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Skeletal Deformities in Cultured Common Carp *Cyprinus carpio* L.

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Abstract

The appearance of various deformities in common carp, *Cyprinus carpio* are described. Six hundred seventy one fish were examined; 24.9% showed different types of deformities. Of these, 37.6% had semi-operculum, 18.2% had spinal deformity, 17.4% had head deformity, 11.4% had multiple-deformities, 11.2% had eye deformities, and 4.2% had stumpbody. Deformities were observed in both sexes. Growth of deformed fish was substantially slower than that of the normal fish. The reason for deformities could not be determined, but possible causes are discussed.

Introduction

The common carp *C. carpio* L. stock originated from Taiwan in 1981, and since then it has been maintained as broodstock at the Fish Culture Project, Riyadh. During carp larval rearing some deformed fish, particularly those with semi-operculum, were first recorded in 1991. The percentage of deformed fish was minimal, and no attention was given to the problem at that time. However, in 1993 it was noted that the percentage of deformed fish has considerably increased, and aside from semi-operculum deformity, other types of deformities were also noted. In view of these observations, it was decided to describe the various types of deformities seen in this population, and to examine the factors that might have caused these deformities.

In the larval rearing of common carp, skeletal deformities have been reported and found to be related to either vitamin C deficiency in the diet (Dabrowski et al.1988) or to a strong water current (Backiel et al.1984).

Deformities are common in both wild and cultured fish populations, but their frequencies are greater in hatchery populations. Available evidence suggest that abnormalities are induced during the embryonic and post-embryonic periods of life. However, the etiology of these syndromes is not yet well understood.

Several factors have been implicated for the appearance of deformations in fish, and can possibly be caused by environmental disturbances or toxicants (Couch et al.1979, Backiel et al. 1984, Weis and Weis 1989, Wiegand et al.

1989, Grady et al. 1992), parasites (Hoffman et al. 1962, Treasurer 1992), nutritional deficiencies (Rucker et al.1970, Lim and Lovell 1978, Akiyama et al. 1985, Dabrowski et al.1988, Frischknecht et al. 1994, Quigley 1995), genetic basis (Matsui 1934, Rosenthal and Rosenthal 1950, Tave et al.1983, Mair 1992), or may be caused by traumatic injury (Breeder 1953, Gunter and Ward 1961), or culture techniques (Romanov 1984, Leary et al. 1991). Deformities may also be noninheritable congenital defects (Tave et al. 1982, Dunham et al. 1991, Handwerker and Tave 1994, Tave and Handwerker 1994).

The present study describes various types of deformities found in common carp during its rearing in Saudi Arabia and suggests possible causes for the deformities.

Materials and Methods

Carp breeding and larval rearing

Every year three to four pairs of carp breeders with an average weight of about 1.5 kg were selected and induced to spawn in 10-m^2 concrete tanks by providing nylon netting artificial substrate at the bottom and a cover at the water surface. Nets were removed and eggs attached to the netting were hatched in 900 1 fiberglass aerated tanks with flow-through water system. Water temperature was maintaned at 26 to 29°C. Other water quality parameters are salinity 1.5 ppt, dissolved oxygen 4.8 to 7.5 mg·l, pH 7.3 to 8.5, alkalinity 180 to 210 mg·l and total water hardness 850 to 1000 mg·l. Two day old larvae were initially reared on egg custard and *Artemia* nauplii for one week, thereafter, the larvae were gradually weaned to a dry diet (protein 34%, fat 4%, fiber 3%, ash 11%, calcium 1.2%, salt 0.3%, phosphorus 1%, vitamin A 20 1 u·g, vitamin D 6 1 u·g, vitamin B 25 1 u·g, manufactured and information provided by Grain Silos and Flour Mills Organization, Riyadh, Saudi Arabia.)

In 1997, three pairs of two-year old carps were bred and the methods used for larval rearing were the same as described above. One thousand four week old post-larvae were stocked in four aerated 10-m^2 concrete tanks (250 fish per tank) and reared for eight months. The fish were fed a 34% protein tilapia diet, and the feeding rate was fish weight dependent, ranging from 10 to 3% of body weight daily. Tank water was completely exchanged daily in the morning with fresh water, and leftover feed and excreta were removed by sweeping while changing the water.

Examination of deformities

After eight months of rearing the tanks were drained and all fish were caught, counted, and weighed; deformed fish were separated. The abnormal fish were anaesthetized and radiographed, using a medical X-ray system. The X-ray pictures were used for examination of the skeleton. Vertebrae involved in the lordosis and scoliosis curvature were numbered from the head to the tail region.

Results and Discussion

Out of a total of 671 surviving fish, 167 (24.9%) showed different types of deformities. The deformities were externally apparent and were identified as semi-operculum, spinal deformity, head deformity, stumpbody, multiple deformities and eye deformities (Table 1).

Semi-operculum

Semi-operculum was the most common deformity observed in the common carp since 37.6% of the deformed fish had semi-operculum. The deformities were first observed at two months of age and the degree of deformity was variable but in most cases operculum was usually shortened with involuted edges (Fig. 1). In some fish it was minimally shortened, while others had an operculum that was so malformed that the posterior gill lamellae were exposed. The semi-operculum deformity was caused because of abnormal development of either the subopercle or both the subopercle and opercle, and the operculum was shortened. The branchiostegal membrane was also observed to be deformed. The deformity usually occurred only on one side, however, some of the fish had a bilateral semi-operculum. Fish with this kind of deformity swam normally, but growth was very slow (Table 1).

Dabrowski et al. (1988) reported operculum deformity in *C. carpio,* and found it to be associated with vitamin C deficiency in the flaked diet. Operculum deformity has also been reported in hatchery raised *Oreochromis niloticus* L. (Mair 1992, Tave and Handwerker 1994), and *T. mossambica* (Handwerker and Tave 1994). The operculum deformity was found to be noninheritable (Handwerker and Tave 1994, Tave and Handwerker 1994). In *Oncorhynchus mykiss* (Walbaum) vitamin C deficency related operculum deformity has also been reported (Frischknecht et al. 1994). In all these studies, the fish had operculum deformity only on one side and the other operculum was normal; whereas in the present study it was found on both sides of some fish.

Spinal deformity

About 18.2% of the deformed fish had spinal deformity. The predominant types of spinal deformities observed were lordosis and scoliosis (Figs. 2b, c, d, e). The most prevalent abnormality of the spinal column was lordosis, and

Table 1. Percentage of deformity and mean size of deformed and normal common carp.

Types of deformity	Percentage of deformity	Average length (cm)	Average weight (g)
Semi operculum	37.6	21.5	172.7
Spinal deformity	18.2	23.1	246.6
Head deformity	17.4	22.2	219.4
Stumpbody	4.2	18.3	123.5
Multiple deformity	11.4	23.7	286.6
Blind	11.2	19.6	113.7
Normal	—	26.3	301.7

many fish had spinal columns showing curvatures up to 45° (Fig. 2e). Lordosis is characterized by the formation of a V-shaped curvature of the spinal column (Figs. 2c, d, e, f). The spinal column deformity vary with the degree of deformity and in the number of flexions of the vertebral column. The deformities first appeared when the fish were about two weeks old. X-ray radiograph showed that many of the vertebrae in the curvature region were deformed and fused. The affected vertebrae were both in the anterior and posterior region of the spinal column (Figs. 2c, e). However, the most frequently affected vertebrae were generally in the anterior half of the spinal column. Some specimens showed one point of curvature at the center of the vertebral column, either between 10 to 16 (Fig. 2c) or between 18 to 20 (Fig. 2d) vertebrae, whereas some specimens showed more than one point of curvature in the vertebral column, one between 13 to 15 vertebrae and the other between 20 to 22 vertebrae (Fig. 2f). In one specimen, two curvatures were noted, one between 19 to 22 and the second in the distal region between 31 to 32 vertebrae (Fig. 2e). Some specimens showed scoliosis at the center of the vertebral column, between 13 to16 vertebrae (Fig.2b). Fish with spinal deformities either swim upside down or sideward, and the growth was slow compared to a normal fish (Table 1). The causes of lordosis in *C. carpio* could not be established but in a number of marine fish lordotic deformation is noted to occur only in fish that had no gas in their swim bladder (Kitajima et al. 1994). In several fish species the spinal malformation was found to be associated with the absence of a functional swim-bladder (Iseda et al. 1979, Kitajima et al. 1981, Daoulas et al. 1991, Chatain 1994, Andrades et al. 1996). In the present study the deformed fish had normal swim-bladder. Spinal deformities were reported in *C. carpio* (Backiel et al. 1984) and strong water current was found to be responsible for such. On the other hand, Dabrowski et al. (1988) and Frischkenecht et al. (1994) suggested that vitamin C deficiency in the diet was responsible for the spinal column deformity.

Head deformity

About 17.4% of deformed fish had head deformity (Figs. 3a, b, c) while 11.2% of deformed fish were blind. In some deformed fish, the head appeared larger or smaller in comparison to normal fish that appeared to be due to

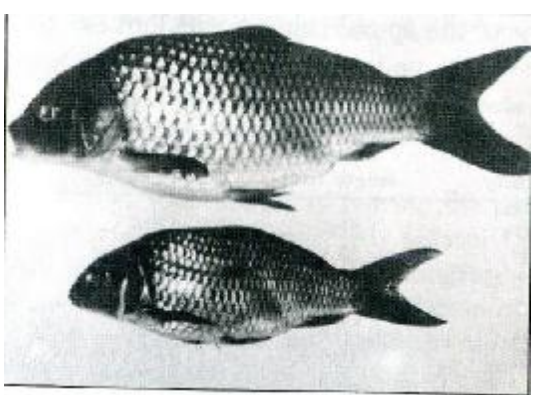
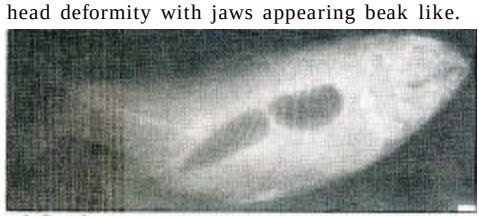


Fig. 1. Normal common carp (top) and a carp with a semi-operculum (bottom).

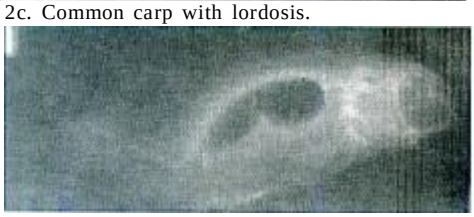
2a. Fish with a normal vertebral column.

2b. Fish showing scoliosis; the fish also shows head deformity with jaws appearing beak like.

2c. Common carp with lordosis.

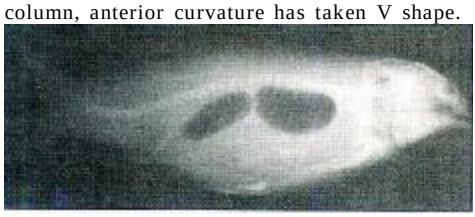


2d. Lordotic vertebral column with one flexion.



2e. Lordosis with two flexures in the vertebral column, anterior curvature has taken V shape.

2f. Fish with two lordotic flexures.



2g. Deformed head with beak-like appearance of the jaws.

2h. Stump-bodied common carp with deformed vertebral column.

2i. Fish with deformed body showing head deformity, dorso-ventral compression of body and lordosis.

Fig. 2. X-ray radiographs of normal and deformed common crap.

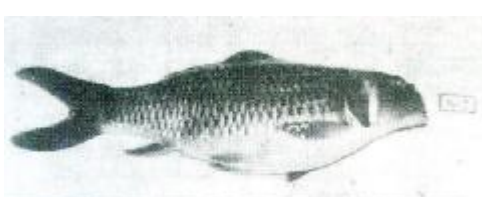


Fig. 3a. Common carp with deformed head and semi-operculum.

Fig. 3b. Common carp with deformed head and lordosis.

Fig. 3c. Common carp with deformed head and scoliosis..

ossification and compression of bones. There were various deformations of the head, including beak like appearance (Fig. 2g), inward bending of the lower jaw, and shortening of the neurocranium (pug-headedness) and upper jaw. The fish affected with head deformity swam normally, but growth was slow compared to normal fish (Table 1). Head deformities have been reported in many species of freshwater and marine fish (Riehl and Schmitt 1985, Quigley 1995). Jaw deformity could be caused by many factors such as mechanical injury, nutritional deficiencies, parasitism, teratogenic substances, and adverse environmental conditions or genetic aberration (Quigley 1995).

Stumpbody

Stumpbody is caused by an abnormal ossification of the trunk vertebrae. About 4.2% of the deformed fish had stumpbody (Fig. 4). Deformed fish were shortened along the anterior-posterior axis, more deep bodied with shortened trunk compared to a normal fish (Fig. 4). Deformities ranged from slightly shortened to much shortened fish. The posterior region of the fish trunk appeared compressed and many of the vertebrae were fused.

X-ray radiography revealed that the fish with stumpbodies also had semi-operculum and lordosis (Fig. 2h). The fish affected with such deformity swam upside down or sideward and growth was very slow (Table 1).

Stumpbody has been reported in *Sarotherodan aureus* (Steindachner) *(Tilapia aurea)* (Tave et al. 1982) and in channel catfish *Ictalurus punctatus* (Rafinesque) (Dunham et al. 1991) and found to be noninheritable.

Multiple deformities

About 11.4% of the deformed fish had multiple deformities (Figs. 2i, 3a, b, c), including semi-operculum, spinal deformity, head deformation, and stumpbody. The affected fish with such deformities swam upside down or sideward, and growth was slow compared to a normal fish (Table 1). Similar to the present study, multiple deformities were reported in *S. aureus* (Tave et al. 1982), *C. carpio* (Dabrowski et al. 1988), *Carassius auratus* L. (Wiegand et al. 1989) and *O. mykiss* (Frischknecht et al. 1994).

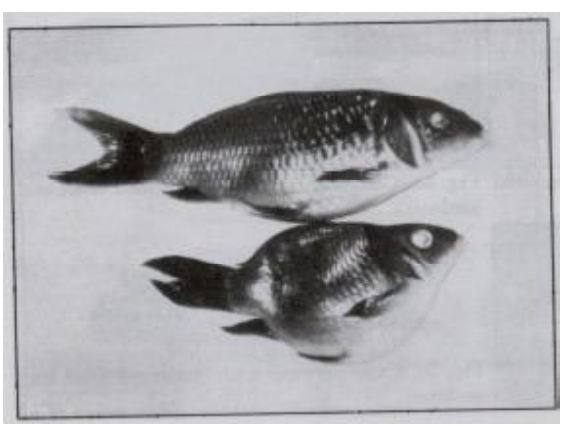


Fig. 4. Common carp with semi-operculum (top) and with stumpbody (bottom).

All types of deformities were observed in both sexes. Average length and weight of abnormal fish were substantially lower than that of normal fish (Table 1), probably because of their inability to feed normally. The exact cause of deformities could not be established because of lack of sufficient data. The deformities may have been caused either by environmental disturbance, nutritional deficiency in the feeds, a genetic mutation, or a combination of the three factors. Inbreeding can also elicit such abnormalities in fish species but in the absence of a sound evidence no single specific reason for skeletal anomalies can be established. More research therefore is needed to exactly identify the factors causing such deformities.

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