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ECONOMIC ASPECTS OF THE EXPERIMENTAL REARING OF ASP, *ASPIUS ASPIUS* (L.), IDE, *LEUCISCUS IDUS* (L.), AND DACE, *LEUCISCUS LEUCISCUS* (L.), UNDER CONTROLLED CONDITIONS

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ABSTRACT. The profitability of rearing larval asp, *Aspius aspius* (L.), ide, *Leuciscus idus* (L.), and dace, *Leuciscus leuciscus* (L.), was assessed in a system of 12 aquaria with a combined volume of 600 dm^3. Two feeding variants were used: a) natural feed exclusively; b) natural feed plus formulated feed after seven days of rearing. All rearing variants were profitable and posed relatively low financial risks. The variant in which only natural feed was used was the most profitable. The savings incurred by the addition of formulated feed did not offset the profit lost from lower larval stock survival rates. In light of profitability, the most important aspect of larval rearing was the price of the stocking material, which was 250% higher for asp than for ide or dace. In both feeding variants, asp rearing was the most profitable and the values of the indices used to describe profitability were the best.

Key words: RHEOPHILIC CYPRINID FISH, EXPENDITURES, PROFITABILITY, ANALYSIS OF THE BREAK-EVEN POINT

INTRODUCTION

The disappearance of autochthonous species of rheophilic fish that are attractive to recreational fisheries from the waters of Poland and other European countries is a progressive process that has been observed for many years (Penczak et al. 1998). Natural resources of these fish are being depleted progressively by limitations of natural spawning grounds and migration routes, the pollution of the natural environment, and the construction of dams and other barriers (Penczak et al. 1998, Penczak and Kruk 2000). The artificial reproduction of rheophilic fish is one of the activities aimed at reinforcing endemic populations of the representatives of this group of fish (Wojda et al. 1993, Śliwiński 2000, Kucharczyk et al. 2006). The reproduction of these species is also ben-

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eficial in that it increases the range of species available for potential buyers, it better utilizes existing production facilities, and leads to improved production methods (Śliwiński 2000). It is indisputable that the condition for the commercial reproduction and rearing of rheophilic cyprinid fish is its profitability.

The aim of the current work is to evaluate the profitability of rearing larval asp, *Aspius aspius* (L.), ide, *Leuciscus idus* (L.), and dace, *Leuciscus leuciscus* (L.), in experimental semi-closed systems and to present the conditions that must be met to ensure the profitability of rearing.

MATERIALS AND METHODS

The foundation for the analysis was technical and production data from the rearing of asp, ide, and dace in a system of 12 aquaria with volumes of 50 dm^3 each. The initial study material was asp, ide, and dace larvae obtained from the controlled reproduction of spawners at the hatchery of the Department of Lake and River Fisheries, University of Warmia and Mazury in Olsztyn. The three species were reared simultaneously for a period of three weeks in semi-closed water systems. The following basic parameters were monitored: water temperature, photoperiod, dissolved oxygen content in the water, and the quantities of nitrogen compounds. During rearing the water temperature was 25°C. The rearing tanks (50 dm^3 aquaria) were illuminated with fluorescent light for 12h (photoperiod 12L:12D). Rainwater was used to supply the system, and it was delivered separately to each aquaria after it had been filtered through biological substrate. Since a high stocking density was applied (200 indiv. dm^{-3}), it was necessary to exchange some of the water with fresh tap water. All of the experimental and control groups were fed three times daily at five-hour intervals. Two feeding variants were applied: one group was fed only natural feed (nauplii of *Artemia* sp.); the second received natural feed for the first week, and then Artemia supplemented with Perla feed for the next seven days during which the quantity of Artemia did not exceed 50% of the ration fed to the group receiving only natural feed. In the last week of rearing, the fish were fed only formulated feed.

Costs and profits were analyzed, and then the threshold parameters were calculated that guaranteed rearing profitability, as follows: break-even point; minimum price; planned price; the border level of mean variable costs. The economic safety margin of rearing was calculated based on the price of juvenile fish and mean variable costs. The parameters are elements of the so-called profitability threshold analysis (Turkowski 1995, Soliman et al. 2000, Luderer et al. 2007).

REARING COSTS

Rearing costs were analyzed in categories of fixed and variable costs. Costs were calculated in accordance with the principles of the actual production costs (Sawicki 2001). The calculations were based on the direct costs, and the analysis omitted overall costs linked to hatchery operations, building depreciation, administrative costs and others that were not dependent on the scale of the analyzed venture (i.e., those that were the same prior to the realization of rearing). Similar principles were applied in other studies of the economic effectiveness of such ventures (Manteuffel-Szoege and Interewicz 1998, Turkowski 2002). Variable costs depended on stocking density and the length of the rearing period; however, fixed costs comprised of depreciation and capital costs were unchanged.

Depreciation was calculated with the linear method (Bombeo-Tuburan et al. 2001, Gomes et al. 2006). The basis for calculating depreciation write offs was the anticipated exploitation period of the equipment and fittings (Samonte et al. 1993, Bombeo-Tuburan et al. 2001, Gomes et al. 2006). The calculations were based on the actual time the equipment was used for rearing, which was, including preparation time, one month. The equipment was used for different purposes for the other eleven months.

The measure of capital costs was designated as the potential benefits (interest payments) lost as a result of using financial resources to purchase equipment (Allen et al. 1984, Warnecke et al. 1993, Thorarinsson and Powell 2006). Although not usually found in typical accounting analyses, capital costs are a significant element of economic analyses, and this applies also to the branch of aquaculture (Agbayani et al. 1991, Bacon et al. 1996, Shang et al. 1998, Triño et. al. 1999, De Ionno et al. 2006, Ofor 2007). These costs were calculated according to the following formula:

$$K_k=I^{\leftrightarrow}p_r \qquad (1)$$

where:

K_k – capital costs (PLN),

I – expenditures incurred for equipment purchased (PLN),

p_r – real interest rate.

The real interest rate was calculated according to the formula (Smaga 2000):

$$p_r = (p_n - f) \times (1 + f)^{-1} \tag{2}$$

where:

p_n – nominal interest rate,

f – inflation rate.

The calculations were based on the current profitability rate of long-term treasury bonds (6.0% in July 2008) as the nominal interest rate. The inflation rate was 4.6%, which was drawn from the index of price increases of consumer goods and services measured as the price relation between June 2007 and June 2008. Prices and labor costs were those of July 2008. The price of Artemia was converted from USD to PLN at an exchange rate of 1 USD = 2.0276 PLN as of July 16, 2008. The price of stocking material used for calculating costs and potential revenue and income was taken from the "Price List of Stocking Material" from the Regional Board of Water Management in Gdańsk for 2008.

INCOME

Income was calculated by subtracting the total variable and fixed costs incurred in production from the value of the material produced:

$$D = Q \times c - (K_z + K_s) \tag{3}$$

where:

D – income (PLN),

Q – number of juvenile individuals of a given species reared in one production cycle (indiv.),

c – price of juvenile individuals of a given species (PLN indiv.$^{-1}$),

K_z – variable costs (PLN),

K_s – fixed costs (PLN).

The income and revenue presented in the current paper refer to potential values that would be achieved if 100% of the stocking material produced was sold. Studying sales possibilities requires specialist market and marketing research, which is of a wholly different character from and outside the scope of the current work. According to Pastusiak (2003), assuming that the value of production is equal to that of sales provides the foundation for calculating the profitability threshold and the remaining parameters that determine the profitability of rearing.

BREAK-EVEN POINT (BEP)

The profitability threshold refers to the amount of production that is equal to the costs incurred (Turkowski 1995, Soliman et al. 2000, Luderer et al. 2007). Further increases in production, under the same price conditions, generates revenue above costs. Thus, the more production increases above the BEP, the more profitable the venture will be. BEP was calculated according to the following formula (Turkowski 1995):

$$x = K_s \leftrightarrow (c - a)^{-1} \qquad (4)$$

where:

x – break-even point (indiv.),

a – average variable costs (PLN indiv.$^{-1}$),

The average variable costs were calculated as follows:

$$a = K_z \leftrightarrow Q^{-1} \qquad (5)$$

MINIMUM PRICE

The minimum price is that at which there are neither losses nor gains, and the cost of production is equal to that of the revenue earned. This price is calculated with a transformation of equation (4) in which potential or planned production that is possible to achieve under given rearing conditions is used instead of production at the profitability threshold:

$$c_{min} = (Ks \leftrightarrow Q^{-1}) + a \qquad (6)$$

where:

c_{min} – minimum price (PLN indiv.$^{-1}$),

PLANNED PRICE

The planned price is that which ensures achieving a determined income. It was calculated with a transformation of formula (6):

$$c_{plan} = (K_s + D) \leftrightarrow Q^{-1} + a \qquad (7)$$

where:

c_{plan} – planned price (PLN indiv.$^{-1}$),

D – planned income (PLN).

BORDER LEVEL OF AVERAGE VARIABLE COSTS

The border level of average variable costs is the maximum value at which a given venture does not produce losses and is at the threshold of profitability (zero level of profit and loss). This was calculated with the following formula:

$$BLAVC = (c_{ryn} \cdot Q - K_s) \cdot Q^{-1} \tag{8}$$

where:

BLAVC – border level of average variable costs (PLN indiv.$^{-1}$),

c_{ryn} – market price (PLN indiv.$^{-1}$).

MARGINS OF SAFETY

The margins of safety of the venture were analyzed in the study in terms of the the price of juvenile individuals (MSVP) as well as the margins of safety of the venture in terms of average variable costs (MSVAVC). MSVP was calculated as follows:

$$MSVP = (c_{ryn} - c_{\min}) \cdot c_{ryn}^{-1} \cdot 100\% \tag{9}$$

where:

MSVP – margin of safety of the venture in terms of price (%).

The MSVAVC was calculated according to the following formula:

$$MSVAVC = (BLAVC - a) \cdot BLAVC^{-1} \cdot 100\% \tag{10}$$

where:

MSVAVC – margin of safety of the venture in terms of the average variable costs (%).

RESULTS

The results of the three-week rearing period of larval asp, ide, and dace were expressed as the survival and the final sizes of the fish. These differed among the species and were dependent on the feeding treatment applied. The survival rates of the species reared ranged from 66 to 79%. Independently of the feeding treatment applied, the highest length and weight growth at the end of the experiment was noted in asp. The juvenile ide and dace were distinctly smaller (Table 1).

TABLE 1

Survival, length and weight (mean ± SD) of asp, *Aspius aspius*, ide, *Leuciscus idus*, and dace, *Leuciscus leuciscus* at the beginning and end of the experiment

Parameter	*A. aspius*		*L. idus*		*L. leuciscus*	
	Artemia	Artemia + feed	Artemia	Artemia + feed	Artemia	Artemia + feed
Initial length (mm)	9.55 ± 0.40	9.55 ± 0.5	8.1 ± 0.24	8.1 ± 0.25	9.12 ± 0.40	9.12 ± 0.41
Initial weight (mg)	3.16 ± 0.19	3.16 ± 0.20	1.6 ± 0.20	1.6 ± 0.30	3.0 ± 0.40	3.0 ± 0.50
Final length (mm)	23.55 ± 1.49	22.71 ± 1.67	17.88 ± 1.58	18.93 ± 1.32	17.94 ± 1.59	15.59 ± 1.93
Final weight (mg)	88.43 ± 17.31	74.24 ± 21.72	35.72 ± 1.89	48.16 ± 2.13	49.12 ± 1.98	49.60 ± 3.32
Survival (%)	72	66	79	72	75	70

REARING COSTS

Variable costs comprised the majority of the rearing expenditures and ranged from 97.55 to 98.38% of overall costs (Table 2 and 3). The fixed costs of each rearing variant were minimal (5.92 PLN), and were from 1.62 to 2.23% of the overall costs (Tables 2 and 3). Independently of the feeding treatment, the highest variable costs (including the minimal share of fixed costs) and simultaneously the overall costs were incurred by rearing larval asp, followed by ide and then dace (Tables 2 and 3). The purchase costs of the larvae determined this, and were 27 and over 45% higher for asp at the same stocking density than they were for ide or dace, respectively (Tables 2 and 3). The stocking material was the major variable cost in each rearing variant. The highest was in the feeding treatment with the addition of formulated feed, and was from 49 to 64%, (Table 3). A slightly lower share was noted in the treatment without the addition of formulated feed, in which it ranged from 45 to 60% (Table 2). The addition of formulated feed lowered the feeding costs by almost half (from 49.05 PLN to 25.72 PLN), and, if, in the feeding treatment without the addition of formulated feed, the feeding costs of 13 to 18% were the second largest component of the variable costs, (Table 2), then the share of this in the feeding variant with the addition of formulated feed ranged from just 7 to 10% (Table 3). In the second variant, labor costs comprised a greater share than did those for feeding (Table 3). Electricity costs were relatively low, and did not exceed 8% of the overall costs in any of the rearing variants (Tables 2 and 3). The other components of the variable costs, including water and sewage charges, chemicals, cleaning products and others, were at a similar level (Tables 2 and 3).

TABLE 2

Expenditures and rearing costs of asp, *Aspius aspius*, ide, *Leuciscus idus*, and dace, *Leuciscus leuciscus* fed Artemia nauplii

Itemization	Expen-diture	*A. aspius* Unit cost (PLN)	*A. aspius* Cost (PLN)	*A. aspius* Share (%)	*L. idus* Unit cost (PLN)	*L. idus* Cost (PLN)	*L. idus* Share (%)	*L. leusciscus* Unit cost (PLN)	*L. leusciscus* Cost (PLN)	*L. leusciscus* Share (%)
Stocking material (indiv.)	10000	0.0220	220.00	60.24	0.016	160.00	52.42	0.012	120.00	45.25
Feeding, including:				13.43			16.07			18.49
Artemia (cysts + incubation)(kg)	0.420	116.78	49.05		116.78	49.05		116.78	49.05	
Labor, including:				13.05			15.62			17.97
Stocking (rgh)	0.17	11.00	1.83		11.00	1.83		11.00	1.83	
Cleaning + feeding (rgh)	3.33	11.00	36.67		11.00	36.67		11.00	36.67	
Supervision and monitoring (rgh)	0.83	11.00	9.17		11.00	9.17		11.00	9.17	
Electricity				5.13			6.14			7.07
Water heating (kwh)	48.0	0.3536	16.97		0.3536	16.97		0.3536	16.97	
Lighting (kwh)	0.6	0.3536	0.21		0.3536	0.21		0.3536	0.21	
Aeration (kwh)	4.4	0.3536	1.56		0.3536	1.56		0.3536	1.56	
Water consumption + sewage charges (m^3)	3.17	4.89	15.50	4.24	4.89	15.50	5.08	4.89	15.50	5.84
Chemicals, cleaning products, and others			8.33	2.28		8.33	2.73		8.33	3.14
Total Variable Costs			359.29	98.38		299.29	98.06		259.29	97.77
Capital costs (PLN)	1/6	3.01	0.50		3.01	0.50		3.01	0.50	
Set of 12 aquaria (unit)	1/6	14.16	2.36		14.16	2.36		14.16	2.36	
Installation (unit)	1/6	8.33	1.39		8.33	1.39		8.33	1.39	
Incubators for Artemia (unit)	1/6	10.00	1.67		10.00	1.67		10.00	1.67	
Total Fixed costs			5.92	1.62		5.92	1.94		5.92	2.23
Overall costs			365.21	100.00		305.21	100.00		265.21	100.00

TABLE 3

Expenditures and rearing costs of asp, *Aspius aspius*, ide, *Leuciscus idus*, and dace, *Leuciscus leuciscus* fed Artemia nauplii and formulated feed

Itemization	*A. aspius*				*L. idus*				*L. leusciscus*			
	Expen-diture	Unit cost (PLN)	Cost (PLN)	Share (%)	Expen-diture	Unit cost (PLN)	Cost (PLN)	Share (%)	Expen-diture	Unit cost (PLN)	Cost (PLN)	Share (%)
Stocking material (indiv.)	10000	0.022	220.00	64.35	10000	0.016	160.00	56.78	10000	0.012	120.00	49.65
Feeding, including:				7.52				9.09				10.56
Artemia (cysts + incubation) (kg)	0.210	116.78	24.52		0.210	116.78	24.52		0.210	116.78	24.52	
Labor, including:	0.240	5.00	1.20		0.220	5.00	1.10		0.200	5.00	1.00	
Stocking (rgh)				13.94				16.92				19.72
Cleaning + feeding (rgh)	0.17	11.00	1.83		0.17	11.00	1.83		0.17	11.00	1.83	
Supervision and monitoring (rgh)	3.33	11.00	36.67		3.33	11.00	36.67		3.33	11.00	36.67	
Electricity	0.83	11.00	9.17		0.83	11.00	9.17		0.83	11.00	9.17	
Water heating (kwh)				5.48				6.65				7.75
Lighting (kwh)	48.0	0.3536	16.97		48.0	0.3536	16.97		48.0	0.3536	16.97	
Aeration (kwh)	0.6	0.3536	0.21		0.6	0.3536	0.21		0.6	0.3536	0.21	
Water consumption + sewage charges (m^3)	4.4	0.3536	1.56		4.4	0.3536	1.56		4.4	0.3536	1.56	
Chemicals, cleaning products, and others	3.17	4.89	15.50	4.53	3.17	4.89	15.50	5.50	3.17	4.89	15.50	6.41
Total Variable Costs			8.33	2.44			8.33	2.96			8.33	3.45
Capital costs (PLN)			335.97	98.27			275.87	97.90			235.77	97.55
Set of 12 aquaria (unit)	1/6	3.01	0.50		1/6	3.01	0.50		1/6	3.01	0.50	
Installation (unit)	1/6	14.16	2.36		1/6	14.16	2.36		1/6	14.16	2.36	
Incubators for Artemia (unit)	1/6	8.33	1.39		1/6	8.33	1.39		1/6	8.33	1.39	
Total Fixed costs	1/6	10.00	1.67		1/6	10.00	1.67		1/6	10.00	1.67	
Overall costs			5.92	1.73			5.92	2.10			5.92	2.45
			341.88	100.00			281.78	100.00			241.68	100.00

PROFIT

Each of the rearing variants studied was profitable and ended with positive financial results (Table 4). The highest profit was earned by the rearing of asp larvae, and was about 1435 PLN for the feeding treatment without the addition of formulated feed. This was over 66% higher than the rearing of ide or dace under similar conditions (Table 4). Although the addition of formulated feed lowered variable costs (Table 2 and 3), it also lowered larval survival enough that the savings in feeding costs did not compensate for it (Tables 2, 3, and 4). The most significant factor in rearing profitability was the price of the stocking material. The price of juvenile asp was 250% higher than that for ide or dace (Table 4). Despite the lowest survival rate, the asp reared with the addition of formulated feed generated a profit of 1308 PLN thanks to the high market price for this species. This was in excess of 66 and 65% higher than the profit earned by rearing ide and dace, which both had substantially higher survival rates (Table 4).

TABLE 4

Economic results of two rearing variants of asp, *Aspius aspius*, ide, *Leuciscus idus*, and dace, *Leuciscus leuciscus*

Itemization	*A. aspius*		*L. idus*		*L. leuciscus*	
	Artemia	Artemia + feed	Artemia	Artemia + feed	Artemia	Artemia + feed
Sale price (PLN indiv.$^{-1}$)	0.25	0.25	0.10	0.10	0.10	0.10
Income (PLN)	1435	1308	485	438	485	453
Average variable costs (PLN indiv.$^{-1}$)	0.05	0.05	0.04	0.04	0.03	0.03
Break-even point (unit)	30	30	95	96	90	90
Minimum price (PLN indiv.$^{-1}$)	0.05	0.05	0.04	0.04	0.04	0.03
Forecast price (PLN indiv.$^{-1}$)	0.19	0.20	0.17	0.18	0.17	0.18
BLAVC (PLN indiv.$^{-1}$)	0.25	0.25	0.10	0.10	0.10	0,10
MSVP (%)	80	79	61	61	65	65
MSVAVC (%)	80	80	62	61	65	66

BREAK-EVEN POINT (BEP)

The break-even point was similar to the profit level. The lowest, which was the most advantageous, was for asp and, regardless of the feeding treatment, was 30 individuals (Table 4). This means that even such a low production scale returns the fixed and variable costs invested in the venture, and each additional individual increases potential profit. BEP for ide and dace were also very advantageous since they were just below the actual scale of production, but in comparison with asp they were about three-fold higher (Table 4). This was determined primarily by the higher market price for asp.

PLANNED PRICE

The theoretical profit of 1000 PLN earned by the rearing variants analyzed was realistic with regard to asp since only with regard to this species was the planned price of 0.19 and 0.20 PLN indiv.$^{-1}$ in both feeding treatments lower than the market price (Table 4). It was impossible to achieve the preceding profit from the rearing of the other two species since the calculated planned price was higher than the market price (Table 4).

MARGINS OF SAFETY

Economically, rearing asp was the safest venture since the market price and the average variable costs were at the high level of about 80% in both feeding variants (Table 5). The rearing of the other two species were at much lower, although still safe, levels of about 65% for ide and 61% for dace (Table 4). The values of the margins of safety in all the rearing variants with regard to both price and average variable costs were essentially the same (Table 4). The reason for this was the specific value of the minimal price and the border average variable costs. Because of the small share of fixed costs in the overall costs (Tables 2 and 3), the minimal prices were at the lowest level that was equal to, in principle, the average variable cost (Table 4). However, for the same reason, the border average variable cost was at the highest level equal to the market prices (Table 4). The preceding indicators attest to the relatively low financial risk of rearing larval rheophilic cyprinid fish.

DISCUSSION

The value of the production of juvenile rheophilic cyprinid fish as stocking material has reached high levels in Poland in recent years (Mickiewicz et al. 2007). This is due in part to the relative simplicity of rearing technology, as well as to the good biological conditions for stocking that prevail in running waters in early summer (Wojda 2004). To date, no results regarding the economic aspects of rearing rheophilic cyprinid fish under controlled conditions have been published, which makes direct comparisons difficult. In comparison with the rearing of other fish species, differences in the cost structure stem from the various feeding and habitat requirements of these species, as well as from varied rearing techniques. The similarly low levels of fixed costs and the respectively high variable costs, the relatively similar share of feeding costs, and the relatively high survival rates ranging from 67 to 96% are all worthy of note (Table 5).

TABLE 5

Survival and expenditures for controlled rearing of selected fish species

Itemization	Survival (%)	Fixed costs (%)	Variable costs (%)	Stock (%)	Feed (%)	Labor (%)	Energy (%)	Maintenance, repairs, other (%)
A. aspius								
Artemia	72	2	98	60	13	13	5	7
Artemia + feed	66	2	98	64	8	14	6	7
L. idus								
Artemia	79	2	98	52	16	16	6	8
Artemia + feed	72	2	98	57	9	17	7	8
L. leuciscus								
Artemia	75	2	98	45	18	18	7	9
Artemia + feed	70	2	98	50	11	20	8	10
S. lucioperca[a)]	67	-	100	27	10	36	27	-
P. mesopotamicus[b)]								
0	-	-	100	30	14	56	-	-
3	96	4	96	26	16	50	1	3
6	86	6	94	22	25	42	1	4
9	84	6	94	17	39	33	1	4

a) Zakęś and Szkudlarek (1996) reared summer fry to fall fry, b) Jomori et al. (2005) 0, 3, 6, 9 respectively of the 45-day rearing of larval P. mesopotamicus in earthen ponds preceded by 0-, 3-, 6-, and 9-day rearing under controlled conditions

The results of rearing under controlled conditions indicate that production is highly profitable, especially that of asp. This form of rearing may be an interesting alternative to rearing in earthen ponds. In comparison to pond production, larval survival and production intensity is decided higher under controlled conditions (Wolnicki 2005). Survival as high as over 90% can be achieved in closed systems (Kupren et al. 2008), but in ponds it is substantially lower, and because environmental conditions are impossible to control it is difficult to predict the results of rearing. Of the species analyzed in the current work, the technology for rearing juveniles in ponds is best developed for ide (Wojda 2004, Mickiewicz et al. 2007), and mortality at the conclusion of rearing fluctuates at about 50% (Cieśla 1996). Rearing under controlled conditions makes it possible to produce stocking material without earthen ponds, which can also lead to improvements in pond rearing. The initial rearing of the South American fish pacu, *Piaractus* *mesopotamicus* (Holmberg), larvae under controlled conditions followed by later rearing in ponds was more economically effective as the period of controlled rearing increased (Jomori et al. 2005). The poorest economic results were noted when the larvae were stocked directly into the ponds (Jomori et al. 2005).

The high intensity production of stocking material under controlled conditions requires attention and the appropriate professional qualifications, but it also permits achieving high production yield, which is the main reason for the intense development of recirculating systems (Jomori et al. 2005, Kupren et al. 2008). Improving the physicochemical parameters of the water in closed systems, the use of additional devices such as feeders (Papandroulakis et al. 2002) or powering the systems with solar energy (Fuller 2007) should lead to increasing intensity with the simultaneous decrease in the costs of this method for producing stocking material.

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STRESZCZENIE

EKONOMICZNE ASPEKTY WYCHOWU EKSPERYMENTALNEGO LARW BOLENIA, *ASPIUS ASPIUS* (L.), JAZIA, *LEUCISCUS IDUS* (L.), I JELCA, *LEUCISCUS LEUCISCUS* (L.) W WARUNKACH KONTROLOWANYCH

Oceniono opłacalności podchowu larw bolenia *Aspius aspius* (L.), jazia *Leuciscus idus* (L.) i jelca *Leuciscus leuciscus* (L.) w systemie 12 akwariów, o łącznej pojemności 600 dm^3. Stosowano dwa warianty żywieniowe: a) wyłącznie z pokarmem naturalnym oraz b) z pokarmem naturalnym i z paszą zadawaną w późniejszym okresie podchowu. Wszystkie warianty podchowu były opłacalne i cechowały się względnie niskim ryzykiem finansowym.

Największe dochody osiągnięto w wariantach, w których stosowano wyłącznie pokarm naturalny. Oszczędności w kosztach żywienia związane z dodatkiem pasz były mniejsze od spadku przychodów związanych z niższą przeżywalnością obsad w tych wariantach podchowu. Z punktu widzenia opłacalności podchowu najistotniejszym czynnikiem okazała się cena zbytu materiału zarybieniowego, która w przypadku bolenia była o 250% wyższa od cen jazia oraz jelca. W obu wariantach żywieniowych podchów larw bolenia cechował się najwyższą opłacalnością i najlepszymi wskaźnikami określającymi warunki tej opłacalności. W wariancie z karmieniem pokarmem naturalnym oraz z dodatkiem pasz dochód z tytułu podchowu larw bolenia kształtował się odpowiednio na poziomie 1435 zł oraz 1308 zł i był o ponad 65% wyższy od analogicznego podchowu larw dwóch pozostałych gatunków ryb.