Response of larval and juvenile rudd *Scardinius erythrophthalmus* (L.) to different diets under controlled conditions

J. Wolnicki, J. Sikorska, R. Kamiński

Pond Fishery Department in Żabieniec, The Stanisław Sakowicz Inland Fisheries Institute in Olsztyn, Olsztyn, Poland

ABSTRACT: The growth and survival of rudd *Scardinius erythrophthalmus* (L.) were evaluated in a laboratory at 25°C. In 20-day Experiment 1, first-feeding larvae at the age of 4 days post-hatch (initially: TL = 5.7 mm, BW = 0.9 mg) were fed live *Artemia* nauplii or commercial dry feed (Aller Futura Larvae, AFL) or combinations of both. Even the longest period of initial feeding of nauplii (6 days) was insufficient to obtain satisfactory larval growth after weaning to AFL (TL = 12.4 mm and BW = 17.7 mg vs. TL = 18.9 mm and BW = 68.5 mg for the nauplii-fed fish, significant differences). Nauplii-fed older larvae (24 days post-hatch) were then used in Experiment 2, in which they were fed AFL or Ewos AgloNorse (EAN) dry feeds for 40 days. The EAN diet proved to be significantly ($P \leq 0.05$) superior to AFL regarding the final fish growth (TL = 36.5 mm and BW = 506.8 mg vs. TL = 33.4 mm and BW = 392.0 mg), final survival rates (97.6% vs. 100%) and the incidence of spinal deformities (0% vs. 13.5%).

Keywords: rudd; larvae; juveniles; feeding; growth; survival; body deformities

The rudd, *Scardinius erythrophthalmus*, is a cyprinid fish species inhabiting either stagnant waters (littoral zone of lakes, dam reservoirs, ponds) or the lower reaches of slowly-flowing streams and rivers throughout Europe and western Asia (Załachowski, 2000). In Europe, this fish occurs commonly, but its populations rarely become abundant enough to dominate other fish species (e.g. Ravera and Jamet, 1991). Lelek (1987) designated *S. erythrophthalmus* as an endangered European freshwater fish species.

The first attempts at the controlled propagation and larval rearing of *S. erythrophthalmus* were probably performed in the mid-1960s in the Netherlands (Klein Breteler, 1979). Since then, considerable knowledge has been amassed regarding the reproductive biology and techniques to stimulate the reproduction of this species (e.g. Kucharczyk et al., 1997; Bonisławska and Winnicki, 2002; Kopiejewska et al., 2004). In contrast, much remains unknown about larval rearing under controlled conditions, and this might be a bottleneck in the mass production of juveniles for stocking natural waters.

The aim of the present study was: (1) to evaluate the growth and survival of *S. erythrophthalmus* larvae from the first feeding in response to a dry commercial diet used exclusively or after initial feeding with live food; (2) to assess growth, survival, and the incidence of body deformities in older larvae and early juveniles, in response to two dry commercial diets.

MATERIAL AND METHODS

Aged 4 days post-hatch the first-feeding *S. erythrophthalmus* larvae (the pooled offspring of 3 female

Table 1. Feeding schedule employed in Experiment 1 with first-feeding *S. erythrophthalmus* larvae

Experimental group	Feeding schedule
L20F0	days 1–20 – live *Artemia* nauplii
L6F14	days 1–6 – live *Artemia* nauplii days 7–20 – Aller Futura Larvae dry feed
L4F16	days 1–4 – live *Artemia* nauplii days 5–20 – Aller Futura Larvae dry feed
L2F18	days 1–2 – live *Artemia* nauplii days 3–20 – Aller Futura Larvae dry feed
L0F20	days 1–20 – Aller Futura Larvae dry feed

and 3 male spawners) of initial total length of 5.7 ± 0.2 mm (mean ± SD) and mean wet body weight of 0.9 mg were used in Experiment 1. To stimulate ovulation in the females, mGnRH analogue Ovopel was used according to the standard propagation technique (Horváth et al., 1997).

A 20-day experiment was conducted in ten 10 dm^3 glass flow-through aquaria with a density of 50 larvae per dm^3. The experimental design comprised five feeding groups, all in duplicate (Table 1). The larvae were fed manually every 3 hours between 08:00 and 20:00. The live *Artemia* nauplii (EG grade, INVE Aquaculture B.V., Belgium) were fed in noticeable excess considered *ad libitum*. The daily feeding rates of the dry commercial diet for cyprinid fish (Aller Futura Larvae, Aller Aqua, Denmark; crude protein 64%, crude fat 12%, carbohydrates 5%, ash 11% as declared by the producer), always slightly excessive, were based on the visual assessment of larval appetite. The finest grade of the dry diet ("000") was used from the onset of the experiment until D13, and from D14 onward grade "00" was applied (particle size of 0.1–0.2 mm and 0.2–0.3 mm, respectively).

Experiment 2 was conducted on *S. erythrophthalmus* larvae aged 24 days after hatching with the initial total length of 18.9 ± 1.3 mm and body weight of 68.5 ± 15.9 mg (mean ± SD). Prior to Experiment 2, the larvae were reared for 20 days exclusively on live *Artemia* nauplii in Experiment 1 (group L20F0, Table 1). The fish were stocked in four glass flow-through aquaria of 10 dm^3 volume at a stocking density of 16.5 individuals per dm^3. Two commercial dry diets, Aller Futura Larvae (grade "0"; particle size 0.3–0.4 mm) and feed for marine fish larvae (AgloNorse Standard, Ewos, Norway; grade "1", particle size 0.4 mm; crude protein 59%, crude fat 20%, carbohydrates 5% and ash 12%, manufacturer's data) were evaluated in duplicate for 40 days. The feeding technique was the same as in Experiment 1. The daily rates of dry feeds were based on the visual assessment, and maintained at about satiation level.

In both experiments, the aquaria were continuously supplied with filtered, aerated water from the recirculation system. The temperature of 25°C (range ± 0.5°C), which is an optimum temperature for larvae and juveniles of most cyprinid fish species (Wolnicki, 2005), was kept in the aquaria throughout the experiments. The dissolved oxygen content in the aquaria was maintained at 70–90% of air saturation. Total ammonia and nitrites were kept at about 0.1 mg/dm^3 and below 0.02 mg/dm^3, respectively, and pH was 7.5–7.8. Temperature and oxygen were monitored systematically, whereas the remaining parameters twice a day. Fluorescent illumination of the aquaria (around 700 lx at the water surface) was provided between 08:00 and 21:00 (13L:11D). The aquaria bottom was cleaned of uneaten food and faeces twice a day. The dead fish were removed and counted during and after the cleaning of aquaria.

In Experiment 1, an initial random sample of 50 larvae was collected at the onset of day one (D1). At the end of D20, samples of 40 larvae were taken from each aquarium, and then all the remaining fish were counted. The final sample collected from group L20F0 was the initial sample for Experiment 2 (n = 80). Samples taken on the final day (D40) of Experiment 2 numbered 50 juvenile individuals per treatment. All of the fish sampled were preserved in 4% formalin.

In both experiments the individual total length (TL; measured to the nearest 0.01 mm) and individual wet body weight (BW; 0.1 mg) of the fish were determined in all samples (except the initial sample in Experiment 1, when mean BW was determined on the basis of the total fish biomass). The final survival rates and percentages of deformed individuals were determined as well. Duncan's multiple range test was used to compare the mean values of TL and BW. Survival percentages and percentage shares of deformed individuals were normalized using angular transformation, according to Sokal and Rohlf (1969). The level of significance was set at $P \leq 0.05$.

Table 2. Initial and final characteristics of *S. erythrophthalmus* fed live food or dry feed or their combinations for 20 days in Experiment 1

Parameter	Experimental group				
	L20F0	L6F14	L4F16	L2F18	L0F20
Initial total length (mm ± SD)			5.7 ± 0.2		
Final total length (mm ± SD)	18.9 ± 1.3^{a}	12.4 ± 1.1^{b}	10.9 ± 0.9^{c}	9.9 ± 0.8^{d}	9.0 ± 0.6^{e}
Initial body weight (mg)			0.9		
Final body weight (mg ± SD)	68.5 ± 15.9^{a}	17.7 ± 5.7^{b}	10.8 ± 3.2^{c}	8.2 ± 2.1^{d}	5.7 ± 1.6^{e}
Final survival rate (%)	98.7^{a}	44.8^{d}	94.5^{c}	96.7^{b}	96.3^{bc}

data for fish size are mean ± SD except the initial BW (only mean), initial n = 50, final n = 80; for the survival rates, initial n = 1 000; within rows, data with different superscripts are significantly different at $P \leq 0.05$

RESULTS

In Experiment 1, all the differences in the final *S. erythrophthalmus* mean length and weight were significant (Table 2). The fastest growth was noted in the larvae fed exclusively live food (group L20F0; TL = 18.9 mm, BW = 68.5 mg). The final survival rate recorded for these larvae (98.7%) was also significantly the highest. Larvae fed exclusively dry feed (group L0F20) grew the slowest (TL = 9.0 mm, BW = 5.7 mg). Fish fed the combinations of live food and dry feed grew faster when the initial feeding period with the live diet was longer. In group L6F14, there were massive losses between D11 and D20 resulting in the lowest final survival rate of 44.8%.

During the first 10 days of Experiment 2, all the fish completed the larval period and became juveniles, which was indicated by the scale cover.

In Experiment 2, fish fed Ewos AgloNorse grew significantly better than those fed Aller Futura Larvae diet (final TL = 36.5 mm v. TL = 33.4 mm, respectively), significantly higher was also their final survival rate (100% v. 97.6%, respectively) (Table 3). The latter diet also resulted in a significantly higher (13.5% vs. 0.0%) incidence of body deformities (spinal curvature).

DISCUSSION

In most cyprinid fish species the larval ability to utilize dry formulated diets from the first feeding is low (Wolnicki, 2005). For example, satisfactory growth performance and/or survival were not achieved when exclusively dry diets were fed to larval asp, *Aspius aspius* (Wolnicki, 2005), gudgeon,

Table 3. Initial and final characteristics of *S. erythrophthalmus* fed Ewos AgloNorse (EAN) or Aller Futura Larvae (AFL) dry feeds for 40 days in Experiment 2

Parameter	Experimental group	
	EAN	AFL
Initial total length (mm ± SD)	18.9 ± 1.3	
Final total length (mm ± SD)	36.5 ± 3.0^{a}	33.4 ± 2.7^{b}
Initial body weight (mg ± SD)	68.5 ± 15.9	
Final body weight (mg ± SD)	506.8 ± 135.9^{a}	392.0 ± 95.8^{b}
Final survival rate (%)	100.0^{a}	97.6^{b}
Final share of deformed fish (%)	0.0^{b}	13.5^{a}

data for fish size are mean ± SD, initial n = 80 and final n = 50; for the survival rates, n = 330; for the share of deformed individuals, n = 50; within rows, data with different superscripts are significantly different at $P \leq 0.05$

Table 4. Relative growth rates for wet body weight (*RGR*, %/day) and survival rates (S, %) of larval cyprinids fed exclusively live *Artemia* nauplii from the first feeding at 25°C. Fish density 40–60 indiv/dm^3; duration of feeding 20–21 days; data shown in decreasing order of *RGR*

Species	Initial BW (mg)	Final BW (mg)	*RGR* (%/day)	S (%)	Source
Cyprinus carpio	1.2	95.1	24.4	95.0	Wolnicki (2005)
Leuciscus cephalus	1.4	108.4	24.3	93.0	Wolnicki and Myszkowski (1999a)
Scardinius erythrophthalmus	0.9	68.5	23.9	98.7	Present paper
Vimba vimba	2.3	110.9	21.4	99.2	Wolnicki (1996a)
Aspius aspius	2.6	118.1	21.1	99.0	Wolnicki and Myszkowski (1999b)
Chondrostoma nasus	6.3	168.0	17.8	98.0	Wolnicki and Myszkowski (1998)
Leuciscus leuciscus	3.0	81.2	17.0	99.9	Kujawa (2004)
Leuciscus idus	3.0	78.4	16.8	98.6	Kujawa (2004)
Barbus barbus	9.5	121.1	12.9	99.3	Kujawa (2004)

relative growth rates (Myszkowski, 1997) were calculated according to the formula: $RGR = 100\ (e^G - 1)$ where $G = (\ln BW_f - \ln BW_i)\ n^{-1}$; BW_i and BW_f = the initial and final body weight, respectively; n = the number of feeding days

Gobio gobio (Awaïss et al., 1992), chub, *Leuciscus cephalus* (Wolnicki and Myszkowski, 1999b; Shiri Harzevili et al., 2003), ide, *L. idus* (Shiri Harzevili et al., 2004; Hamáčková et al., 2007), dace, *L. leuciscus* (Lepičova et al., 2002; Shiri Harzevili et al., 2005), European minnow, *Phoxinus phoxinus* (Stalmans and Kestemont, 1991; Kestemont and Stalmans, 1992) or tench, *Tinca tinca* (Wolnicki and Górny, 1995b; Wolnicki, 2005). Considerably improved rearing results were attained when the first-feeding larvae were initially fed natural food before being weaned to dry formulated feeds (Wolnicki, 2005). The supplementation of dry diets with natural food turned out to be another similarly effective solution (Wolnicki and Korwin-Kossakowski, 1993; Wolnicki and Górny, 1995a).

In contrast to all the aforementioned species, only a few cyprinids demonstrate relatively fast growth and very good survival when fed dry feeds exclusively from the very beginning of exogenous feeding: barbel, *Barbus barbus* (Wolnicki and Górny, 1995c; Fiala and Spurný, 2001; Policar et

Table 5. Relative growth rates for wet body weight (*RGR*, %/day) and survival rates (S, %) of larval cyprinids fed exclusively dry formulated feeds from the first feeding at 25°C. Fish density 40–60 indiv/dm^3; duration of feeding 15–20 days; data shown in decreasing order of *RGR*

Species	Initial BW (mg)	Final BW (mg)	*RGR* (%/day)	S (%)	Source
Chondrostoma nasus	6.3	100.0	14.8	98.0	Wolnicki and Myszkowski (1998)
Vimba vimba	2.3	20.9	11.7	99.1	Wolnicki (1996a)
Leuciscus cephalus	1.3	8.5	9.8	13.3	Wolnicki (2005)
Scardinius erythrophthalmus	0.9	5.7	9.7	96.3	Present paper
Tinca tinca	0.7	4.4	9.6	82.4	Wolnicki et al. (unpubl. data)
Leuciscus idus	3.0	10.0	8.4	41.0	Wolnicki and Górny (1995a)
Barbus barbus	12.0	36.0	7.6	99.0	Wolnicki and Górny (1995c)

RGR calculations see Table 4

Table 6. Relative growth rates for wet body weight (*RGR*, %/day) of juvenile cyprinids fed exclusively dry formulated feeds at 25°C. Fish density 4.0–16.5 indiv/dm^3; duration of feeding 20–40 days; data shown in decreasing order of *RGR*

Species	Initial BW (mg)	Final BW (mg)	*RGR* (%/day)	Source
Barbus barbus	89.6	510.0	6.0	Wolnicki (1997)
Leuciscus idus	58.0	182.3	5.9	Wolnicki (1996b)
Scardinius erythrophthalmus	68.5	506.8	5.1[1] 4.5[2]	Present paper
Vimba vimba	110.9	467.3	4.9	Wolnicki (1996a)
Chondrostoma nasus	168.0	573.0	4.2	Wolnicki and Myszkowski (1999a)

[1]on Ewos AgloNorse; [2]on Aller Futura Larvae
RGR calculations see Table 4

al., 2007), goldfish, *Carassius auratus* (Abi-Ayad and Kestemont, 1994; Kaiser et al., 2003), nase, *Chondrostoma nasus* (Wolnicki and Myszkowski, 1998; Spurný et al., 2004), roach, *Rutilus rutilus* (Köck and Hofer, 1989) and vimba, *Vimba vimba* (Wolnicki, 1996a).

In the present study, when *S. erythrophthalmus* larvae were fed live food from the onset of exogenous feeding, they were among the fastest growing cyprinids, with a relative growth rate in wet weight of 23.9%/day (Table 4). On the other hand, when fed dry formulated feed exclusively, the larvae of this species grew very slowly in comparison with the other cyprinids in the same period of life (Table 5). However, although larvae in Experiment 1 grew poorly on the dry diets, their final survival rates were high in most of the experimental groups. Mass larval losses recorded for group L6F14 (Table 2), as the only exception, were difficult to explain.

The results of the present study suggest that *S. erythrophthalmus* larvae may require a relatively long period of the initial feeding of live food to improve their ability to utilize Aller Futura Larvae for growth. The major reason may be that this dry diet does not meet all the nutritional needs of the larvae. Larval cyprinids most often need about 5 days of the initial feeding of natural food, but in the case of some species and some dry diets, not less than 8–12 days are necessary (Kujawa, 2004; Wolnicki, 2005). As indicated by the current results, 6 days of the initial feeding of *Artemia* nauplii (Experiment 1) may be insufficient. On the other hand, a 20-day period of feeding live food, preceding Experiment 2, proved to ensure growth rates on both dry feeds evaluated in the present work that were comparable to those noted for the cyprinids that utilized dry diets most effectively, such as *B. barbus* or *L. idus* (Table 6).

In conclusion, the fast growth, maximum survival, and the lack of body deformities in older larvae and early juveniles fed Ewos AgloNorse in Experiment 2 prove the usefulness of this diet for *S. erythrophthalmus*, and most likely for other cyprinid species as well. This finding is noteworthy because this diet (1) is for marine fish species, (2) contains as much as 20% fat. According to many experimental data (Wolnicki, 2005; Kamler and Wolnicki, 2006), feeding to young cyprinids high fat diets, i.e. containing more than 10%, usually results in a gradual increase of fat content in the fish body, a decrease in body minerals, and finally disruption in the process of bone mineralization, resulting in further skeletal malformations.

REFERENCES

Abi-Ayad A., Kestemont P. (1994): Comparison of the nutritional status of goldfish (*Carassius auratus*) larvae fed with live, mixed or dry diet. Aquaculture, 128, 163–176.

Awaïss A., Kestemont P., Micha J.C. (1992): Nutritional suitability of the rotifer, *Brachionus calyciflorus* Pallas for rearing freshwater fish larvae. Journal of Applied Ichthyology, 8, 263–270.

Bonisławska M., Winnicki A. (2002): Effects of egg incubation temperature on the condition of newly hatched fish larvae. Acta Scietatis Polish Piscaria, 1, 5–20.

Fiala J., Spurný P. (2001): Intensive rearing of the common barbel (*Barbus barbus* L.) larvae using dry starter feeds

and natural diet under controlled conditions. Czech Journal of Animal Science, 46, 320–326.

Hamáčková J., Lepičová A., Prokeš M., Lepič P., Kozák P., Policar T., Stanny L.A. (2007): Success of nursing ide (*Leuciscus idus* L.) fry related to the period of feeding with live food. Aquaculture International, 15, 255–265.

Horváth L., Szabó T., Burke J. (1997): Hatchery testing of GnRH analogue-containing pellets on ovulation in four cyprinid species. Polish Archives of Hydrobiology, 44, 221–226.

Kaiser H., Endemann F., Paulet T.G. (2003): A comparison of artificial and natural foods and their combinations in the rearing of goldfish, *Carassius auratus* (L.). Aquaculture Research, 34, 943–950.

Kamler E., Wolnicki J. (2006): The biological background for the production of stocking material of 11 European rheophilic cyprinids. A review. Archiv für Hydrobiologie, 158/4, 667–687.

Kestemont P., Stalmans J.M. (1992): Initial feeding of European minnow larvae, *Phoxinus phoxinus* L. 1. Influence of diet and feeding level. Aquaculture, 104, 327–340.

Klein Breteler J.G.P. (1979): First experiments concerning controlled reproduction and rearing of fry and fingerlings of rudd, *Scardinius erythrophthalmus* L. EIFAC Technical Paper, 35, 184–188.

Köck G., Hofer R. (1989): The effect of natural and artificial diets upon tryptic activity of roach and whitefish. Polish Archives of Hydrobiology, 36, 443–453.

Kopiejewska W., Terlecki J., Chybowski Ł. (2004): Cyclic development of sex cells in artificially bred rudd *Scardinius erythrophthalmus* (L.). Acta Scientiarum Polonorum – Piscaria, 3, 43–48.

Kucharczyk D., Kujawa R., Mamcarz A., Wyszomirska E. (1997): Induced spawning in rudd (*Scardinius erythrophthalmus* L.). Polish Archives of Hydrobiology, 44, 209–213.

Kujawa R.J. (2004): Biological basis of the rearing of rheophilic cyprinid fish larvae under controlled conditions. Wyd. UWM, Olsztyn, Poland. Rozprawy i Monografie, 88, 88 pp.

Lelek A. (1987): Threatened Fishes of Europe. AULA-Verlag, Wiesbaden, Germany, 236–239.

Lepičova A., Hamáčková J., Lepič P. (2002): Rearing of early fry of dace (*Leuciscus leuciscus* L.) under controlled conditions. Bulletin VÚRH Vodňany, CR, 37, 16–23.

Myszkowski L. (1997): Pitfalls of using growth rate coefficients. Polish Archives of Hydrobiology, 44, 389–396.

Policar T., Kozák P., Hamáčková J., Lepičová A., Musil J., Kouřil J. (2007): Effects of short-time *Artemia* spp. feeding in larvae and different rearing environments in juveniles of common barbel (*Barbus barbus*) on their growth and survival under intensive controlled conditions. Aquatic Living Resources, 20, 175–183.

Ravera O., Jamet J.L. (1991): The diet of the rudd (*Scardinius erythrophthalmus*, L.) in relation to the possible consequences for the removal of this species from an eutrophic lake. Archiv für Hydrobiologie, 123, 99–109.

Shiri Harzevili A., De Charleroy D., Auwerx J., Vught I., Van Slycken J. (2003): Larval rearing of chub, *Leuciscus cephalus* (L.), using decapsulated *Artemia* cysts as direct food. Journal of Applied Ichthyology, 19, 123–125.

Shiri Harzevili A., Vught I., Auwerx J., De Charleroy D. (2004): Larval rearing of ide (*Leuciscus idus* (L.)) using decapsulated Artemia. Archives of Polish Fisheries, 12, 191–195.

Shiri Harzevili A., Vught I., Auwerx J., De Charleroy D. (2005): Successful feeding of dace, *Leuciscus leuciscus* larvae using an artificial diet. European Aquaculture Society Special Publication, 36, 470–473.

Sokal R.R., Rohlf J.R. (1969): Biometry. The principles and practice of statistics in biological research. H.F. Freeman and Co., San Francisco, USA, 776 pp.

Spurný P., Fiala J., Mareš J. (2004): Intensive rearing of the nase *Chondrostoma nasus* (L.) larvae using dry starter feeds and natural diet under controlled conditions. Czech Journal of Animal Science, 49, 444–449.

Stalmans J.M., Kestemont P. (1991): Production de juvéniles de vairon *Phoxinus phoxinus* L. á partir de larves obtenues en conditions contrôlées. Bulletin Francaos de la Pêche et de la Piscivulture,320, 29–37.

Wolnicki J. (1996a): Intensive rearing of larval and juvenile vimba, *Vimba vimba* (L.), fed natural and formulated diets. Polish Archives of Hydrobiology, 43, 447–454.

Wolnicki J. (1996b): The effects of temperature and feeding conditions on the growth and survival of reared ide, *Leuciscus idus* L., larvae. Komunikaty Kybackie, 2, 8–10.

Wolnicki J. (1997): Intensive rearing of larval and juvenile barbel *Barbus barbus* (L.) on dry commercial diets. Roczniki Nauk Polskiego Zwiazku Wędkarskiego, 10, 7–14.

Wolnicki J. (2005): Intensive rearing of early stages of cyprinid fish under controlled conditions. Archives of Polish Fisheries, 13, 5–87.

Wolnicki J., Korwin-Kossakowski M. (1993): Survival and growth of larval and juvenile tench, *Tinca tinca* (L.), fed different diets under controlled conditions. Aquaculture and Fisheries Management, 24, 707–713.

Wolnicki J., Górny W. (1995a): Controlled rearing of ide (*Leuciscus idus* L.) larvae using live food and dry feed. Aquaculture, 129, 255–256.

Wolnicki J., Górny W. (1995b): Suitability of two dry diets for intensive rearing of larval tench (*Tinca tinca* L.) under controlled conditions. Aquaculture, 129, 256–258.

Wolnicki J., Górny W. (1995c): Survival and growth of larval and juvenile barbel (*Barbus barbus* L.) reared under controlled conditions. Aquaculture, 129, 258–259.

Wolnicki J., Myszkowski L. (1998): Growth and survival of larval nase *Chondrostoma nasus* (L.) fed different diets at two water temperatures. European Aquaculture Society Special Publication, 26, 276–277.

Wolnicki J., Myszkowski L. (1999a): Comparison of survival, growth and stress resistance in juvenile nase *Chondrostoma nasus* (L.) fed commercial starters. European Aquaculture Society Special Publication, 27, 256–257.

Wolnicki J., Myszkowski L. (1999b): Larval rearing of rheophilic cyprinids, *Aspius aspius* (L.) and *Leuciscus cephalus* (L.), on live, dry or mixed diet. European Aquaculture Society Special Publication, 27, 258–259.

Załachowski W. (2000): Rudd, *Scardinius erythrophthalmus* (Linnaeus, 1758). In: Brylińska M. (ed.): Freshwater fishes of Poland, PWN, Warszawa, Poland, 278–281.

Received: 2007–10–24
Accepted after corrections: 2008–06–11

Corresponding Author

Doc. dr hab. Jacek Wolnicki, Pond Fishery Department, The Stanisław Sakowicz Inland Fisheries Institute in Olsztyn, ul. Główna 48, Żabieniec, 05-500 Piaseczno, Poland
Tel. +48 22 756 74 86, fax +48 22 756 20 44, e-mail: jawol@infish.com.pl

INSTITUTE OF AGRICULTURAL ECONOMICS AND INFORMATION

Slezská 7, 120 56 Prague 2, Czech Republic

Tel.: + 420 227 010 111, Fax: + 420 227 010 116, E-mail: redakce@uzpi.cz

In this institute scientific journals dealing with the problems of agriculture and related sciences are published on behalf of the Czech Academy of Agricultural Sciences. The periodicals are published in English.

Journal	Number of issues per year	Yearly subscription in USD
Plant, Soil and Environment	12	285
Czech Journal of Animal Science	12	285
Agricultural Economics (Zemědělská ekonomika)	12	285
Journal of Forest Science	12	285
Veterinární medicína (Veterinary Medicine – Czech)	12	285
Czech Journal of Food Sciences	6	150
Plant Protection Science	4	85
Czech Journal of Genetics and Plant Breeding	4	85
Horticultural Science	4	85
Research in Agricultural Engineering	4	85
Soil and Water Research	4	85

Subscription to these journals be sent to the above-mentioned address.

INSTRUCTIONS TO AUTHORS

The journal publishes original scientific papers and critical reviews of articles in English. Manuscripts should have abstracts (including keywords). The author is fully responsible for the originality of the paper, its subject, and its formal correctness. The author's declaration that the paper has not been published anywhere else should be enclosed. The Board of Editors decides on the publication of papers, taking into account peer reviews, scientific importance, and manuscript quality. Good laboratory practices and ethical rules must be followed. The SI international system of measurement units should be used. Manuscripts must be grammatically and linguistically correct, and authors whose native language is not English are advised to seek the help of a native English-speaker. Manuscripts containing language errors are disfavored in the reviewing process and may be returned to the author for rewriting before peer review and/or before acceptance.

Only manuscripts assessed by leading experts in the field will be published. If such reviews are not available within four months after registration of the manuscript, the peer review process is terminated, and the authors are notified. They can resubmit the manuscript, after its thorough revision and/or update, either to the Czech Journal of Animal Science or another journal for a new assessment. This should eliminate a long waiting period and probable rejection of the manuscript.

If a revision of the manuscript following the recommendation of the reviewers is requested, the modified manuscript must be re-submitted within three weeks. The authors may, however, request an extension of the re-submission deadline if necessary. All parts of the manuscript, including tables and figures (even unchanged) must be re-submitted. A detailed reply by the authors to every point of the reviewer's recommendations must be attached to the revision manuscript. It is not necessary to accept all the requests of the reviewers, but a clear explanation of why the reviewers' comments were not accepted must be provided. If the deadline for re-submission is missed, the paper will be removed from the reviewing process.

The proof reading must be returned within two days. Only errors originating during preparation of the document for printing can be corrected. Standard proof marks will be used. No changes in the manuscript after acceptance for publication are permitted.

Manuscripts should be sent by e-mail as attachments. Alternatively, they can be submitted in duplicate in hard copy, and a properly labelled Compact Disk (CD) with identical contents, including figures, should be enclosed.

Copyright. The journal is protected by copyright held by the publisher after the manuscript has been accepted for publication. As regards the transfer of rights, the corresponding author assumes responsibility for all the authors. No part of this publication may be reproduced, stored, or transmitted in any form or by any means without the written permission of the publisher.

Manuscript layout. The Microsoft (MS) Word for Windows word-processing software should be used for creating the text in non-formatted style strictly following the journal layout. If any abbreviations are used in the paper, they must be appropriately explained when they are used in the text for the first time. It is not advisable to use any abbreviation in the title of the paper or in the abstract. Tables, graphs and other Word documents are to be submitted on separate pages appended to the article. The document must not be formatted in columns, heading styles, etc. This unique MS Word file must be saved under the first author's surname only. In the printed version lines should be numbered. Graphs should be provided in MS Excel, and they should be stored with the original data. Photographs and autotypes should be submitted in high resolution (min. 300 dpi) TIFF or JPG format. All tables, graphs and photos should be numbered in the order in which they are included in the text, using Arabic numerals.

The Title of the Paper should be short and informative, and no subtitles or numbering of "serial" articles (Part I, Part II, etc.) should be used.

The Abstract should not have more than 500 words. It should contain important information on methods used to solve the problem, a clear description of results and their statistical significance, and brief and unambiguous conclusions drawn from the results. References and discussion of the results should not be included in the abstract.

Keywords should not repeat nouns used in the title and should describe the studied problem as best as possible.

The Introduction section should provide information on the present state of research in the field concerned and on the objective of the study. It should also include references to literary sources used by the authors to document their present findings, but not all literary sources that have been published to date. References in the text should agree with those in the list of references. It is recommended to include references to papers from peer periodicals only. Citations from non-available sources (reports, national journals, proceedings, thesis, etc.) should be omitted. Papers published by one or two authors are to be cited by their names, those published by three or more authors by the name of the first one, et al. If more than one paper by the same author/two authors/first author, et al., published in the same year is cited, they should be differentiated by YEARa,b,c both in the text and the list of References. Names and year of publication are to be cited by including them in the text directly, e.g. "...as published by Brown (1995)" or indirectly – citing authors and year of publication in parentheses (Green and Grey, 1996), (Jakl et al., 2002). Several papers cited together should be arranged according to the year of publication starting with the oldest one.

Material and Methods. All preliminary material, conducted experiments, their extent, conditions and course (experimental design) should be described in detail in this section. All original procedures that were used for the processing of experimental material and all analytical methods used for evaluation should also be detailed. Data verifying the quality of the acquired data should be indicated for the methods used. The entire methodology is to be described only if it is an original one; in other cases it is sufficient to cite the author of the method and to mention any particular differences. Methods of statistical processing including the software used should also be listed in this section.

Results and Discussion. The results obtained from the experiments including their statistical evaluation and any commentary should be presented graphically or in tables in this section. The author should confront partial results with data published by other authors, whose names and year of publication are to be cited by including them in the text directly or indirectly.

References should be arranged in alphabetical order according to the surname and initials of authors. The year of publication cited in parentheses, the full title of the paper in English with the language of publication in parentheses, e.g. (in Czech) should follow. The title of the periodical should be preferably typed in full. Use of official ISI Journal Citation Reports or Current Contents abbreviations is an alternative but should be used only in exceptional cases.

In the case of books or proceedings, the title should be followed by the name of the publisher, its location (Paris, New York, etc.) and the total number of pages.

Only papers cited in the text should be included in the list of references. All names of the authors must be printed in English transcription without non-English letters. Authors are responsible for the accuracy of their references.

Examples of references in the list:

Brown J. (1995): Estradiol determination in post-partum sows. Journal of Endocrinology, 198, 155–169.

Gabler M.T., Heinrichs A.J. (2003): Dietary protein to metabolizable energy ratios on feed efficiency and structural growth of prepubertal Holstein heifers. Journal of Dairy Science, 86, 268–274.

Papers published in monographs or proceedings should be cited as follows:

Kalab J. (1995): Changes in milk production during the sexual cycle. In: Hekel K. (ed.): Lactation in Cattle. Academic Press, London, 876–888.

Janson L., Ahlin K.A. (1992): Postpartum reproductive performance in cattle selected for high and low fat content. In: Proc. 43rd Annu. Mtg., European Association for Animal Production (EAAP), Madrid, Spain, 93–95.

The Corresponding Author should include his or her full name including all academic, scientific and pedagogic titles and the detailed address of the institution with postal code, telephone and fax numbers, and e-mail address. The author who is responsible for any correspondence with the journal should be clearly indicated.

The Declaration of the Authors must be carefully completed and signed by the first author.

Offprints: Free reprint in Portable Document Format (PDF) sent via e-mail as an attachment.

Compliance with these instructions is obligatory for all authors. If a manuscript does not comply exactly with the above requirements, the editorial office will not accept it for consideration and will return it to the authors without reviewing it.