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Cost analysis of octopus ongrowing installation in Galicia

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Abstract

Recent years have seen the opening of several octopus fattening installations in Galicia with varying results, although such installations, in principle, do show promise. The technology for rearing octopus is scant since the full biological cycle cannot as yet be reproduced in captivity and the production system is based on capturing juveniles in the wild, containing them in different types of cage and feeding them with trawled species of little commercial value. Given the present state of our knowledge, then, it is particularly interesting to carry out economic studies that look at the viability of such fattening installations from a cost analysis point of view, both to evaluate the present system and to look at possible future alternatives. To do this we have defined a model installation based on the installations operating in Galicia and using the same techniques and methods. The minimum size of the installation is established as 43 cages with an annual production of 38,728 kg, a minimum selling price of 5.80 € kg^{-1}, a maximum buying price of juveniles of 4.58 € kg^{-1}, maximum price of buying feed of 0.155 €, a benefit/cost index of 4.11% and benefit/investment index of 1.81%. The cost analysis indicates that, in the present circumstances, this is a business involving low profits and high risk, not only because the variable costs are high, but also because the margins of the parameters analysed are very narrow and the benefits closely depend on variations in costs.

Key words: break-even point, aquaculture economics.

Resumen

Análisis de costes de una explotación tipo de engorde de pulpo *(Octopus vulgaris)* en Galicia

Durante los últimos años se han creado algunas empresas en Galicia para el engorde del pulpo, con resultados dispares, aunque, en principio, han mostrado el gran potencial que tiene el cultivo de esta especie. Sin embargo, la tecnología disponible actualmente es escasa, no habiéndose cerrado aún de forma artificial el ciclo biológico, por lo que el sistema de producción se basa en la captura de juveniles en el medio natural, estabulación en distintos tipos de jaulas, y alimentación con distintas especies de crustáceos y peces de bajo valor comercial, fundamentalmente descartes de la pesca de arrastre. En esta situación es particularmente interesante realizar estudios económicos en el ámbito de la viabilidad y la analítica de costes tanto para evaluar el sistema actual de engorde, como las posibles alternativas futuras. Para ello se ha establecido una explotación tipo, que está basada en las explotaciones existentes en Galicia y en la que se utilizan los métodos y técnicas actualmente disponibles. En base a ello se ha determinado el tamaño mínimo de explotación (43 jaulas, producción anual de 38.728 kg), precio mínimo de venta (5,80 € kg^{-1}), precio máximo de adquisición de juveniles (4,58 € kg^{-1}) y precio máximo de adquisición de alimento (0,155 € kg^{-1}), así como el índice beneficio/costes de explotación (4,11%) y el índice beneficio/inversión (1,81%). El análisis de costes indica que en las circunstancias actuales se trata de un negocio de rentabilidad baja y de alto riesgo, no sólo porque los costes variables sean altos, sino porque los márgenes de los parámetros analizados son muy estrechos, y los beneficios tienen una alta dependencia de las variaciones de los costes.

Palabras clave: umbral de rentabilidad, economía de la acuicultura.

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Introduction

The ongrowing of octopus in Galicia on an industrial scale began in 1996, and 12 tonnes were produced in 1997 (JACUMAR, 2003). Interest basically arose from the results obtained for this species at the Coastal Centre of Vigo belonging to the *Instituto Español de Oceanografía* (Iglesias *et al.*, 1997) and at the Department of Biochemistry and Molecular Biology of the University of Santiago (Rama-Villar *et al.*, 1997). During recent years, four companies have been set up and, although the results have varied widely, the potential for cultivating this species is clear. However, the technology is poorly understood since the full biological cycle cannot yet be reproduced artificially and juveniles for fattening cannot be produced on a sufficient scale; furthermore, no specialist feed is commercially available. For this reason, juveniles must be captured in the wild and kept in different types of cages, while their feed consists of different crustacean and fish species of low retail value, basically the by-catch from trawling. In 1998, 1999 and 2000, the above mentioned firms produced 32, 31 and 27.6 tonnes, respectively, although this fell to 14.6 tonnes in 2001 (JACUMAR, 2003). At the same time, several studies have been carried out, some in collaboration with these companies, looking at the parameters involved and trying to identify factors that might help improve production (Rama Villar *et al.*, 1997; Luaces Canosa and Rey Méndez, 1999; Tuñón *et al.*, 2001, 2002; Rodríguez *et al*, 2003; Rey Méndez *et al.*, 2003).

Under these circumstances, an economic study of the viability and a cost analysis would be especially interesting to evaluate the present system of fattening and possible future alternatives. The objective of the present study was to determine the profit threshold, the maximum price of juveniles and feed to obtain a zero profit, and certain indices of profitability from the cost analysis. For this, a model installation, based on those already existing in Galicia and using currently available methods and techniques, was defined.

Material and Methods

The present study uses cost analysis (Mishan, 1982; Mao, 1986; Ballestero, 2000) to calculate certain indices related with the profitability and the technical-economic efficiency of the model installation. Threshold values for the two most limiting production factors (the maximum prices of juveniles and feed) which determine profitability are established.

To carry out the study, a model installation was established, in which all the usual tasks associated with the commercial production process were carried out. To define this model, data provided by the Marine Resource Department of the Galician Autonomous Government concerning several experimental projects and the annual reports on the same were used. An average year in full production was studied, using data from the aquaculture experiments carried out. Data from previously published experimental papers (Rama Villar *et al.*, 1997; Tuñón *et al.*, 2001 and 2002; Rodríguez *et al.*, 2003; Rey Méndez *et al.*, 2003) were also used. The technical characteristics and prices of different production methods were obtained from several companies already working in this field (Corelsa, Acuitec S.L., Disaplast S.A, etc.) and the official data bases of prices (price records from the College of Architects, Madrid, agro-food price records of the Polytechnic University of Valencia, etc.).

Figures 1A and B show a detailled and a general view of the floating cages, respectively.

A

B

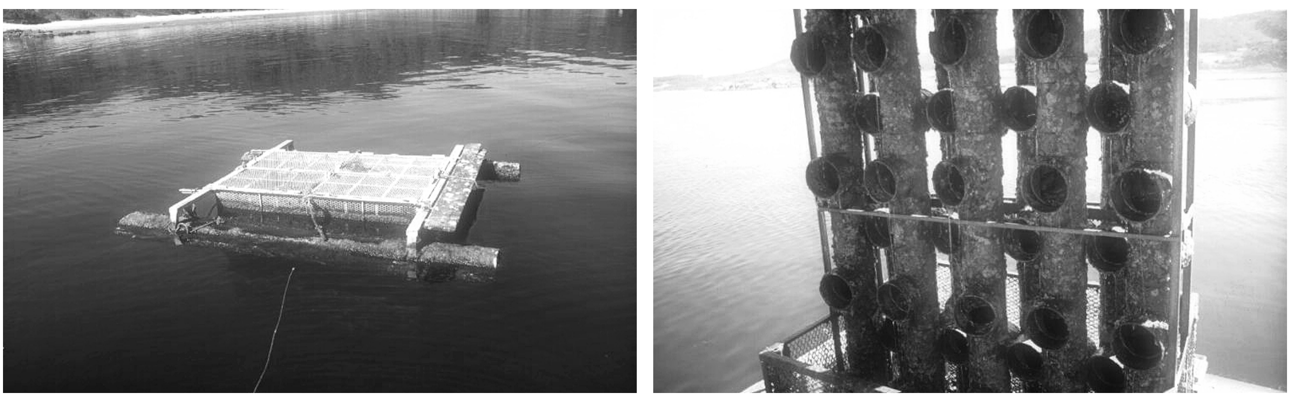

Figure 1. A: A general view of the floating cages. B: A detail.

Table 1. Overhead costs (Euros)

Heading	Useful life (years)	Present value	Residual value	Depreciation	Opportunity cost	Subtotal
Cages C-160	20	300,000	60,000	12,000	420	12,420
Galvanising of cages	5	23,700	0	4,740	166	4,906
Containers	20	54,000	10,800	2,160	76	2,236
Boat	20	150,253	52,589	4,883	171	5,054
Crane-truck	10	33,000	11,550	2,145	75	2,220
Auxiliary equipment	10	4,620	462	416	15	430
Onshore infrastructure	20	45,600	9,120	1,824	64	1,888
Containers for transport	10	600	60	54	2	56
Total						29,210

The level of interest used is 3.50%.

The model installation consisted of 50 floating cages (type C-160), each containing 200 octopus. The galvanised steel cages were rectangular in shape and contained PVC «T» columns for use as refuges. The installation used a vessel equipped with a 1,100 kg hydraulic hoist, a truck with a crane, land installations (quay, warehouse, cold rooms etc.) and auxiliary equipment (baskets etc). Two ongrowing cycles per year were made (each lasting 3-4 months), starting with juveniles weighing 800 g, which reached 2.5-3 kg at the end of the process. Feed mainly consisted of by-catch from trawlers, basically crab, horse mackerel, blue whiting, etc.

In ongrowing assays carried out in Galicia and Asturias (Rama Villar *et al*., 1997; Tuñón *et al*., 2001; Tuñón *et al*., 2002; Rey Méndez *et al*., 2003; Rodríguez *et al*., 2003), the conversion index (CI) and survival rate varied widely, the former between 5 and 11, and the latter between 52 and 94%. Based on their experience, the commercial company Arrecifes del Atlántico S.L. suggests a CI of 5.8 and a survival rate of 78%, figures that are very close to the mean values calculated for previous ongrowing experiments. For this reason, we have chosen these values for the costs analysis.

The costs were calculated from the initial investment required and overhead costs (assets and depreciating equipment), fixed running costs (personnel, fuel, maintenance, financing costs) and variable costs (acquisition of juveniles and feed, production insurance). The costs structure obtained from the following data are depicted in Tables 1, 2 and 3.

The overhead costs have been divided as follows:

— Type C-160 cages, self-floating, rectangular and with a capacity of 200 octopuses.

— Heat galvanising of cages, including transfer to land and return trip to workshop.

— Containers for octopus. Battery of containers formed of PVC «T» piece with tops, to house octopuses individually.

Table 2. Fixed running costs (Euros)

Heading	Useful life (years)	Present value	Residual value	Operating capital	Opportunity cost	Subtotal
Permanent staff	1	26,144	0	26,144	915	27,059
Maintenance	0.5	7,933	0	7,933	139	8,072
Permits	0.5	1,534	0	1,534	27	1,561
Fuel	0.5	4,868	0	4,868	85	4,953
Electricity	0.5	2,160	0	2,160	38	2,198
Insurance	0.5	2,880	0	2,880	50	2,930
Fixed taxes	0.5	330	0	330	6	336
Financial costs	1	10,661	0	10,661	373	11,034
Office costs	0.5	1,058	0	1,058	19	1,077
Total						59,219

The level of interest used is 3.50%.

Table 3. Variable costs

Heading	Unit cost	Maximum production	Opportunity cost	Subtotal
Juveniles	2.271	45,240	3,595	106,319
Feed	0.696	45,240	1,102	32,589
Production insurance	0.760	45,240	602	34,984
Total				173,893

The level of interest used is 3.50%.

— Craft: 12 m catamaran for aquaculture, fitted with 1,100 kg hoist.

— Crane truck. Two axled truck with 1,500 kg crane, equipped with cold storage for transporting octopus.

— Auxiliary equipment. Tubes with nets to transport juveniles from capture vessels, baskets and boxes for feed.

— Land infrastructure: 130 m^2 storeroom, toilet, cloakroom and office. Cold room (30 m^2).

— Boxes for sending octopuses to market. Two containers with plastic covers.

Fixed running costs are divided as follows, considering in the calculation of opportunity costs the occasional non-availability of capital during the whole year or its partial availability (column «useful life» of Table 2 with a value of 1 or 0.5, respectively).

— Permanent staff: one foreman (full time) and one assistant (half time).

— Annual maintenance. Estimated at 2% of the value of the cages, containers for octopus, vessel, crane and land sites.

— Permit and charge for using base in port.

— Fuel. Fuel for boat, crane and truck for transporting octopus.

— Electricity for cold store and offices. Calculated for refrigerating power of 5-6,000 fg h^{-1}, compressor working 15 h day^{-1} and mean consumption of 1.5 KW for 8 h day^{-1}.

— Insurance. Compulsory insurance of boat and truck.

— Fixed taxes. Tax on economic activities.

— Financial costs. Initial investment (100%) at 7.5% for 8 years: monthly payments.

— Office costs, fungibles. Telephone, various office materials, water.

As regards variable costs, we have considered the non-availability of capital in the first two sections and its partial availability in the third:

— Acquisition of juveniles. Juveniles weighing 800 g are acquired for two ongrowing cycles per year. A mortality rate of 22% and a price of 4.21 € per juvenile are considered.

— Feeding. The feed is basically the by-catch of trawling activity and consists mainly of crab, horse mackerel, blue whiting, etc. A mean conversion index of 5.80 and mean price of 0.12 € are considered.

— Insurance of production. This is calculated from the number of cages and mean biomass.

Income is based on the estimated sale of 45,240 kg of commercial size octopus with a mean price of 6.01 € kg^{-1}. The opportunity cost (Samuelson and Nordhaus, 1990) generated is applied to parts of the budget where we think the capital would be available to a greater or lesser extent (half or complete year). Table 4 resumes the costs and income structure of the installation.

The parameters and indices used in the present costs analysis were: benefit, benefit/operating cost ratio, benefit/investment ratio, marginal costs and breakeven

Table 4. Summary of costs and income

Costs and income	Euros	Percentage of total costs
Fixed costs		
Overhead	29,210	11.14 %
Running	59,219	22.57%
Subtotal	88,429	33.71%
Variable costs		
Juveniles	106,319	40.53%
Feed	32,589	12.42%
Production insurance	34,984	13.34%
Subtotal	173,893	66.29%
Total costs	262,322	100%
Total income	271,892	

point (Blanco Dopico, 1994; Layard and Glaister, 1994; Cantero Desmartines, 1996).

— Benefit is taken as the difference between income and outgoings on an annual basis before taxation.

— The benefit/operating cost ratio is the ratio between the benefits and capital circulating in each annual cycle, the costs being the sum of all the fixed running costs and the variable costs.

— Marginal costs represent the mean variable costs per unit produced, taken as a reference for the efficiency of the installation.

— Breakeven point for a mean sales price indicates the price per kilo of octopus above which the installation begins to generate a profit; it is, therefore, an overall index of the technical and economic efficiency of the installation.

Lastly, after defining the characteristics of the costs structure, we calculate the *maximum price of acquiring juveniles* (€ per individual) and the *maximum price of feed* (€ kg^{-1}), for a profit to be obtained (B = 0 €).

Results

Tables 1, 2 and 3 reflect the information used to establish overhead costs, fixed running costs and variable costs, while Table 4 resumes the costs and income structure. As can be seen, variable costs are greater than fixed cost, representing 66.29%. The cost of acquiring juveniles (40.53%) is noteworthy, while feed only accounts for 12.42%. Fixed costs account for 22.57% of the total costs, and overhead costs 11.14%.

The size at which income matches costs is calculated at 43 cages (Table 5), which means an annual output of 38.7 tonnes at a minimum selling price of 5.80 €, and a maximum acquisition price of juveniles and feed of 4.58 and 0.155 € kg^{-1}, respectively. The benefit/operating costs ratio of this operation is 4.11% and the benefit/investment ratio 1.81%.

Table 5. Results of cost analysis

Costs analysis	Results
Minimum size of installation (No. of cages)	43 (producing: 38,728 kg)
Minimum selling price (€ kg^{-1})	5.80
Maximum price of acquiring juveniles (€ $unit^{-1}$)	4.58
Maximum price of acquiring feed (€ kg^{-1})	0.155
Benefit/fixed running costs ratio (%)	4.11
Benefit/Investment ratio (%)	1.81

Discussion

We have established a costs structure for an octopus ongrowing facility in cages which permits analysis of a specific situation reflecting present-day conditions, but which also permits analysis of other situations arising from changes in technology, rising and falling prices and the specific conditions of each company. It is, therefore, a useful and sensitive tool for economic analysis.

The minimum size of the installation (43 cages) implies a yearly production figure of 38,728 kg of octopus. This is the break-even point of the operation, when costs and benefits are equal. Another question, which is not considered in this study, is whether this type of operation adapts itself to the economics of scale that have been calculated for sea-bream in the Mediterranean (García García *et al.*, 2001) and, if so, what is the necessary size for an installation to generate a given profit level.

The high level of the variable costs calculated (66%) is normally associated with high risk operations in the agrifood industry. However, in most marine aquacultural activities, especially those involving the fattening of fish (e.g. sea-bream, sea bass and salmon), variable costs are generally higher than fixed costs (García García, 2001; Paquotte *et al.*, 1996). In this type of installation, however, feed is the greatest variable, accounting for 25-60% of total production costs, the exact value being related with the degree of technical sophistication. In salmon fattening operations in Norway, feed represents 60% of the total costs (Paquotte *et al.*, 1996) despite their technical nature and efficiency. In the Mediterranean, the cost of feed for sea-bream represents 35% of the total (García García, 2001), the technology still being relatively young and evolving towards more efficient systems. In the case under study, feed only represents 12%, which coincides with the characteristics of operations still in their «family-business» stage.

Within the variable costs, the acquisition of juveniles represents 41% of total costs, thus becoming the most critical point in the operation. Furthermore, the maximum predicted cost (4.58 € each) is very close to the present price of 4.21 €. This price may fluctuate widely from year to year due to the short life cycle of the octopus and the degree to which it is exploited, meaning that the commercial viability of the installation may be uncertain in years of low natural abundance. Moreover, any increase in the demand for juveniles by these installations will inevitably increase the price and, once again, question the viability. Another factor, mentioned by Rey Mendez (1999), is the reticence of fishermen in Galicia to provide live specimens lest the aquacultural product bring down the price of natural octopus. The continued provision of unwanted fish may also be a problem for the same reason.

Feed is also a limiting factor. Besides possible supply problems, the maximum price of feed (0.155 €) also gives little room for manoeuvre since this is very close to the present price of 0.12 €. If this price increases because of increased demand from octopus rearing, then it, too, must be expected to rise. Furthermore, by-catch consisting largely of crabs and other crustaceous species cannot be considered as unlimited. However, results suggest that octopus feed should contain crustaceans or molluscs to limit mortality (Tuñón *et al*., 2001; Aguado and García García, 2002), so the alternative of using a feed composed entirely of low value fish is not really viable. Furthermore, if the lipid content of the fish used is high (15-20% wet weight), octopus growth is much lower and the conversion index correspondingly high (García García and Aguado, 2002).

The minimum selling price in the model is 5.80 €, which is very close to the actual 6.01 €. The benefit/operational cost and benefit/investment ratios are very low (4.11 and 1.81%, respectively), underlining the low return and high risk, which is even more pronounced in the capital invested long term. If we make the calculations with a higher selling price, such as occurred at the end of 2002/beginning of 2003, these indices increase substantially. For example, if the mean selling price were 7.20 € kg^{-1}, the same indices would stand at 27.20 and 12.00%, figures that begin to look attractive to potential investors.

All the above leads us to conclude that, in the present circumstances, we are dealing with a high-risk, low-profit business, not only because the variable costs are high, but also because the margins of the parameters analysed are very narrow, any benefits showing a very close dependence on variations in costs. To lessen the risk and bring costs down, it is necessary to have available a dependable source of juveniles at a stable price, which will only be possible when they can be produced artificially. Indeed, this has been the object of several studies in recent years in Spain (Villanueva, 1995, Villanueva *et al*., 1995; Iglesias *et al*., 1996, 1997 and 2000; Navarro and Villanueva, 2000; Carrasco *et al*., 2003; Roo *et al*., 2003; Villanueva *et al*., 2003) and, although results have been disappointing so far, such research will undoubtedly lead to the mass production of juveniles in the future, as in the case of turbot and sea-bream. However, the cost of any juveniles produced must be below the threshold price or, if the margin is very narrow, the productive capacity of installations must be increased (by increasing the number of cages); this assumes, of course that such economics of scale are applicable to octopus, which seems likely. Feed is another important risk factor and an artificial food (preferably dry) will need to be developed to ensure its continuous supply at a stable price. Given that the conversion factor applied here is 5.80 and the maximum cost of this feed to produce one kilo of octopus is 0.90 €, if the cost of obtaining juveniles does not fall substantially, the price of any future feed must not exceed this. Research is also in progress into feed and nutrition (García García and Aguado, 2002; Aguado and García García, 2002; Cerezo and García García, 2003) but, given the behaviour and biological characteristics of the species in question (very different from that of fish, for which commercial diets have been successfully developed), much work remains to be done.

Once these problems and others, such as the high mortality rate (Rey Méndez, 1999), have been overcome and the necessary technology has been developed, there is no reason not to believe that the aquacultural rearing of octopus will be of great economic potential.

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