

Care of Brood stock

Christian Gillet, INRA (France)

Prerequisite:

There are fewer publications about Arctic charr spawners than on trout or salmon spawners. But on the one hand, many results and practices from other salmonid are valid on Arctic charr in broad lines. On the other hand, considering the large number of strains in Arctic charr and the adaptive plasticity that characterize this species, in detail temperature thresholds and dates mentioned in the text are not valid for all the ecotypes. However, the effects of environmental changes on individual physiology are unlikely to differ markedly between populations of the species. The purpose of this text is to provide information about rearing conditions and environmental requirements of spawners and to indicate the dates of the different steps of the reproductive cycle.

Development of a brood stock, age of spawners, date of gametogenesis and rearing conditions:

Development and management of a brood stock:

There must be enough fish at the origin of the brood stock to prevent inbreeding. The offspring of 30 females and 30 males are suitable to constitute the next generation. In an aquaculture program destined to enhance wild stock, it is important to conserve all the genetic diversity of the wild population and to select spawners throughout the entire spawning period. In a brood stock destined to a program of genetic selection, it is necessary to start with a large amount of genetic variability. Example of a breeding program (link to the Swedish pages).

Age of sexual maturation:

This can vary according to strain, sex and growth rate. Moreover, it can be changed by photoperiod manipulations. Generally, males become mature when they are two or three years old and females at three or four. In an anadromous Canadian strain, maturity occurs at an older age (5+ in rearing condition and 10+ in wild environment. Anadromous strains often mature later than landlocked strains). The 5 generation selected Swedish brood stock mature as 3-4 years old at a mean weight of 1.5-2 kg. At maximum growth rate, some females of the Lake Geneva strain become mature at the end of their second year but they produce eggs of small size that exhibited poor survival. Protracted photoperiodic cycles stimulated the onset of maturation whereas continuous long days act conversely. In the Lake Geneva strain, long day treatments beginning in fall when fish are 18 months old stimulated the onset of maturity. Fish spawn in May and June or July, i.e. six months earlier than controls.

Date of different stages of gametogenesis and spawning period:

In Arctic charr strains that spawn in fall or in early winter, gametogenesis starts in spring. Subsequently, gonadal development accelerates during the second half of summer, when the daylength quickly decreases. In strains that spawn in spring or in summer, gametogenesis has not been described. The spawning window lasts some weeks (3 to 6 weeks) in most of the wild Arctic charr populations but some strains such as the Canadian Fraser strain have a duration of the spawning window longer than 3 months.

Rearing tanks:

Brood Arctic charr can be reared in circular tanks, raceways, cages or earthen ponds. Temperature, photoperiod and feeding rate probably exert a more important influence on the course of gametogenesis than the form or the dimensions of rearing tanks.

Rearing temperature suitable for the course of gametogenesis:

Gonadal growth of males and females occurs in a large range of temperatures. Gonadal development has been observed at 4°C as well as 16°C. In females, rearing temperature probably exerts a lesser influence than growth rate on gonadosomatic index (GSI) and oocyte size. On the other hand, ova produced by females at temperatures $\geq 12^{\circ}\text{C}$ have a lower content in unsaturated fatty acids (essential for egg viability) than those reared at colder temperatures ($\leq 8^{\circ}\text{C}$). In Sweden, it has been observed that

warm summer and autumn temperatures reduce viability of eggs in Arctic charr reared in netcages in shallow lakes.

Rhythm of spawner growth:

There is a seasonal variation in growth of spawners during the reproductive cycle, even when fish are kept at a constant cold temperature (4°C). Specific growth rate is low in winter and early spring, and then it rapidly increases from May. Maximal values for growth rate are observed in early summer, then it decreases at the end of summer and it become almost nil about a month before the onset of spawning period, when spawner almost totally stop to feed. The amount of supplied feed must be adapted to these changes in growth rhythm, particularly in summer, when specific growth rate can temporarily exceed 1.5% per day.

Feeding requirements and rates:

The composition of pellets for spawners has not been the subject of specific research in Arctic charr but feed finalised for trout and salmon spawners seem suitable for charr: Lipid quality and level seem important. Highly unsaturated fatty acids are required in sufficient amount as well as antioxidants as vitamin C and E. In an experiment, spawners were fed daily at 0.8 or 0.4 % of their body weight to compare the effect of two different feeding rates on egg production. In 4+ fish, eggs were bigger in fish fed at 0.8% (85 mg versus 75 mg), GSI were and condition coefficients superior (18.65 versus 16.63 and 1.39 versus 1.30, respectively) but relative fecundity remained constant (2250 eggs/kg). In 3+, there was no difference for all these parameters between fish fed at 0.8 or 0.4 %.

Fecundity and egg size, effects of growth and age:

As in the rainbow trout, relative fecundity (egg number/kg) is positively correlated to the growth registered during the beginning of vitellogenesis (spring and early summer) whereas egg size is positively correlated to the growth registered during the end of vitellogenesis (end of summer, early fall), when oocytes are quickly developing. Relative fecundity and egg mean weight differ according to strains and also to the age of fish. By example, in Arctic charr from Lake Geneva, in rearing conditions, females that mature in their second year have 5600 eggs/kg of 32 mg in weight, at 3, they have 3200 eggs/kg of 48 mg and at 4, 2600 eggs/kg of 61 mg.. GSI tend to decrease with the size of fish. This relationship is also confirmed within each year class. Consequently, it could be advantageous to have spawners of small size to enhance egg production.

Sensibility of spawners to diseases:

When Arctic charr gonads are developing, spawners become more sensitive to furunculosis, especially if water temperature is above 10°C. Arctic charr is very sensitive to BKD and spawners can transmit the bacteria to their offspring. Thus, it is important to ensure that spawners are not unaffected carriers of BKD. Fungal disease is generally chronic among spawning Arctic charr, with mature males much more sensitive than females. The fungus disease spreads very rapidly when the temperature is around 8°C. In a water at a temperature below 5°C, the occurrence of the fungus disease is lower than at 8°C and the development of fungus is strongly reduced compared to 8°C. Preventive treatments appears to reduce the severity of outbreaks. Malachite green is very efficient to prevent fungal disease, especially when it is administrated drop by drop to produce a low (<1 ppm) and long exposure. But Malachite green is forbidden in fish for human consumption. Several antiseptic products as hydrogen peroxide, formalin, chloramine T, bronopol can be use to prevent the development of fungus. However, the posology is not accurately defined for the treatment of Arctic charr spawners by all these chemicals.

Environmental requirements, environmental and physiological manipulations of spawners.

Shift of the spawning period by photoperiod treatments:

As in the rainbow trout, long day treatment applied in winter or in early spring stimulate the onset of gametogenesis whereas short days accelerate the completion of gonadal development and facilitate the release of gametes. Thus it is possible to advance the spawning period by about 3 months using long days (or continuous light) during 3 months in winter followed by a transfer to short days until ovulation. Conversely, the spawning period is delayed by 2 months when the spawners are kept under a long day regime from mid summer until spawning. But the whole period of ovulation extends over more than three months when the spawners are maintained under a long day regime during the spawning period. When the spawners are transferred to a short day regime before the onset of

ovulation period, spawning period extends by 1.5 months as in control. Generally, in advanced spawnings, eggs are smaller than in control. Conversely, in delayed spawnings, eggs are larger.

Effect of temperature on gamete release:

Arctic charr require coldest water during the spawning period. However, thermal thresholds favourable to trigger the ovulation could differ between the strains. In Arctic charr originated from Lake Geneva, ovulation is inhibited when water temperature is above 11°C. Ovulations occur earlier and are more synchronized between the different females at 5°C than at 8°C. At 10°C, males produce a lower quantity of milt than at 5°C and the milt contains few spermatozoa at 10°C whereas spermatocrite is high at 5°C. Temperature act both on the hypothalamo-pituitary axis and directly on the gonad to control the ovulation. At 10°C, a dopaminergic inhibition of gonadotropin secretion (LH) occurs and the ovary secrete little MSI (17 α -hydroxy-20 β -dihydroprogesterone) whereas, after a transfer from 10 to 5°C, the plasma level of MSI quickly increase and the dopaminergic inhibition is suppressed in some days. Thus it is recommended to transfer Arctic charr to cold water (< 7°C) some weeks before the onset of ovulation. To date, the effect of high summer temperature during the development of gonads is not evaluated. This is a concern of increasing importance with respect to the global warming.

Spawning induction:

It is possible to induce and to synchronize ovulation in Arctic charr using gonadotropin releasing hormone analogues (GnRH_a) alone or in combination with an antidopamine product: pimoziide metoclopramide or domperidone. The more potent GnRH_a to induce ovulation in Arctic charr are Azagly, D Arg6 sGnRH, D Ala6 LH-RH and D Trp6 LH-RH. At 5°C, all these GnRH_a have a high efficiency at low doses (10 to 30 μ g/kg). At 7 or 8°C, it is possible to induce a high rate of ovulation by a combination of a low dose of D Arg6 sGnRH with a pimoziide treatment (5 mg/kg). All the ovulations are grouped within a ten-day period. At 10°C, it is necessary to use a high level of GnRH_a in combination with pimoziide or a sustained release preparation of GnRH to induce a high rate of ovulation. At 10 °C egg viability is generally lower than at 5 or 8°C. In males, milt production can be stimulated by GnRH_a or pituitary power treatments.

Check frequency, fertilisation and induction of triploidy.

Overripening in Arctic charr ova:

At 5°C, after ovulation, ova exhibited a high fertilisability for 8 days or more. At 8°C, ova overripe two time more quickly than at 5°C. It is recommended to check the females during the spawning period once a week at 5°C but more frequently when water temperature is at 8°C. But repeat handling stresses can block ovulation, even in anaesthetized fish. Consequently, it is better to group the ovulation.

Fertilisation:

Arctic charr ova can be fertilised in a large temperature and pH ranges: Fertilisation rates do not differ at 6 , 10 et 14 °C or for pH included in a 6-9 pH range. The longest duration of sperm motility was observed at pH 8.5 in a buffered solution by Tris HCl at 0.2 osm. It is recommended to use an extender buffered between 8 and 9, at 0.2 osm when the quantity of milt available is low (< 2 ml for 100 ml of ova). Otherwise, it is possible to simply fertilise the ova by mixing the ova with the milt for several males and then, by adding one water volume for one ova volume. When the pH of coelomic fluid is inferior to 8, it useless to fertilise the spawn because it is overripe.

Production of triploid Arctic charr:

It is possible to induce triploidy (to produce sterile fish) by retention of the second polar body by a pressure shock of 650 bar, applied 40 min after fertilisation at 8°C, the shock lasting 5 min.

Recovery of spawners:

After the spawning period, it is recommended to strip all the females and to completely remove the ova. Females of Arctic charr that retained ova after ovulation are generally more sensitive to fungus disease and they do not eat for several weeks.