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# German experiences in the propagation and rearing of fingerling pikeperch *(Stizostedion lucioperca)*

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Three different procedures have been used to propagate pikeperch in Germany, all requiring spawners that have been reared in ponds at favourable nutritional conditions. The simplest method of propagation is to spawn pikeperch in ponds. Semi-artificial reproduction is possible in cages or basins. Good results are obtained by inducing spawning after hypophysation and artificial insemination. Egg adhesiveness must be neutralized and eggs incubated in Zug jars at water temperatures of about 16–18°C. It is advisable to use well-prepared nursing ponds for advanced fry rearing. To produce one-summer-old fingerlings in polyculture, the proper food supply in the pond is very important. An adequate density of prey fish is a prerequisite for the harvest of large fingerlings in autumn which are well suited for a successful stocking in natural waters.

## 1. Introduction

Pikeperch is widespread in lakes and streams in Germany, but nowhere large populations are encountered. The pikeperch prefers turbid and unstratified waters rich in small fish. Its range has been extended continuously to the west during this century. In 1881–1882, pikeperch were first stocked in Lake Constance and in the Rhine (Lehmann 1931, Schmidt 1993). As pikeperch is considered to be of high market value among the freshwater fish species in Central Europe, fishermen are interested in enhanced yields.

Catches of pikeperch often fluctuate. The average catch of pikeperch in the German inland fishery was 262 t per year between 1938 and 1941. Although no reliable data exist on the total pikeperch yield in Germany, figures concerning the yield in Eastern Germany are available for a lake and river area of nearly 115 000 ha managed by commercial fishermen. Table 1 shows that the pikeperch yield in these areas averaged only 1–2% of the total yield of marketable freshwater fish. It increased during the late sixties and the early seventies and thereafter decreased again. Variable catches may be caused by fluctuating water temperatures and supplies of small plankton in spring which affect fry survival (Rogowski & Tesch 1960, Tesch 1962, Anwand 1967) or by a shortage of prey fish (Barthelmes 1988).

Fingerling rearing of pikeperch is aimed, first of all, at introducing this species into suitable waters without pikeperch populations, but also can be used with a view to increase pikeperch stocks, especially for angling, although this can only be recommended if specific conditions are met.

Pikeperch culture has been accomplished for many decades in several European countries. In this paper we will describe German experiences in the propagation and rearing to fingerling stage of this species.

Table 1. Total yield of marketable freshwater fish and of pikeperch in Eastern Germany (former GDR) 1951–1990 (Statistics of the Ministry of Agriculture).

| Year | Total yield of freshwater fish (t) | Yield of pikeperch (t) | Yield of pikeperch (% of total fish) |
|---|---|---|---|
| 1951 | 768 | 82.0 | 1.2 |
| 1952 | 276 | 88.8 | 1.4 |
| 1953 | 424 | 108.2 | 1.7 |
| 1954 | 265 | 88.2 | 1.4 |
| 1955 | 430 | 97.9 | 1.5 |
| 1956 | 900 | 100.4 | 1.7 |
| 1957 | 712 | 88.1 | 1.3 |
| 1958 | 892 | 84.6 | 1.2 |
| 1959 | 980 | 149.6 | 1.9 |
| 1960 | 7 581 | 165.1 | 2.2 |
| 1961 | 7 237 | 143.7 | 2.0 |
| 1962 | 7 909 | 139.1 | 1.8 |
| 1963 | 7 586 | 127.8 | 1.7 |
| 1964 | 9 072 | 129.9 | 1.4 |
| 1965 | 9 430 | 110.7 | 1.2 |
| 1966 | 10 942 | 161.0 | 1.5 |
| 1967 | 10 273 | 173.1 | 1.7 |
| 1968 | 12 207 | 212.5 | 1.7 |
| 1969 | 13 568 | 228.9 | 1.7 |
| 1970 | 13 156 | 252.4 | 1.9 |
| 1971 | 13 845 | 309.4 | 2.2 |
| 1972 | 12 111 | 290.7 | 2.4 |
| 1973 | 13 121 | 303.4 | 2.3 |
| 1974 | 13 357 | 281.8 | 2.1 |
| 1975 | 14 781 | 286.6 | 1.9 |
| 1976 | 13 187 | 311.2 | 2.4 |
| 1977 | 16 118 | 250.6 | 1.6 |
| 1978 | 15 040 | 219.3 | 1.5 |
| 1979 | 12 502 | 180.7 | 1.4 |
| 1980 | 12 170 | 173.6 | 1.4 |
| 1981 | 15 647 | 146.4 | 0.9 |
| 1982 | 17 152 | 145.1 | 0.8 |
| 1983 | 19 324 | 162.5 | 0.8 |
| 1984 | 20 860 | 176.4 | 0.8 |
| 1985 | 22 296 | 187.6 | 0.8 |
| 1986 | 22 668 | 196.6 | 0.9 |
| 1987 | 22 986 | 180.3 | 0.8 |
| 1988 | 24 428 | 173.6 | 0.7 |
| 1989 | 25 197 | 170.0 | 0.7 |
| 1990 | 22 215 | 196.7 | 0.9 |

## 2. Propagation

Three methods of propagation are generally used in pikeperch culture: natural spawning in ponds, semi-artificial reproduction in cages or tanks, and artificial insemination and incubation of the eggs after stripping mature fish.

Spawners should be reared in ponds with favourable nutritional conditions, e.g., stocked with prey fish (usually cyprinid species). An inadequate supply of suitable prey can reduce the fertility of the spawners (Horvath *et al.* 1984). The pikeperch is only able to swallow relatively small prey fish, usually < 40% of the length and < 8–9% of the weight of the pikeperch, respectively (Steffens 1960b, 1961). Pikeperch adults from 4 to 6 years are best suited for reproduction (Steffens 1960b, Horvath *et al.* 1984).

### 2.1. Natural spawning in ponds

Natural spawning in ponds is very simple, reliable and often does not require any preparation. In Germany, semi-intensively managed carp ponds < 10 ha of 1-m depth are used in this manner for pikeperch co-culture. A hard, sandy bottom without mud deposit is required. Carp are generally stocked at 400–750 $K_2$ (two-summer-old carp)/ha. The carp receive grain as supplementary feed.

Before about 1960 usually one female pikeperch spawner and 2 male spawners per ha were stocked (Steffens 1960ab), what resulted in high numbers of poorly growing progeny. Thereafter, the number of spawners was reduced to one female and two male spawners per 1–4 ha (Anwand & Herms 1965). However, the desired effect of obtaining larger fingerlings was not achieved in all cases.

Spawning takes place at water temperatures of 12–15°C, usually during the first half of May, depending on the climatic conditions. Fingerling pikeperch are harvested in autumn together with marketable carp (see Section 3.1.).

## 2.2. Semi-artificial reproduction in cages or tanks

Reproduction of pikeperch in cages requires spawning nests. These are made of a wooden frame (180 × 70 cm) covered with wire netting or ropes attached with coniferous branches and are hung about 50 cm above the bottom of the cage (Schlumpberger & Schmidt 1980). Cages may have a volume of 30–50 $m^3$ and are stocked with 2–5 female and 4–10 male spawners. In general, the brood fish spawn within 1–3 days after stocking. The use of gonadotropic hormones is only necessary in exceptional cases.

The adhesive eggs attach to the substratum of the nest after spawning and subsequently may be incubated in flow-through tanks (e.g. 4 m long, 0.8 m wide, waterlevel 0.3 m, inflow rate 2–5 l/min). Water temperatures should be approximately 16–20°C.

Another way to incubate spawning nests is to use a mist chamber which is a small room where water is sprayed from the ceiling (Entz & Woynárovich 1947). These chambers enable an excellent supply of oxygen, a precise regulation of incubation temperature, prevent *Saprolegnia* infection and conserve water (Woynárovich 1960). Eggs have to be transferred into tanks to hatch (Müller 1957).

Semi-artificial reproduction also can be carried out by keeping male and female spawners in pairs in flow-through plastic tanks (4 $m^3$) with spawning brushes after hypophysation (see Section 2.3.). Spawning, breeding and first development of the fry take place in these tanks.

The duration of embryonic development is dependent on water temperatures (Table 2). At incubation temperatures ranging from 13.5 to 18.6°C, eggs hatch between 200 and 72 hours (Schlumpberger & Schmidt 1980). The hatching period is often extended and can be accelerated by a short-term increase of temperature. According to Geldhauser (1992), it is advisable to reduce the incubation temperature by approximately 1°C per day shortly before hatching, to ensure a constant and full development before hatching. Thereafter, an increase in temperature of 1 to 3°C per day results in fast and complete hatching. Hatching success rate using this method is about 90%.

Table 2. Incubation time of pikeperch eggs at water temperatures of 10, 15 and 20°C, respectively (Woynárovich 1955).

| Water temperature, °C | 10 | 15 | 20 |
|---|---|---|---|
| Incubation time, hrs | 264 | 82 | 66 |

## 2.3. Artificial propagation

Stripping and artificial insemination is the most reliable method for obtaining high numbers of fertilized eggs and fry. Good nutrition and healthy status of the spawners are very important for successful reproduction (Zienert 1992). Sexes may be distinguished by the shape of the fish, however, precise distinction is often only possible by biopsy. Males frequently do not show “running” semen in spring.

Parental pikeperch are kept in plastic or concrete tanks during the prespawning period for some time (about 4 weeks) and water temperature is increased from 13 to 16°C. Maturity of the females may be examined by taking some eggs from the ovary with the help of a thin (2.5 mm) catheter. To assess spawning condition, eggs are treated with a solution consisting of 60% alcohol, 30% acetic acid and 10% formaldehyde. If the germinal vesicle is already in a peripheral position and lipid droplets have concentrated, hormone injections can be used to stimulate final maturation and ovulation (Zienert 1992).

Ovulation and spermiation are stimulated by injections of human chorionic gonadotropin (HCG) or carp pituitary extracts. HCG is applied at a rate of 200 IU/kg body weight (bw) to females and of 100 IU/kg bw to males; pituitary extracts are applied at 3–5 mg dry pituitary gland/kg spawner, with males often needing only 50% of that required by females. Depending on the degree of ripeness and the temperature conditions, the total amount of HCG should be injected in several (3–5) partial doses. In the case of carp pituitary extracts, 2 injections at 12-hour intervals between injections are recommended. Intramuscular and intraperitoneal applications both are effective.

Following hormonal stimulation, water temperature is increased gradually to 19–20°C. Time of ovulation is established by careful observation of the spawners. About 10–12 hrs after the last injection and at the beginning of spawning, eggs can be stripped very easily. Sperm is collected with a pipette. Pikeperch fecundity averages 200 000 eggs/kg bw (range = 50 000–450 000), however, not all of these eggs can be stripped (Table 3). The diameter of eggs prior to water hardening is 0.6–0.9 mm and the weight of 1 500–2 000 eggs is 1 g.

For artificial insemination, about 2 ml of sperm is used to fertilize 100 g of eggs (semi-dry technique). A fertilization solution of 0.3% NaCl is used which prevents rapid sticking of eggs. Adhesiveness is then neutralized by washing the eggs in an alkaline protease solution (0.5%). A mixture of 100 g talcum and 20 g NaCl per 10 l water also can be used for this purpose. Swollen eggs (after 60–75 min water hardening) have a diameter of about 1.0–1.5 mm.

Fertilized eggs are incubated in Zug jars (7 l) at 0.5–5 l per jar. Water flow should be moderate (at first 0.5 l/min, later on 4–5 l/min). Suitable water temperature is 16–17°C. As mentioned before, hatching can start after 2–3 days, however it can be protracted to 7 days. To accelerate hatching, it is possible to stop the inflow of the incubator after 4 days for a short time, thereby reducing oxygen supply.

Larvae are siphoned from the incubator into holding boxes having high oxygen concentrations. Stocking density in boxes may be about 15 000 larvae/l. The size of hatched larvae is about 4–5 mm. Boiled egg yolk and small sieved plankton (< 150 µm) or *Artemia* nauplii can be offered at first feeding.

Table 3. Average weight of eggs per female stripped after hypophysation (Zienert 1992).

| Average weight of females (kg) | Average weight of eggs (g/female) | Average weight of eggs (g/kg female) |
|---|---|---|
| 1.4 | 180 | 129 |
| 1.4 | 130 | 93 |
| 3.7 | 175 | 47 |
| 5.8 | 153 | 26 |
| 6.0 | 225 | 38 |
| 6.4 | 200 | 31 |

## 3. Fingerling rearing

### 3.1. Production of autumn fingerlings without advanced fry rearing

For many years pikeperch fingerlings were reared in ponds together with carp using the natural spawning method as described in Section 2.1. This does not require additional treatment of the ponds. It is only necessary to support the development of high quantities of natural fauna for the fish by properly applying organic and inorganic fertilizers while avoiding oxygen depletion in the pond water. Growth of the pikeperch should be observed by regular samples and measurements.

As was shown by Steffens (1960b), pikeperch fingerlings feed mainly on invertebrates. According to investigations from 24 ponds, the most important food organisms are *Daphnia longispina, Corethra plumicornis,* Cyclopidae, *Cloeon dipterum, Glyptotendipes* sp. and *Chironomus plumosus* (Table 4). With increasing size of pikeperch,

Table 4. Percentage by weight[1)] of important food organisms ingested by pikeperch fingerlings at the ages of 1–5 months in ponds (Steffens 1960b).

| Age of pikeperch (months) | 1 | 2–3 | 4 | 5 | 1–5 avg. |
|---|---|---|---|---|---|
| Average size | | | | | |
| cm | 4.6 | 6.9 | 8.4 | 9.2 | |
| g | 0.7 | 2.9 | 4.4 | 6.7 | |
| Number of fish | 45 | 36 | 44 | 201 | 326 |
| Number of ponds | 3 | 3 | 5 | 13 | 24 |
| Hirudinea | | | | 9 | |
| *Daphnia pulex* | | 8 | | | |
| *Daphnia longispina* | 27 | 5 | 36 | 5 | 18 |
| *Ceriodaphnia sp.* | | | 4 | | |
| Copepoda | 41 | 5 | 11 | 14 | |
| *Asellus aquaticus* | | | | 5 | |
| *Cloeon dipterum* | | | | 49 | 12 |
| *Chirononus plumosus* | 4 | 10 | 24 | 10 | |
| *Glyptotendipes sp.* | 14 | 17 | 7 | 4 | 11 |
| *Endochironomus sp.* | 4 | 3 | | | |
| *Corethra plumicornis* | 6 | 46 | 13 | 8 | 18 |
| Pisces | | 6 | | | |

[1)] Only food organisms comprising > 3% of total diet weight are listed larger food organisms are ingested. Important taxa of prey for pikeperch fingerling nutrition in ponds are zooplankton as well as macrobenthos and organisms living in the vegetation. Fish of suitable size which could be taken as prey were only present in one of the examined ponds. From an energetics standpoint, chironomid larvae and *Cloeon dipterum* are the most significant sources of pikeperch nutrition in ponds during the first summer (Fig. 1).

High densities of fish in a pond (carp and especially pikeperch fingerlings) increase feeding pressure on the zooplankton, benthic and vegetation fauna. This causes a considerable reduction in the supply of natural food, especially at the end of the summer. Whereas carp will grow because they receive grain as supplementary feed, pikeperch often starve and fingerlings will stop growing by late September and October.

Fingerling size in autumn corresponds inversely to stocking density and relates to the number of fish that survive. These numbers are mainly the result of the degree of success of natural spawning, although fertility and the nutritional conditions of individual ponds can have an impact in this regard. Ponds which were stocked at > 10 000 fingerlings/ha produced pikeperch of mean size = 7.7 cm and an average yield of 20 000 fingerlings/ha, while ponds stocked at < 10 000 fingerlings/ha produced pikeperch of mean size = 12.7 cm and an average yield of 1 800 fingerlings/ha (Steffens 1960b).

Stocking less than one female spawner per ha (see Section 2.1.) can reduce the production of fingerlings but increase their size. Unfortunately, this does not hold true in all cases (Anwand & Herms 1965). In general, large fingerlings (> 140 mm) are only produced reliably if the number of fish harvested is less than 1 000 pikeperch fingerlings/ha (Table 5), but results vary depending on ambient conditions (mainly temperature and nutrition).

Using the methods described above, pikeperch fingerlings have been reared in several pond farms in Eastern Germany for many years (Steffens 1960ab, Anwand & Herms 1965) and were used for stocking natural waters (Table 6). Production of fingerling pikeperch averaged 14 000/ha for many years. Weight gain in the ponds used for pikeperch production was 50 kg/ha for pikeperch and 520 kg/ha for marketable carp.

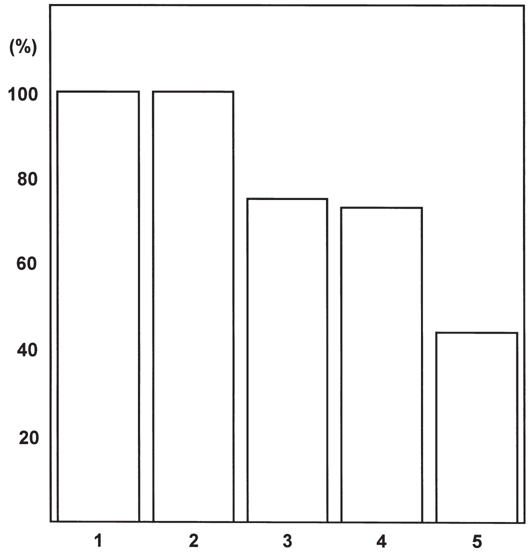


Fig 1. Relative value (most important organisms = 100%), corresponding to energy (joules) content, of food organisms ingested by pikeperch fingerlings during the first summer in carp ponds (Steffens 1960b): 1. *Chironomus plumosus* + *Glyptotendipes*. — 2. *Cloëon dipterum*. — 3. *Corethra plumicornis*. — 4. Centropagidae + Cyclopidae. — 5. *Daphnia longispina*.

Pikeperch fingerlings must be harvested very carefully in autumn. They follow the water flow when the pond is drained (Eckstein 1924, Steffens 1960a). This makes harvest of fingerlings during night hours possible for the fish farmer using a fishing box installed at the back of the monk. By using this procedure, most pikeperch fingerlings may be collected without damage before harvest of carp begins. Since fingerlings often have to be transported to far-off places they must be kept in clean, well-oxygenated water until the beginning of the transport.

Table 5. Size of pikeperch fingerlings from ponds in which fewer than 1 000 fish/ha were harvested in autumn (Steffens 1960, Anwand & Herms 1965).

| No. of fingerlings/ha harvested | Avg. size of fingerlings (cm) | (g) |
|---|---|---|
| 143 | 16 | 29.5 |
| 468 | 14–20 | 46.5 |
| 833 | 14 | 35.0 |

### 3.2. Production of autumn fingerlings by rearing advanced fry and subsequent fingerling production

Natural spawning of pikeperch in carp ponds and subsequent fingerling rearing until autumn often result in large numbers of small fingerlings, owing to the shortage of zooplankton and zoobenthos during September and October, and because fish density is hard to control. Therefore, to produce larger fingerlings in ponds, a more precise method of stocking ponds with advanced fry is needed. Rearing of advanced fry requires good nutritional conditions during the first weeks of life. It is suitable to offer small prey fish to advanced fry until harvest in autumn.

Table 6. Aquaculture production of pikeperch fingerlings and fry in East Germany (former GDR) 1951–1990 (Statistics of the Ministry of Agriculture).

| Year | No. of fingerlings | No. of advanced fry |
|---|---|---|
| 1951 | 334 000 | – |
| 1952 | | – |
| 1953 | 518 000 | – |
| 1954 | 869 000 | – |
| 1955 | 97 000 | – |
| 1956 | 375 000 | – |
| 1957 | 580 000 | – |
| 1958 | 487 000 | – |
| 1959 | 940 000 | – |
| 1960 | 834 000 | – |
| 1961 | 546 000 | – |
| 1962 | 864 000 | – |
| 1963 | 1 568 000 | – |
| 1964 | 795 000 | – |
| 1965 | 321 000 | – |
| 1966 | 361 000 | – |
| 1967 | 830 000 | – |
| 1968 | 342 000 | – |
| 1969 | 456 000 | 175 000 |
| 1970 | 626 000 | – |
| 1971 | 891 000 | 125 000 |
| 1972 | 464 000 | – |
| 1973 | 580 000 | – |
| 1974 | 548 000 | 500 000 |
| 1975 | 253 000 | – |
| 1976 | 418 000 | – |
| 1977 | 818 000 | 77 000 |
| 1978 | 17 000 | 270 000 |
| 1979 | 101 000 | 767 000 |
| 1980 | 20 000 | 311 000 |
| 1981 | 40 000 | 254 000 |
| 1982 | 80 000 | 23 000 |
| 1983 | 30 000 | 283 000 |
| 1984 | 2 000 | 25 000 |
| 1985 | 44 000 | – |
| 1986 | 6 000 | – |
| 1987 | 15 000 | 11 000 |
| 1988 | 116 000 | 64 000 |
| 1989 | 50 000 | 348 000 |
| 1990 | 39 000 | 163 000 |

#### 3.2.1. Rearing advanced fry in ponds

Fry stocking in ponds is pointless if the water temperature is too low. Food uptake and growth of pikeperch fry in ponds is poor at water temperatures below 18–20°C. To rear advanced fry, prepared ponds should be used. The development of natural food must be promoted by using organic and inorganic fertilizers while preventing a drop in oxygen content.

In accordance with the trophic state of the pond, stocking density may be at maximum 100 000 fry/ha. After 4–5 weeks, advanced fry having a length of 5–7 cm (early summer fingerlings) can be harvested, with a survival rate near 50%. Pond culture of advanced fry is a simple method, but yields are not predictable and results often vary from year to year and from pond to pond.

#### 3.2.2. Rearing advanced fry in troughs

Advanced fry have been reared in flow-through plastic troughs (4 × 0.8 × 0.4 m) having a water volume of about 0.9 $m^3$ (Schlumpberger & Schmidt 1980). Water temperature was 18–20°C, but according to Hilge (1990) growth is much better at 24–26°C. Light intensity of a maximum of 100 lux is recommended; total darkness prevented fry from feeding and resulted in total mortality (Schlumpberger & Schmidt 1979). The outlets of the rearing units must be screened with fine-meshed material (mesh size 0.2–0.3 mm). Water flow should be 7–8 l/min per trough.

Small planktonic organisms caught in lakes or ponds are fed to the pikeperch fry. Fry initially prefer nauplii and *Bosmina,* and as they grow switch to copepodids and adult copepods. For first feeding pikeperch, plankton must be sieved through a 0.2-mm mesh, and for fry = 6.5 mm, mesh size should be increased to 0.3 mm. Larvae must start feeding by the fourth day after hatch at the latest. High plankton density is necessary for fast growth and good survival of fry. At least 0.5–1.0 ml of plankton biomass per liter of trough volume must be fed to the pikeperch fry twice daily. Rearing units must be cleaned regularly by siphoning.

Stocking densities in the troughs should approximate 30–60 fry/l at the beginning of rearing. However, it is difficult to accurately count the number of small fry (4–5 mm, 0.3–0.5 mg). At a size of 10 mm, fry density should not be higher than 28 fry/l. Depending on the stocking density, a size of 20 mm is achieved after 19–28 rearing days (Table 7). Survival rates vary between 27 and 44% for the total rearing period.

This method of rearing advanced fry is labour-intensive and therefore expensive. Health of the pikeperch, particularly with regard to ectoparasites, must be watched carefully (Schlumpberger & Schmidt 1979).

### 3.2.3. Rearing advanced fry in illuminated net cages

There have been limited attempts to rear fry in cages (Schlumpberger & Ziebarth 1981, Jäger *et al.* 1984). Mesh size of the cages (2×2×2 m) was 0.8 mm and the cages were illuminated (200 W) between 19.00 and 04.00 hrs to attract plankton. Prefed fry were stocked at 11.8 mm (16 mg), at a density of 2 fry/l. At water temperatures of 20–21°C, pikeperch reached a size of 21.4 mm (90 mg) within 7 days, with a survival rate of 77%. Provided that suitable lakes exist, this method may hold promise for producing advanced fry (early summer fingerlings).

Table 7. Rearing period (days) of pikeperch fry from 5 to 20 mm in troughs at different stocking densities (Schlumpberger & Schmidt 1979).

| Stocking density at harvesting (fry/l) | Rearing period 1 Growth from 5–10 mm | Rearing period 2 Growth from 10–20 mm | Total |
|---|---|---|---|
| 5 | 13 | 6 | 19 |
| 7 | 16 | 10 | 26 |
| 13 | 21 | 7 | 28 |

### 3.2.4. Production of large fingerlings

Several authors have noted that the value of stocking small autumn pikeperch fingerlings may be limited or doubtful for enhancing the population in waters in which this species is already present (Rahn 1958, Schmidt 1959, Tesch 1961, Anwand 1968, Steffens 1986). This is probably caused by the relatively weak condition of pond-reared fish which starved in the ponds and by stocking at the wrong time.

Unlike small autumn fingerlings, fast-growing advanced fry may be well suited for stocking in lakes (Anwand 1968). However, the advanced fry stage is also the right starting point for rearing well-conditioned, large autumn pikeperch fingerlings, which are favoured for stocking purposes by anglers.

The continued rapid growth of pikeperch fingerlings over the entire first growing season is only possible by providing them with prey fish of appropriate size. Pikeperch stocked as advanced fry reached a much larger size in autumn when the fish had small cyprinids available as forage compared to pikeperch receiving only invertebrates (Table 8).

Appropriate densities of pikeperch to stock in carp ponds depends first of all on the supply of prey fish. Cyprinid fry (e.g., tench) can be used for this purpose. In several southern European countries (e.g., Austria), the recently introduced *Pseudorasbora parva* proved to be useful in this regard. On average, stocking densities of 3 000–5 000 advanced fry/ha are recommended (Hofmann *et al.*

Table 8. Results of rearing pikeperch advanced fry in monoculture to fingerling stage in ponds stocked with cyprinid fry compared to carp ponds without cyprinid fry stocking (Nagel 1959).

| Pond size (ha) | Stocking of advanced pikeperch fry (No./ha) | Harvest of pikeperch fingerlings (No./ha) | Survival (%) | Size (cm) |
|---|---|---|---|---|
| Ponds stocked with cyprinid fry | | | | |
| 0.32 | 31 200 | 11 131 | 36 | 16.4 |
| 0.24 | 29 166 | 12 187 | 42 | 15.7 |
| 0.25 | 32 000 | 12 608 | 39 | 16.2 |
| Ponds stocked without cyprinid fry | | | | |
| 0.11 | 18 181 | 9 054 | 50 | 11.2 |
| 0.11 | 27 272 | 9 800 | 36 | 9.8 |

1987). Temperature also is very important for the growth of pikeperch using this method, as good growth resulting in large fingerlings can be obtained only in warm summer months.

## 4. Conclusions

Semi-artificial reproduction as well as stripping and artificial insemination are suitable procedures for production of pikeperch fry. Rearing of advanced fry in well-prepared monoculture nursing ponds is advisable. For producing one-summer-old pikeperch fingerlings in polyculture in carp ponds, the proper food supply is very important. Adequate densities of prey fish are necessary to produce large fingerlings in autumn, which are well suited for successful stockings in natural waters.

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