8. REPRODUCTIVE TRAITS IN AQUATIC ANIMALS

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8.1 Reproductive cycle

Controlled breeding is only possible if there is enough knowledge about the factors governing reproduction to close the reproductive cycle. Lack of such knowledge has prevented the establishment of breeding programs for several of the farmed species. The elements of controlled breeding, artificial fertilisation and hatchery rearing, must be possible for a breeding program to begin. Artificial reproduction has been achieved for the farmed species listed in Table 8.1.

The reproductive behaviour varies greatly between species. The majority of aquaculture species are season breeders, which are related to climatic conditions like temperature, day length, rainy season and floodwaters. Some species such as salmonids spawn all eggs at once, while other species like flatfishes are batch spawners. The Pacific salmon species spawn once in their lifetime and die soon afterward while other species spawn once a year and for several years, as do rainbow trout. In the tropics tilapia may spawn repeatedly with 3-4 weeks intervals.

8.2 Sex determination

The basic pattern throughout the animal world is that there are two sexes, male and females. These species are called bisexual. There is, however, in fish considerable variation in sexuality. In some species there are hermaphrodites, in which males and females exist in the same animal. They may first be one sex then the other or both male and female at the same time. Unisexual fish are also known, whereby females produce only female offspring.

8.2.1 UNISEXUAL FISHES

Unisexual fish are rare and none of the fish species farmed is known to belong to this group. Unisexuality occurs either by gynogenese or by hybridogenesis. In gynogenese sperm of a closely related species trigger development of eggs, but do not fuse with it and the result is only female triploid offspring. Natural gynogenese occur in Poeciliopsis species and Carassius auratus gibello. Hubbs and Hubbs (1932) were first to described gynogenese in Poecilia formosa.

In hybridogenesis, gametic fusion occurs and the paternal genome is expressed, but only the haploid female genome is transmitted to the ovum. Hybridogenese in the genus Poeciliopsis has been described by Schults (1971).
8.2.2 HERMAPHRODITES

According to Purdom (1993) three forms of hermaphrodites are found:

- Protogynous hermaphrodites, in which individuals develop first into females and later into males. This is the most common form, examples are grouper (Epinephelus tauvina) and cockoo wrasse (Labrus bimaculatus)

- Protandros hermaphrodites, in which the male state differentiates first, examples are sea bream (Sparus aurata), oysters (Grassostrea gigas and Ostrea edulis). Not all males may undergo sex reversal (Zohar et al., 1978)

- Synchronous hermaphrodites where both male and female states coexist functionally. An example is scallops. This is the least common form of hermaphrodites

Occasionally hermaphrodites may occur in other species, which are normally bisexual. Examples are certain domesticated strains of Xiphophorus helleri (Lodi, 1979). Spontaneous hermaphrodites have been reported in brown trout (O'Farrel and Peirce, 1989). Protandros hermaphrodites have also been observed in clams, scallops and abalones.

Sex reversal in hermaphrodite species can occur at almost any time although it mostly occurs after the reproduction season (Brusle, 1987). The mechanism underlying the initiation of sex reversal is still not fully understood, but it seems evident that environmental factors and social behaviour are implicated. Any possible genetic basis for hermaphrodites is not well understood although genetic factors have been suggested.

8.2.3 BISEXUAL FISHES

Most fish species are bisexual with males and females. In most bisexual species some sort of sex chromosome determines sex either through male heterogamety (female XX and male XY) or female heterogamety (female WZ and male ZZ). Sex chromosomes are morphologically indistinguishable from autosomes in most fish species. In some species sex determination has been said to be polygenic and dependent on many genes distributed on many chromosomes, but this last viewpoint has been criticised by Kallman (1965).

8.3 Sex ratio

The relative frequencies of females and males are called the sex ratio. At hatching or early in the life cycle the sex ratio usually is 1:1. Later in the life cycle the ratio may be skewed for several reasons, the survival may be different in the two sexes, in some species age at sexual maturation and following mortality may be different in males and