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Preliminary observations on the productive responses of the common octopus (*Octopus vulgaris* C.) reared free or in individual nets

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SUMMARY – At the moment the rearing of *Octopus vulgaris* is possible but depends on a better definition of several important aspects: the type of rearing, feeding system and control of intraspecies aggressiveness. The study aimed to evaluate the possibility of rearing the common octopus in single nets in order to reduce cannibalism efficiently and to favour productive responses by limiting the output of energy linked to movement. The subjects were taken directly from the sea, subjected to a period of acclimatisation (10 days) and then used to make up 3 experimental groups reared in tanks with open recirculating water system: Group F = 10 free octopuses living together (LW = 174.5 ± 13.9); Group N = 10 octopuses in individual nets (LW = 172.5 ± 13.9); Group NN = 9 octopuses in a net with a nest (LW = 288.3 ± 24.4). The trial lasted 56 days for groups F and N, and 28 days (final 4 weeks) for group NN. Feeding program was performed "*ad libitum*", 3 times a week, using 3 low cost fish species (*Sardina pilchardus, Boops boops, Trachurus trachurus*). Group F showed an average daily growth rate of 1.94%, reaching a final weight of 512.2 ± 35.2 g compared to 412.5 ± 42.1 g of group N. The increases were significantly different during the whole period of the trial ($P < 0.05$), especially in the first 28 days ($P < 0.01$). The group NN, on the other hand, showed the worst responses. Also mortality was lower in group F (1 death) than in group N and NN (4 deaths). Therefore, an open water system with octopuses living freely presents remarkable advantages; also the sole use of fish, in this context, seems to offer interesting future possibilities. However, the idea of using single rearing modules in tanks or in the open sea should be modified and improved rather than discarded altogether.

Key words: Rearing strategies, common octopus, weight evolution, intraspecies aggressiveness.

RESUME – *"Des observations préliminaires sur les résultats productifs du poulpe commun (*Octopus vulgaris *C.) élevé en communauté ou en filets individuels". En l'état actuel l'élevage de l'*Octopus vulgaris *paraît praticable même s'il exige une meilleure définition de quelques aspects importants liés à la technique d'élevage à adopter : typologie d'élevage, alimentation et contrôle de l'agressivité intraspécifique. L'objectif de l'étude a été d'évaluer la possibilité d'utiliser des filets individuels de contenance du poulpe afin de réduire les phénomènes de cannibalisme et de favoriser les résultats productifs par la limitation des gaspillages énergétiques liés à l'activité motrice. Les sujets, capturés en mer, ont été préliminairement soumis à une période d'acclimatation (10 jours) et par la suite utilisés pour la constitution de 3 groupes expérimentaux à élever en bassins à circuit hydrique ouvert : Groupe F = 10 poulpes libres (PV = 174,5 ± 13,9) ; Groupe N = 10 poulpes en filets individuels (PV = 172,5 ± 13,9) ; Groupe NN = 9 poulpes en filets individuels pourvus d'un nid (PV = 288,3 ± 24,4). L'épreuve a eu une durée de 56 jours pour les Groupes F et N, tandis que le Groupe NN a été constitué par la suite et a évolué seulement dans les 4 dernières semaines. Le programme alimentaire a prévu l'administration "*ad libitum*", 3 fois par semaine, de 3 espèces de poissons de valeur marchande modérée (*Sardina plichardus, Boops boops, Trachurus trachurus*). Le Groupe F a présenté un taux d'accroissement en moyenne égal à 1,94% par jour, en rejoignant un poids final de 512,2 ± 35,2 g en comparaison aux 412,5 ± 42,1 g du Groupe N. Les accroissements en outre ont été significativement différents pour la durée entière de l'épreuve ($P < 0,05$) et surtout dans les premiers 28 jours ($P < 0,01$) : le Groupe NN au contraire a présenté les résultats productifs les moins bons. La mortalité également a été sensiblement plus faible dans le Groupe F (1 décès) en comparaison avec celle relevée dans les Groupes N et NN (4 décès). Par conséquent il est possible d'affirmer que l'élevage en communauté du poupe dans les systemes hydriques ouverts présente des avantages notables. Aussi l'emploi exclusif du poisson dans ce contexte de millieu paraît offrir des perspectives intéressantes. Toutefois, la possibilité d'utiliser des modules individuels d'élevage du poulpe en bassins ou en mer ne doit pas être écartée, mais plutôt doit être modifiée et améliorée.*

Mots-clés : *Stratégies d'élevage, poulpe commun, évolution du poids, agressivité intraspécifique.*

Introduction

Octopus is arousing growing interest because of the possibility of including it advantageously

among the "new species" reared in fishfarms. It is a species which may be easily kept in captivity, displaying excellent ability to adapt, and high survival rates. In the natural state (Mangold, 1983) it can live in very diversified habitats and these characteristics make it particularly suitable for rearing.

As things are at the moment, the issues related to octopus farming must start with the supposition that rearing may be possible, even if we do not yet have adequate control of its reproduction. However there are some fundamental aspects to consider for octopus farming.

Main problems related to octopus rearing

A summary of points to consider:

Capture and transport

When non-traumatic methods of trapping are used, which are often the same as the traditional methods, the percentage of survival is very high (even 100%) also due to the remarkable ability of *Octopus vulgaris* to resist even outside its natural aquatic environment.

Acclimatisation

When it is introduced into a captive environment it manifests the predatory instinct very quickly (within a few hours), particularly when capture and transport are carried out with minimum stress. In a recent study (Cagnetta *et al.*, in press) performed in tanks with a closed water cycle the period of adaptation lasted about 10 days.

Feeding

The diet of the common octopus is varied. Even if it seems by now certain that the food preferences of the octopus range in decreasing order of interest from crustaceans to molluscs and fish, the possibility of obtaining low cost food which is widely available justifies further study of the productive responses provided by the use of fish. Also in view of the fact that given the present situation it is not possible to feed this species on commercial dehydrated foods.

Shelter

Octopus lives in a nest, but does not seem to need particular attempts to reproduce its natural habitat. It is possible to keep it even in environments with no shelter or provide it with a rudimental nest in the form of a simple earthenware jar or a PVC tube.

Pecking orders

In a short time precise pecking orders are set up in small or large groups. Generally, cohabitation seems possible as regards both adaptability and production. The main limit is the outbreak of intraspecies aggressiveness which often leads to cannibalism.

Aggressiveness

It seems to depend mostly on disparity of size, density of rearing, individual aggressive potential, the general conditions of the animals and the environment (in particular water characteristics).

Mortality

The principle cause of mortality in *Octopus vulgaris* is cannibalism. In some recent studies (Iglesias *et al.*, 1997; Rama-Villar *et al.*, 1997; Cagnetta *et al.*, in press) carried out in very diverse conditions, very variable rates were found; up to about 30%.

Another element which must not be underestimated is represented by the losses due to flight, linked to its surprising ability to pass through very small openings and spaces unless specific measures are taken to contain it.

No significant damage is observed as being caused by specific pathologies even if farming experiences appears limited so far.

In general, more specific studies on these aspects are to be hoped for.

Rearing strategies

The first studies on the keeping of common octopus were carried out in aquariums and gave preliminary information about its productive potentiality (Mangold and Boletzky, 1973; Mangold, 1983). Lately tests have been carried out in markedly different contexts and these have shown surprising performances both in terms of weight gain and of food conversion indices; tanks with closed or open recirculating water and cages are included in the different types of farming tested (Fig. 1) (Iglesias *et al.*, 1997; Rama-Villar *et al.*, 1997; Cagnetta *et al.*, in press).

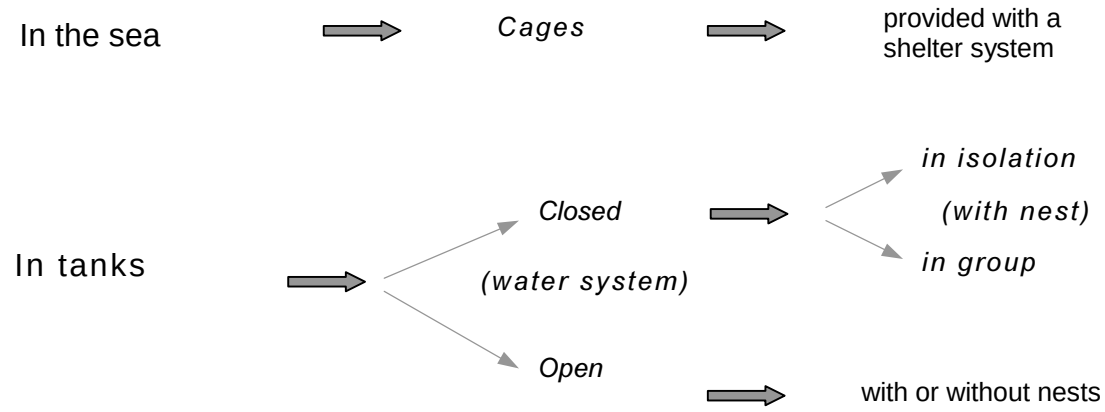

Fig. 1. Rearing strategies.

At present however more specific research is therefore necessary in order to acquire a more precise productive pattern for this species in such different environmental and methodological conditions. The aims of the study were:

(i) To rear octopus in individual nets in order to reduce intraspecies aggressiveness and improve weight gain through reduction of energy consumption due to limitation of movement and of social interaction.

(ii) To evaluate the productive responses of the octopus in an open water recirculation system, without any shelter and in quite high density.

(iii) To propose a feeding programme based exclusively on fish, which is cheap and easy to get hold of.

Materials and methods

The trial was carried out at an Apulian fishfarm for fattening valuable fish species and which had already practised keeping octopus for direct sale of the "live" product.

For this purpose 3 rectangular tanks were used, each with a capacity of 2 m^3, having an open recirculating water system with a constant change of water of about 0.5 l/s.

The subjects were captured from the sea and first of all given an adequate period of acclimatisation (10 days); 3 experimental groups were set up:

Group F = 10 free octopuses kept together;

Group N = 10 octopuses in individual nets;

Group NN = 9 octopuses in nets provided with a nest.

It must be stressed that none of the subjects in nets were tied in any way to fixed supports able to impede totally interaction with others and with members of the same species.

The trial was carried out during the months of November and December 1998, and lasted 56 d for groups F and N, and 28 d for group NN; this last experimental group in particular was constituted in order to create a variant of group N only for the last 4 weeks on the trial.

The feeding program consisted of prey distributed "*ad libitum*" (whole or in suitable pieces) once a day between h 5.00 and h 7.00 p.m., 3 times a week. In order to ensure that the subjects of N and NN received the same treatments (the food was placed inside the net) as that adopted for the free subjects (F), the latter were also fed singly. Only 3 cheap species of fish were used: (i) *Sardina pilchardus*; (ii) *Boops boops*; and (iii) *Trachurus trachurus*.

The data recorded concerned: (i) mortality; (ii) the weekly weight of subjects; and (iii) the quantity of food captured during each distribution of food.

The main parameters of the water were controlled daily: (i) temperature; (ii) dissolved oxygen; (iii) salinity.

The data collected were analysed using the GLM program of the Statistical Analysis System.

Results

Temperature, dissolved oxygen and salinity of the water

During the trial the temperature of the water (Fig. 2) in the tanks displayed the best weekly averages for the growth of octopus in the first 4 weeks (about 20°C-17°C). In the second half of the trial period the temperature fell to about 16.5°C-15.5°C.

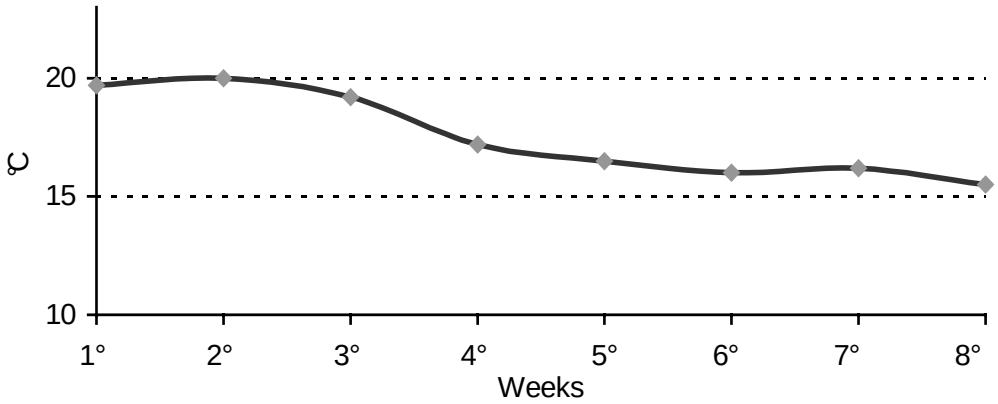

Fig. 2. Evolution of water temperature.

The dissolved oxygen was always above 80% of saturation level while salinity remained between 30 and 33‰.

Octopuses survival

First of all it must be stressed that the octopuses reared in nets (N) immediately displayed

noticeably less growth than that found in the group of free octopuses (F) and that the technical solution proposed in order to limit the intraspecies aggressiveness revealed itself to be unsuitable: out of 10 octopuses at the beginning, in fact, in group F minimum mortality was found (1 octopus) compared to the 4 deaths recorded in group N (Fig. 3).

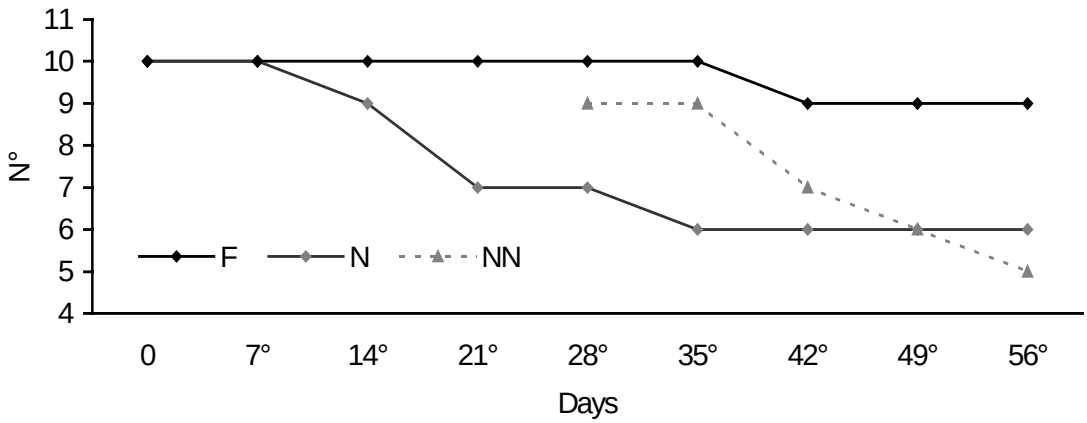

Fig. 3. Number of octopuses which survived during the trial in the 3 experimental groups.

For these reasons it was decided to introduce a new technical variant constituting, from Day 28, a further experimental group (NN) characterised by the presence inside the net of an earthenware vase (nest) of a suitable size. The results obtained in this last case did not confirm the theoretical expectations either (4 octopuses dead).

Moreover, It must be noticed that all dead octopuses were found with body parts missing, often still in the tentacles of the aggressor.

Weights and increases

From an examination of Fig. 4 it is possible to observe the different evolution of weight in the experimental groups.

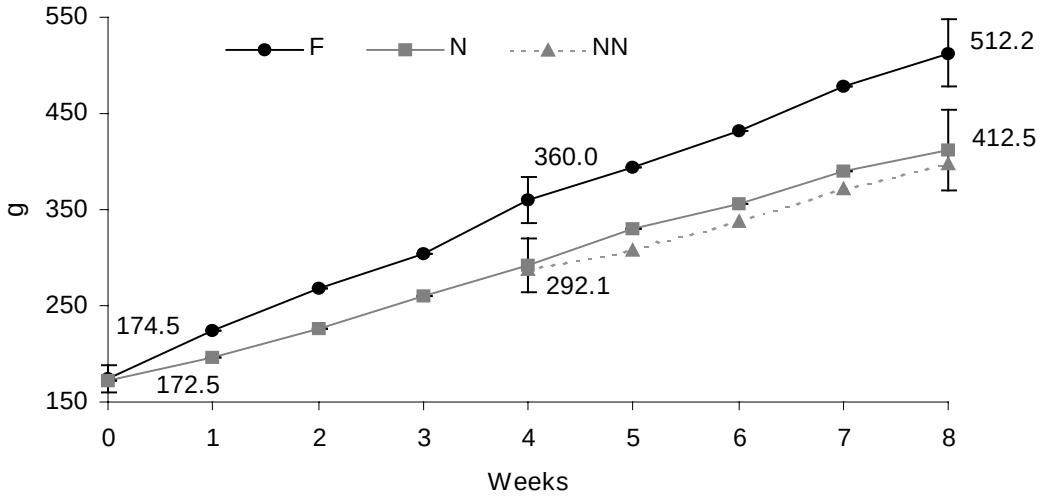

Fig. 4. Weight evolution.

Table 1 shows, on the other hand, the notable difference in growth which distinguishes Group F

from Group N. The increases of the free octopus and those kept in nets were significantly different both in the first half of the trial ($P < 0.01$) and over the entire period ($P < 0.05$). The Group NN displayed the worst responses reaching a final weight of 399 ± 42.8 g corresponding to 82.0 ± 19.6 g growth in 28 days. For this reason Group NN will be not considered subsequently.

Table 1. Weight gains (g)

	F				N			
	No.	$\bar{x}$	±	s.e.	No.	$\bar{x}$	±	s.e.
Increase 0-28 d	10	185.5	±	10.6^{A}	7	115.7	±	12.6^{B}
Increase 29-56 d	9	144.1	±	13.1	6	118.3	±	16.1
Increase 0-28 d	9	333.9	±	22.4^{a}	6	233.3	±	27.5^{b}

$^{A,B}P < 0.01$; $^{a,b}P < 0.05$.

Captured food and conversion index

On average the overall quantity of food captured by each octopus surviving during the whole trial was 781.2 g in group F, and 695.4 g in group N, corresponding respectively to the food conversion index of 2.34 and 2.98. In this regard it must be stressed that the food conversion index did not refer to the food intake and that therefore the indices obtained appear overestimated.

Conclusions

From the results obtained it is possible to affirm that the octopus, while displaying a remarkable capacity for domestication and particularly suitable characteristics for economical exploitation, also has limits. A system which constricts and confines the octopus, like the one used in this research, produces negative effects on its adaptability, with a reduction of productive performance and increased mortality.

The use of individual nets, with or without a nest, in fact does not limit the aggressive potential of the common octopus; on the contrary it finds better conditions for attacking and eating the members of its own species. A more precarious adaptability and pecking order, as well as prey which is more vulnerable because it is unable to move freely, play a determining role here.

However, the idea of using single rearing modules should be modified and improved rather than discarded altogether. It would be particularly interesting to try out rigid modules or systems fixed to supports able to prevent contact between octopuses either in tanks or in the open sea.

An open recirculating water system with sufficient availability of "living space" (1 octopus/200 l) seems to present obvious advantages regarding both production and especially containment of mortality due to cannibalism. The free octopus displayed a daily average growth rate of 1.91%, going from an initial weight of 174.5 ± 13.9 g to a final weight of about 512.2 ± 35.2 g in 56 days of rearing together with a very low incidence of cannibalism.

This last farming technique determines the establishment of precise pecking orders; it is possible to observe this from the positioning of the individual inside the tanks, which remained essentially the same. In this case, intraspecies aggressiveness which is always present in interactive behaviour and especially during feeding, does not give rise to cannibalism as long as the subjects maintain a good general state and adaptability.

The feeding system used also showed that the use of only fish in the diet does not represent a negative factor capable of reducing the behavioural and productive responses of the octopus. In this

respect it must be considered that the temperature during the trial did not always respect the range which is most favourable to the growth of octopus.

However the possibility of an advantageous exploitation of this species still depends on identifying solutions to several important problem areas in order to apply them to farming: the type of rearing, the feeding system and control of aggressiveness are the main areas in question.

Acknowledgements

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