
Food captured (g)	87	35.1	± 0.9^{A}	90	14.4	± 0.9^{B}	88	14.2	± 0.8^{B}
Food reside (g)	87	18.2	± 0.6^{A}	90	4.9	± 0.6^{B}	88	1.4	± 0.6^{C}
Food intake (g)	87	16.9	± 0.7^{A}	90	9.5	± 0.7^{B}	88	12.9	± 0.7^{C}
Food waste (%)	87	51.6	± 2.5^{A}	90	30.7	± 2.4^{B}	88	7.9	± 2.4^{C}
Food retention (min)	87	191.6	± 4.4^{A}	82	120.2	± 4.6^{B}	–	–	–
Voracity (min/g)	87	16.9	± 2.5	82	19.6	± 2.5	–	–	–
Capture time (s)	75	4.6	± 0.3	63	5.3	± 0.4	80	5.2	± 0.3
Chromatic variation (s)	71	3.0	± 0.2^{A}	65	3.8	± 0.2^{B}	71	3.2	± 0.2^{A}

$^{A,B,C}P < 0.01$.

Regarding the management aspect, it is interesting to look at the waste from the 3 foods in relation to the water quality in the tanks and the cleaning which would be necessary in rearing tanks. Tattler was captured and almost completely consumed, producing a very small quantity of waste (7.9%) even if we must bear in mind that most of the waste produced by the use of crab (51.6%) is made up of shell.

It must be said, however, that the results concerning tattler were characterised by high incidence of complete consumption of captured prey; in this group, therefore, it was impossible to evaluate the time of food retention; this was also significantly greater for crab than for fish ($P < 0.01$).

However all the foods used during the trial were well accepted by the octopus, thus confirming that the species is very adaptable also when it comes to food. In fact, the voracity and time spent on capturing food did not present significant differences among groups.

For all pairs of octopuses tested in this study good conditions of cohabitation were verified; the parameters examined were almost similar and did not show significant differences between the bigger and the smaller subjects within pairs.

Conclusions

It is known that the common octopus likes a varied diet even if this study showed that a monodiet can be used.

The superiority of crab compared to tattler and even greater when compared to fish was confirmed. The use of crab, therefore, determined a higher food intake, an advantageous conversion index and, consequently, a higher growth. Moreover, crab also determined more efficient feeding behavioural traits.

On the other hand, the subjects fed on tattler also showed notable productive responses while fish seems to represent a type of food less valid, but was still accepted by octopuses.

Therefore, the evaluation of feeding programmes for this species can consider the possibility of utilising single foods during same period of rearing or in particular situations. The availability of preys and their costs should represent valid elements to evaluate better management strategies especially from the economical point of view.

The exclusive use of a single food during whole rearing period could also seem possible especially for crustaceans and cephalopods but this must be confirmed also in open water systems through more specific field experiments. Moreover, this last feeding technique should determine a better standardisation of the productive process and of the quality of the final product. Also it should allow easier rearing management and consent better control of water quality.

However, the most important aspect is certainly the possibility to set up preliminary points of reference referring to the productive responses of *Octopus vulgaris* fed in captivity using some single foods of its natural diet. Further studies on this subject appear necessary also from the nutritional point of view, regarding the development of feeding techniques; the most important aspect of this would be to allow the passage from natural to commercial dehydrated foods.

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