Aquafarmer Information Sheet:

Triploid Chinese Catfish

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Triploid Induction in Fishes

Triploidy induction is a process whereby an entire chromosome set is added to a fertilized egg. Normal individuals are diploid (2N), receiving one chromosome set (1N) from each parent. Triploid (3N) individuals have an additional chromosome set derived from the second polar body (1N). The second polar body is produced during an egg's meiotic cell division and is normally lost soon after fertilization. If appropriate shock is applied soon after fertilization, the second polar body is retained by the fertilized egg, thus producing a triploid individual.

Triploidy has been induced by culturists and researchers in a large number of fish, shellfish and other animals that have external fertilization. Reasons for inducing triploidy usually relate to either sterility (triploids are functionally sterile), improved growth performance, or some other improved triploid quality. Because triploids are sterile, they can be released to the wild without danger of becoming established (exotic introductions) or of contaminating local gene pools where the species in question is established. This is an important consideration where cultured species have been altered through genetic selection. Often, but not always, triploids grow faster compared with diploids. There is also evidence that with some species, triploids are less aggressive. Triploidy induction combined with sex reversal is also a useful technique for developing all male or all female cultivars (Feist et al. 1996).

Triploidy Induction Methods

Most commonly, triploids are produced through chemical, pressure, or temperature shock to fertilized eggs. Cytochalacin B is used for chemical shock, especially with shellfish (Lutz 1998), while hydraulic pressure shocks of 5,000 to 10,000 psi are more commonly used with fish. Temperature shocks are perhaps the easiest method of triploidy induction for most culturists because only inexpensive, safe equipment and materials are used. High temperatures are used with coldwater species such as salmonids, whereas cold shocks of 2° to 6°C are most effective with warmwater species such as catfish.

Chinese Catfish in Hawaii

Chinese catfish (*Clarias fuscus*) were brought to Hawaii more than 100 years ago, presumably from southern China by immigrant workers hired to work on Hawaii plantations. This fish became established but not abundant on most Hawaiian islands with adequate freshwater resources. During the early 1980's, researchers at the Hawaiian Institute of Marine Biology, University of Hawaii (UH), successfully developed practical seed production and rearing methods for this species in Hawaii. This work was supported by UH, the U.S.Department of Agriculture 406 Program, and U.S. Agency for International Development. Research results were extended to the aquaculture community through workshops and a training video (Fast and Young 1988). As a result, Chinese catfish culture became popular among fish farmers in Hawaii. Production increased from 9,000 pounds per year in 1985 to more than 60,000 pounds per year today (Table 1). At the same time, however, production costs and farm-gate prices remained high. Farmers received wholesale prices ranging from $5.81 per pound in 1985 to $5.25 per pound in 1996. Retail prices are typically $1.00 per pound higher than the wholesale prices. These high prices contributed to a leveling off of market demand at about 60,000

pounds per year and reduced profits to farmers because of increased competition and production costs. As a consequence, the Center for Tropical and Subtropical Aquaculture funded research on triploidy induction as a possible means of reducing production costs and thereby increasing Chinese catfish marketability.

Triploidy with Other Clariid Catfish

Henken et al. (1987) induced triploidy in African catfish (*C. gariepinus*) and compared their growth with normal diploids. They found no significant growth differences, although triploids did have greater fat content. However, Fast et al. (1995) found that triploid Asian catfish (*C. macrocephalus*) grew more than 50 percent larger than diploids, had greater dressed carcass weight and had virtually no gonadal development. These quite different results with closely related clariid catfish species indicated that potential benefits from triploidy are very species-specific.

Triploidy Induction with Chinese Catfish

We produced triploid *C. fuscus* using both temperature and pressure shocks, but found temperature shock most reliable and easiest to use. Temperature shock methods were as follows:

- Eggs were stripped from one or more female fish following HCG injections and were held in a glass or plastic bowl without water added.
- Testes were removed from one or more male fish, macerated and rinsed through a fine mesh net with freshwater to begin fertilization (see Fast and Young 1988 for spawning details).
- The egg and sperm mixture was then gently mixed for about 2.5 minutes, at which time excess water was decanted and the fertilized eggs placed in a Plexiglas cylinder (12 cm diameter x 18 cm high) with fine mesh net (<0.5 mm openings) attached to the bottom.
- The cylinder and eggs were then immersed in an ice chest (about 3 to 4 minutes after fertilization began) containing water at 4° to 5°C.
- Eggs were held in the water for 20 to 30 minutes. The chilled water was circulated using air injection or by some other means, and ice was added as needed to maintain water temperature.
- After 20 to 30 minutes, eggs were removed and placed in incubators at ambient temperatures (25° to 30°C). This normally resulted in 90 percent to 100 percent triploidy induction.

Culture Performance

We compared the culture performance of triploid Chinese catfish that were produced as described above with diploids from the same spawns. After 175 culture days, triploid catfish weighed 312 grams compared with 276 grams for diploids (Table 2). Male fish of each ploidy condition were larger than females, and triploid males were largest of all at 331 grams. Gonadal development was much reduced with triploids, although some female triploids did develop abnormally fatty ovaries. Overall, dressed carcass weight was 91 percent for triploids compared with 88 percent for diploids. Triploids held in 25°C water temperature produced a more favorable feed conversion ratio of 1.6 using Moore-Clark, New Age Pacific pelleted feed, compared with a feed conversion ratio of 2.1 for diploid catfish under similar conditions. Fatty acid profiles indicate greater fatty acid content of triploid fish reared at both high (25°C) and low (21.5°C) temperatures. Average fatty acid content of triploids was 12.1 percent compared with 8.7 percent for diploids (Table 3). This greater fatty acid content of triploids indicates greater human health benefits from eating these fish.

Conclusions

We concluded that culture using triploid Chinese catfish will result in increased growth rates of 13 percent compared with diploids; this will reduce time to reach market size by more than one month. Triploids consume about 24 percent less feed than diploids. With $0.45/lb feed costs, this saves $0.22 in feed costs per pound of fish produced. Our findings also indicate that an all male, triploid stock would give even better growth performance. If such stock were produced through appropriate chromosome and hormonal manipulations, overall growth could be increased by 20 percent compared with culture of normal diploid populations of male and female fish. All male, triploid fish could then be marketable almost two months earlier. In addition, fatty acid profiles of triploids demonstrate that they have more favorable food quality. This has useful marketing value.

Literature Cited

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Table 1. Commercial Chinese catfish production in Hawaii from 1985 through 1996, including total wholesale values and average farm-gate prices (*Data provided by the Hawaii State Aquaculture Development Program*)

Year	Production (in pounds)	Wholesale Value	Average Price per Pound
1996 (estimated)	60,000	$315,000	$5.25
1995	64,000	$351,000	$5.47
1994	68,000	$372,600	$5.48
1993	34,900	$202,900	$5.81
1992	53,100	$299,400	$5.64
1991	60,600	$338,000	$5.58
1990	40,200	$225,800	$5.62
1989	40,900	$216,700	$5.30
1988	43,182	$237,410	$5.50
1987	30,600	$160,752	$5.25
1986	13,200	$ 75,900	$5.75
1985	9,000	$ 52,300	$5.81

Table 2. Live Weights and gutted carcass weights of diploid and triploid Chinese catfish (*Clarias fuscus*) after 175 days of culture

	Diploid (2N)			Triploid (3N)		
	females	males	all	females	males	all
live weight in grams	246	306	276	293	331	312
carcass weight in grams	199	285	242	264	306	285
sample number	25	28	53	30	28	56

All fish were produced from the same spawns and reared in replicate tanks at average temperatures of 21.5°C and 25.0°C.

Table 3. Fillet fatty acid levels in grams per 100 grams dry weight for diploid and triploid Clarias fuscus fed New Age Pacific feed at low temperatures (LT=21.5°C) and high temperatures (HT=25°C) after 175 days of culture.*

	Triploids		Diploids	
Type of Fatty Acid	**HT**	**LT**	**HT**	**LT**
14 myristate	0.60ab	0.67a	047bc	0.45c
16 palmitate	3.05ab	3.33a	2.26c	2.28bc
16:ln-7 palmitoleate	0.72ab	0.77a	0.57bc	0.52c
18 stearate	0.92a	0.92a	0.62b	1.12ab
18:ln-9 oleate	2.05ab	2.14a	1.26b	1.19b
18:2n-6 linoleate	0.43a	0.48a	0.33b	0.32b
18:3n-3 linolenate	0.13ab	0.16a	0.11b	0.10b
18:4n-3 octadecatetraenoate	0.14a	0.16a	0.10b	0.11b
20:ln-9 eocsenoate	0.19b	0.25a	0.17c	0.17c
10:4n-6 arachidonate	1.23a	0.34a	0.93b	0.92b
20:5n-3 eicosapentaenoate	1.23a	1.34a	0.93b	0.92b
22:6n-3 docosahexaenoate	1.99a	2.16a	1.64b	1.54b
Total Fatty Acids	**11.61a**	**12.56a**	**8.59b**	**8.85**

*Means within a row followed by a different letter are significantly different (P<0.05).
Table from Qin *et al.* (in press).