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ECONOMIC ASPECTS OF REARING LARVAL ASP, *ASPIUS ASPIUS* (L.), AND IDE, *LEUCISCUS IDUS* (L.), IN CLOSED RECIRCULATING SYSTEMS

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ABSTRACT. The profitability of rearing the rheophilic cyprinid fish species asp, *Aspius aspius* (L.), and ide, *Leuciscus idus* (L.), in two independent closed recirculating systems was evaluated. The fish were fed live Artemia nauplii exclusively. The rearing of both species was profitable and the financial risk was relatively low. From the point of view of profitability, the purchase price of stocking material was the most significant factor. The price of juvenile asp was 2.5 times higher than that of ide. Rearing larval asp was the most profitable venture.

Key words: CYPRINIDAE, RHEOPHILIC FISH, PRODUCTION COSTS AND PROFITABILITY, CLOSED RECIRCULATING SYSTEMS

INTRODUCTION

The magnitude of stocking the inland running waters of Poland with rheophilic cyprinid fish species is increasing annually (Wojda 2004, Mickiewicz et al. 2007). Because of this, increasing numbers of hatcheries are expressing interest in the production of rheophilic cyprinid stocking material. In Poland, the rearing of juvenile rheophilic cyprinid fish, including ide, *Leuciscus idus* (L.), and asp, *Aspius aspius* (L.), is conducted under controlled conditions and in ponds in both mono- and polyculture with carp (Witkowski et al. 1997, Cieśla et al. 2000). While pond rearing remains the leading production method, the technology for rearing larvae in closed recirculating systems is improving continually rendering this method an increasingly serious alternative especially for rearing the youngest varieties of stocking material. Rearing under

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controlled conditions, usually in aquaria or small tanks with strict control of water quality and environmental conditions is highly effective (Blancheton 2000, Kujawa 2004, Wolnicki 2005). In light of the significant costs linked to this method of rearing, one of the critical aspects of it is economic effectiveness, which, in practice, is actually one of the basic criteria for choosing a stocking material production method. The aim of the current work was to evaluate the economic profitability of rearing larval asp and ide in a closed recirculating system.

MATERIALS AND METHODS

The basis for the analysis was technical and production data from the raring of larval asp and ide in two fully quality-controlled close water recirculating systems (Table 1).

TABLE 1

Basic conditions and results of rearing of asp, *Aspius aspius*, and ide, *Leuciscus idus*

Species	Temperature (°C)	Rearing period (days)	Stocking density (indiv. dm^3)	Mean survival (%)	Total length (mm)
L. idus	25	21	300	91.7	20.5
A. aspius	25	21	300	92.7	20.1

The separate systems for each of the species comprised a large glass tank with a working volume of 50 dm^3 that functioned as a water bath in which were placed 18 smaller tanks with volumes of 1 dm^3 each that held the larvae. The bath was fitted with a heater connected to a thermal regulation unit that maintained a constant water temperature (±0.1°C), fluorescent lighting, and an external turbine filter and rain butt. The water temperature of 25°C during rearing was close to optimal for these species (Kujawa 2004, Wolnicki 2005). One side of the small tanks was replaced with 200 μm bar length mesh gauze, and a rain butt supplied with an external conveyor filter (capacity 400 dm^3 h^{-1}) supplied each small tank and permitted continuous water circulation and oxygenation. External filters with sponges and ceramic substrate permitted maintaining the appropriate oxygen level in the tanks and also ensured the mechanical and biological purification of the water. The parallel rearing of the two species analyzed was conducted for 21 days at a stocking density of 300 indiv. dm^{-3}. The daily photoperiod was stable at 12L:12D. The fish were fed three times daily *ad libitum* with live Artemia nauplii. Every morning prior to feeding, the aquaria were cleaned of feed detritus and fish excrement and 30% of the water was exchanged (about 15 dm^3) with fresh water (from the water mains) of the same temperature.

The cost and profit analysis presented in this paper was performed in categories of fixed and variable costs (Turkowski et al. 2008). Then the threshold parameters that determine profitability were calculated, including the minimum price, the planned price, and the border level of mean variable costs. The margins of economic safety based on the price of juvenile fish and the average variable costs were also calculated.

RESULTS AND DISCUSSION

REARING COSTS

The rearing costs were dominated by the variable costs, which were 93.37 (ide) and 94.07% (asp) of the overall costs (Table 2), and were slightly lower than when rearing the same species in a semi-closed system (98.38 and 97.55%, respectively; Turkowski et al. 2008). The fixed costs for the rearing of both species were low and ranged from 5.93 to 6.63% of the overall costs (Table 2). Despite their relatively low level, they were approximately tree times those incurred during production in semi-closed systems (Turkowski et al. 2008).

The variable costs of larval asp rearing were higher than those for ide (Table 2). This was because of the cost of the stocking material for the venture, which was over 27% higher for asp at the same stocking density than for ide (Table 2). As was the case with rearing these species in a semi-closed system (Turkowski et al. 2008), the purchase of stocking material was the greatest of the variable costs in each rearing variant. Labor costs comprised a similar share of the variable costs for asp and ide at 34.67 and 38.77% of the overall costs, respectively. Similarly significant shares of labor costs were noted in the controlled rearing of other fish species. For example, in pikeperch, *Sander lucioperca* (L.), labor was 36% of the variable costs (Zakęś and Szkudlarek 1996), while for the South American pacu, *Piaractus mesopotamicus* (Holmberg), they ranged from 33 to 56% (Jomori et al. 2005). The production costs in the semi-closed system (Turkowski et al. 2008) were distinctly lower at a maximum of 15.6%.

Costs for energy, water, and sewage were relatively low and did not exceed 4.2% of the overall costs for either asp or ide (Table 2).

TABLE 2

Expenditures and rearing costs of asp, *Aspius aspius* and ide, *Leuciscus idus*

Itemization	*Aspius aspius* Expenditure	Unit cost (PLN)	Cost (PLN)	Share (%)	*Leuciscus idus* Expenditure	Unit cost (PLN)	Cost (PLN)	Share (%)
Stocking material (indiv.)	5400	0.0220	118.80	37.44	5400	0.016	86.40	30.45
Feed, including:								
Artemia (cysts + incubation) (kg)	0.435	114.40	49.76	15.68	0.425	114.40	48.62	17.13
Labor, including:				34.67				38.77
Stocking (rgh)	2.00	11.00	22.00		2.00	11.00	22.00	
Cleaning + feeding (rgh)	7.00	11.00	77.00		7.00	11.00	77.00	
Supervision and monitoring (rgh)	1.00	11.00	11.00		1.00	11.00	11.00	
Electricity				3.30				3.69
Heating water (kwh)	7.2	0.3536	2.55		7.2	0.3536	2.55	
Lighting (kwh)	6.4	0.3536	2.26		6.4	0.3536	2.26	
Filtration (kwh)	9.6	0.3536	3.39		9.6	0.3536	3.39	
Aeration (kwh)	6.4	0.3536	2.26		6.4	0.3536	2.26	
Water consumption + sewage charges (m^3)	0.3	4.89	1.47	0.46	0.3	4.89	1.47	0.52
Chemicals, cleaning products and others			8.00	2.52			8.00	2.82
Total Variable Costs			298.50	94.07			264.95	93.37
Capital costs (PLN)	1/2	2.68	1.34		1/2	2.68	1.34	
Set of 2 aquaria (unit)	1/2	8.33	4.17		1/2	8.33	4.17	
Installation (unit)	1/2	16.6	8.30		1/2	16.6	8.30	
Incubators for Artemia (unit)	1/2	10.00	5.00		1/2	10.00	5.00	
Total Fixed Costs			18.81	5.93			18.81	6.63
Overall Costs			317.30	100.00			283.76	100.00

In this instance, this group of costs were threefold lower with the closed system in comparison to the semi-closed system (Turkowski et al. 2008). The other variable costs for chemicals, cleaning products and others were half those of the semi-closed system (Table 2). Substantial savings in electric energy consumption are typical of recirculating systems in comparison with open systems (Blancheton 2000). Increasing energy and water costs have played an important role, especially in recent years, in the dynamic development of closed recirculating systems used in freshwater and salt-water aquaculture (Hart et al. 1994, Halachmi 2006, Fuller 2007).

PROFIT

Each of the rearing variants tested ended with a positive financial result (Table 3). The greatest profit was earned by rearing asp, and at 934.20 PLN it was fourfold higher than that of rearing ide under the same conditions (Table 3).

TABLE 3

Production and economic results of rearing of asp, *Aspius aspius* and ide, *Leuciscus idus*. BLAVC – border level of average variable costs; MSVP – margins of safety of the venture in terms of price, MSVAVC – margins of safety of the venture in terms of average variable costs

Itemization	*A. aspius*	*L. idus*
Survival (%)	92.7	91.7
Production (indiv.)	5006	4952
Profit (PLN)	934.2	211.4
Average market purchase price (PLN indiv.$^{-1}$)	0.25	0.10
Average variable cost (PLN indiv.$^{-1}$)	0.06	0.05
Break-even point (BEP) (indiv.)	99	404
Minimum price (PLN indiv.$^{-1}$)	0.06	0.06
Planned price (PLN indiv.$^{-1}$)	0.26	0.26
BLAVC (PLN indiv.$^{-1}$)	0.25	0.10
MSVP (%)	75	43
MSVAVC (%)	76	44

These results were lower than those obtained in the semi-closed system (Turkowski et al. 2008) because the production scale was lower. The differences in the profits earned between these two systems certainly would have been more pronounced if it were not for the decidedly higher larval survival rate (>90%) achieved in the closed water system (Table 3). Such high (and even higher) production efficiency was achieved during the rearing of other rheophilic cyprinid species under controlled conditions (Kujawa 2004). Another important factor in the profitability of rearing was the purchase price of the stocking material. The mean market price for juvenile asp individuals was 250% higher than that for ide (Table 3).

BREAK-EVEN POINT (BEP)

The break-even point was analogous to the profit level. The lowest, which is the most advantageous, was noted for asp and was 99 individuals (Table 3). This means that rearing even at such a small scale generates returns on the fixed and variable costs of the venture. The break-even point attained was equally advantageous, because it was much lower than the actual production scale. However, in comparison with asp it was fourfold higher (Table 3). This was determined primarily by the higher market price of asp.

Similar relationships in the break-even point of ide and asp were observed in semi-closed systems (Turkowski et al. 2008). However, to obtain a balance between profit and costs in closed systems it would be necessary to rear a threefold larger quantity of juvenile fish. This was due to the distinctly higher fixed costs of closed systems.

PLANNED PRICE

Earning a theoretical profit of 1000 PLN was not realistic during the rearing analyzed currently; the closest was achieved from rearing asp. The planned price was, in this instance, 0.26 PLN, and was only 0.01 PLN lower than the market price (Table 3). The planned price of the larval asp in the semi-closed system (Turkowski et al. 2008) was substantially lower (0.19 PLN) from the market price (0.26 PLN). The planned profit for the ide rearing was not feasible since the planned price was higher than the market price (Table 3).

MARGIN OF SAFETY OF REARING AS A POTENTIAL COMMERCIAL VENTURE

The greatest economic safety was noted with asp, which, thanks to the market price and the average variable costs, was high at about 76% (Table 3). The rearing of the second species was much lower, but still safe at about 44% (Table 3). The differences in the indices at nearly identical minimum prices and the borders of the average variable costs resulted from the different market prices (Table 3).

The indices above confirm the low financial risk of rearing larval rheophilic cyprinid fish under controlled conditions; however, the risk associated with production in a semi-closed system was substantially lower (Turkowski et al. 2008). One of the ways to increase the profitability of producing stocking material at the very high survival and relatively low energy costs of closed systems is to increase the scale of production. This would permit reducing the relatively high labor costs (Zakęś and Szkudlarek 1996). It would also be helpful to produce the initial stocking material.

Since it is able to ensure very high production effectiveness, the closed water system presented in this paper appears to be suitable for the production of the more difficult species that have specific environmental requirements, but which also command a higher individual price at sale (e.g., ornamental fish; Lim et al. 2003, Sales and Janssens 2003).

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STRESZCZENIE

EKONOMICZNE ASPEKTY PODCHOWU LARW BOLENIA, *ASPIUS ASPIUS* (L.), I JAZIA, *LEUCISCUS IDUS* (L.) W SYSTEMIE O ZAMKNIĘTYM PRZEPŁYWIE WODY

Oceniono opłacalności podchowu larw dwóch gatunków należących do grupy karpiowatych ryb reofilnych, tj. bolenia *Aspius aspius* (L.) i jazia *Leuciscus idus* (L.) w dwóch niezależnych systemach 18 akwariów o zamkniętym systemie obiegu wody i łącznej pojemności 36 dm^3. Ryby karmiono wyłącznie świeżo wyklutymi naupliusami solowca. Wykazano, że podchowy obu gatunków były opłacalne i cechowały się względnie niskim ryzykiem finansowym. Z punktu widzenia opłacalności najistotniejszym czynnikiem okazała się cena zbytu materiału zarybieniowego. W przypadku bolenia była ona o 2,5-krotnie wyższa od ceny jazia. Podchów larw bolenia cechował się najwyższą opłacalnością i najlepszymi wskaźnikami określającymi warunki tej opłacalności. Dochód z tytułu produkcji tego gatunku był przeszło cztery razy wyższy niż w przypadku jazia.