

# Comparison of Two Methods of Attaching Telemetry Transmitters to the Mekong Giant Catfish, *Pangasianodon gigas*

Hiromichi Mitamura<sup>1\*</sup>, Yasushi Mitsunaga<sup>2</sup>, Nobuaki Arai<sup>1</sup> and Thavee Viputhanumas<sup>3</sup>

<sup>1</sup>Graduate School of Informatics, Kyoto University, Kyoto 606-8501, Japan

<sup>2</sup>Faculty of Agriculture, Kinki University, Nara 631-8505, Japan

<sup>3</sup>Inland Fisheries Research and Development Bureau, Kasetsart University Campus, Bangkok 19000, Thailand

For conservation and successful stock enhancement of endangered species, an understanding of the movement patterns and behavior of the target species is indispensable. The Mekong giant catfish, *Pangasianodon gigas*, is endemic to the Mekong Basin and now is threatened with extinction. Although biotelemetry using acoustic transmitters and receivers is expected to reveal its movement patterns and behavior, the most suitable attachment method for the transmitter to the catfish is unknown. In this study we examined the effects of external attachment and surgical implantation on the survival and growth of the catfish, compared with those in control individuals, in an earthen fish pond for approximately 2 months. No fish died during the experimental period. Furthermore, we found no fungal infections in any fish and no significant differences in growth rate among treatment and control fish. However, all transmitters of externally tagged fish were lost during the experimental period. In contrast, transmitters of some surgically implanted fish remained in the peritoneal cavity. In conclusion, the surgical implantation technique is suitable for long-term monitoring of the catfish.

**Key words:** Mekong giant catfish, *Pangasianodon gigas*, mortality, growth rate, external tagging, surgical implantation

## INTRODUCTION

An understanding of the movement patterns and behavior of both wild and hatchery-reared endangered species is indispensable for conservation and successful stock enhancement (Masuda and Tsukamoto, 1998; Mitamura *et al.*, 2005a; Mitamura, 2005). Biotelemetry has recently emerged as a tool in animal biology that can be used to monitor specific individuals. In particular, miniature ultrasonic transmitters attached to a target aquatic species can reveal horizontal location, swimming depth, ambient temperature, and other underwater variables, as well as provide individual identification. This technique can be used to unravel the underwater mysteries of “where do animals go” and “what is their behavior”, which can often be answered by relatively simple direct observation in terrestrial environments.

The Mekong giant catfish is endemic to the Mekong River Basin and grows to a very large size. This catfish is one of the largest freshwater fishes in the world, measuring up to 3 m in length and weighing in excess of 300 kg (Rainboth, 1996). In Southeast Asia, this catfish has historically been popular with the local people, and is one of the most important fisheries species of the Mekong River Basin. The catch number of wild catfish in the Mekong River has declined due to development of the river and overfishing

(Hogan, 2004). This decline in catch number implies that the wild catfish may be close to extinction. Hogan *et al.* (2004) estimated that the total number of wild catfish in the Mekong River has decreased by approximately 90%. At present, the catfish is listed in CITES Appendix I and on the IUCN Red List of threatened species as a Critically Endangered Species.

In Thailand, artificial insemination techniques for the catfish were developed in 1983. The Thai government has approved cultivation of the catfish in earthen ponds and reservoirs for purposes of stock enhancement and the conservation in the Mekong River. Previous studies on the catfish, however, have provided little information on their movements; thus, their behavior under natural conditions remains largely unknown. Biotelemetry using acoustic transmitters and receivers is expected to clarify the behavior (MRC *et al.*, 2002).

Transmitters must be attached to aquatic species in a way that reduces the possibility of trauma and minimizes adverse effects on posture, buoyancy, and locomotion (*e.g.*, increased drag and snagging; Stasko and Pincock, 1977). To meet these requirements, both effective attachment methods and the effects of different attachment techniques on the behavior of aquatic animals and their survival must be investigated and assessed for each species prior to any field-based studies. However, the most suitable method of attachment of the transmitter to the Mekong giant catfish has not been determined.

There are basically three main categories of techniques for attaching transmitters to fish: external attachment, stom-

\* Corresponding author. Phone: +81-75-753-3137;  
Fax : +81-75-753-3133;  
E-mail: mitamura@bre.soc.i.kyoto-u.ac.jp  
doi:10.2108/zsj.23.235

**Table 1.** Mean and S.D. of body weight and total length of control, externally tagged and surgically implanted fish 1 and 55 days after treatment.

		Small				Large			
		days				days			
		1		55		1		55 <sup>*1</sup>	
		Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Control	Weight (kg)	2.8	0.8	4.9	1.0	8.9	1.1	11.4	1.8
	Length (cm)	57.2	2.9	66.8	4.1	88.3	4.1	89.8	4.3
Externally tagged	Weight (kg)	2.4	0.5	5.0	0.4	8.5	0.7	11.1	1.1
	Length (cm)	58.8	4.0	67.4	2.4	88.0	3.6	89.2	3.3
Surgically implanted	Weight (kg)	2.7	1.6	5.2	0.3	9.4	0.4	12.7	1.3
	Length (cm)	60.3	0.3	68.4	1.1	88.5	0.7	90.5	0.7

\*1 Four control, three tagged, and two implanted fish from the large group were identified at the end of the experiment.

ach insertion, and peritoneal cavity implantation (Mellas and Haynes, 1985). Mellas and Haynes (1985) conducted experiments to determine the effects of these three basic attachment techniques on the swimming behavior of rainbow trout (*Salmo gairdneri*) and white perch (*Morone americana*). They determined that stomach insertion appears to be the best method of transmitter attachment. However, as this method may result in transmitter loss through regurgitation in feeding fish, it is unsuitable for long-term tracking and monitoring. For relatively long-term fish tracking and monitoring experiments, both external attachment and internal implantation have been used successfully (Holland *et al.*, 1996; Kasai *et al.*, 1998; Mitsunaga *et al.*, 1999; Mitamura *et al.*, 2002, 2005a, b). However, each attachment method has disadvantages (*e.g.*, instrument loss, muscle damage by wires used for attachment, effects on balance, infection, transmitter expulsion), and the choice of attachment method depends on the particular species under study (Lucas, 1989).

In the evaluation of transmitter attachment methods, the effects of transmitter attachment have also been investigated and assessed for different target species (Mellas and Haynes, 1985). For example, the effects of transmitter attachment on growth, feeding, swimming behavior, and swimming speed have been assessed in juvenile Atlantic salmon (*Salmo salar* L.; McCleave and Stred, 1975; Moore *et al.*, 1990). Similarly, the effects of attachment on growth, mortality, and tissue reactions have been assessed in rainbow trout (Lucas, 1989).

In summary, the effects of attachment methods that may influence experimental results should be determined for each experimental objective, and it is necessary to determine which attachment methods are suited to each species. In this study, in order to determine the most suitable attachment method for the transmitters, we examined the effects of external attachment and surgical implantation on the growth and survival of Mekong giant catfish in an earthen fish pond for approximately 2 months.

#### MATERIALS AND METHODS

Two size groups of immature hatchery-reared Mekong giant catfish (small, 52.0–62.5 cm in fork length, N=15; large, 83.0–94.0 cm in fork length, N=15) were used (Table 1). Prior to external

attachment and surgical implantation, fish were anesthetized using a 0.1% 2-phenoxyethanol solution and were weighed and measured. In addition, fish were marked with spaghetti tags for individual identification. Five large and five small fish were used as non-surgery controls and were marked with spaghetti tags only. Transmitters were attached externally on the pectoral fin and surgically implanted into the peritoneal cavity of five large and five small fish per attachment method (Table 1). Dummy transmitters (V16-4H; 16 mm in diameter, 65 mm in length, 12 g in water, Vemco Ltd., Nova Scotia, Canada) were used for the experiment and represented less than 2% of the body weight of fish before treatment.

For external attachment, a hole was drilled in the spines of the pectoral fin of an individual, and the dummy transmitter was attached with two plastic cables through the hole, using the method of Takai *et al.* (1997). Oxytetracycline hydrochloride and polymixin B sulfate antibiotics were then applied. For surgical implantation, the fish was placed in a bath of fresh bubbling water during the operation. An incision approximately 50 mm in length was made in the abdomen, and the transmitter was inserted. The wound was closed using a needle and suture, followed by application of oxytetracycline hydrochloride and polymixin B sulfate antibiotics. Treatment time was 5–15 minutes, after which the fish was transferred to an anesthetic-free cement tank, where all fish recovered. After no effects of treatment on the behavior of the fish were observed, treatment and control fish were transported to the fish pond (40×80 m, 1 m deep). All marking and treatment was performed on one day (2 May 2002).

The pond was checked daily for dead fish by visual observation during feeding; the fish were not handled during the experiment. Water temperature was uncontrolled, and monitoring of the water temperature for the first month showed a range from 28.5–35.1°C. After approximately 2 months (25 June 2002), all fish were anesthetized, weighed, and measured. The fish that had received surgery were inspected for evidence of healing and infection. Only two of the fish with surgical implantations were randomly sampled, killed, and the internal abdomen surrounding the dummy transmitter inspected, while the other fish were transported to the fish pond without any other inspection.

#### RESULTS

Although no fish died during the experimental period, all dummy transmitters and plastic cables were lost from the pectoral fins of externally tagged fish. Because of the relatively muddy water in the fish pond, the timing of these losses was unknown. The holes that had been drilled in the pectoral fins for attachment of transmitters filled in and

healed. Furthermore, no fish exhibited any large-scale infections of the body or the holes in the pectoral fin. Some pectoral fins, however, were broken. We observed that all groups of fish, including control fish, occasionally bumped against the wall of the pond. These results indicate that externally tagged transmitter attachment is not suitable for long-term monitoring and tracking of Mekong giant catfish.

The surgical incisions healed, and no infections were observed in any of the surgically implanted fish. In addition, the sutures disappeared. The dummy transmitter remained in the abdomen of only one of the two fish examined internally and was accommodated beneath the incision. The transmitter was not encapsulated by tissue, and there was no evidence of tissue damage. The other fish had expelled the transmitter by approximately 2 months after implantation. No exit scars were visible, and the fish was in excellent condition. Therefore, surgical implantation was deemed the more suitable method for long-term monitoring and tracking of Mekong giant catfish.

Six external spaghetti identification tags were lost during the experiment, and thus growth data for these fish were excluded from further analyses. After the experimental period, increase in weight and fork length ranged from 60.0–200% and 8.1–30.9%, respectively, for small fish, and from 27.2–40.2% and 0.0–3.4%, respectively, for large fish. A Kruskal-Wallis test indicated no significant differences in growth rate, as measured by increase in weight or fork length over the experimental period, between the treatment and control fish for each group ( $P > 0.05$ ,  $df = 2$ ). Individual variation in growth rate was observed. Growth rates of small individuals were higher than those of large individuals.

## DISCUSSION

No fish died during the experimental period. Furthermore, there were no significant differences in growth rates among treatment and control fish. These results suggest that attachment had no effect on catfish survival, although the effect of transmitter presence was not evaluated because of transmitter loss during the experimental period.

The external attachment technique has been successfully used in many ultrasonic tracking and monitoring studies of fish (Holland *et al.*, 1996; Takai *et al.*, 1997). However, there are also some reports that fish are affected by this attachment method. Mellas and Haynes (1985) reported that external attachment resulted in severe muscle damage by the attachment wires and that the initial penetration holes were enlarged. Furthermore, Moore *et al.* (1990) found that irritation and infection occurred at the locus of attachment, and some externally tagged fish bled to death during the experiments. In contrast, we found that no fish died or contracted fungal infections during the experimental period, although all dummy transmitters and plastic cables were lost from the pectoral fins of externally tagged fish. This suggests that long-term monitoring of catfish cannot be conducted using external tagging.

Japanese giant catfish (*Silurus biwaensis*) inhabiting Lake Biwa were also tracked for conservation purposes using the same external attachment technique tested here (Takai *et al.*, 1997). These externally tagged catfish could be tracked intermittently in the natural lake for up to 319 days. These fish have unremarkable swimming ability and settling

characteristics that did not result in the loss of transmitters and thus may allow successful long-term tracking. In contrast, Mekong giant catfish have remarkable swimming ability, and we observed that fish frequently ran against the wall of the cement tank or other obstacles, which might have caused the loss of the transmitters. The initial penetration holes had healed, and no fish contracted fungal infections, which indicates that transmitters may be lost relatively soon after implantation in captive fish. Although the external attachment technique itself had no effect on fish survival, the results showed that external attachment of transmitters was not a suitable method for long-term monitoring of the catfish.

Surgical implantation of transmitters may produce stress. However, physiological stress examination by Jepsen *et al.* (2001) showed that chinook salmon (*Oncorhynchus tshawytscha*) recovered within a few days after implantation. Other studies by visual observation of behavior or physiological examination in 4 different species have demonstrated that the stress lasts for about 1 hour to 4 days (Lucas, 1989; Moore *et al.*, 1990; Close *et al.*, 2003; Hiraoka *et al.*, 2003). These results imply that the surgically implanted catfish might have recovered after a short period in this study; hence, the stress produced by implantation might not seriously affect the long-term monitoring of Mekong giant catfish.

The incisions of all surgically implanted fish healed well, and no sutures were visible. However, an examination of the abdominal cavities of two randomly selected fish resulted in the recovery of only one dummy transmitter. This dummy transmitter had been in the abdomen for 55 days and was not encapsulated by tissue. In some fishes such as perch and trout, fatty tissue was deposited around internally implanted transmitters (Mellas and Haynes, 1985; Lucas, 1989), and this tissue reaction and encapsulation may prevent the movement of the transmitter within the body cavity (Lucas, 1989). However, differences in ambient temperature during the experiments or in the inflammatory responses of each species may affect the encapsulation of transmitters (Lucas, 1989). The encapsulation of transmitters may have no appreciable effect on fish mortality and growth (Marty and Summerfelt, 1986). Taking into account the absence of tissue damage in the catfish abdomen, the surgical implantation technique is suitable for monitoring catfish.

One of two dummy transmitters was not recovered from within the abdomen, which indicates that this transmitter was expelled during the experimental period. This phenomenon has also been reported by other researchers (Lucas, 1989; Moore *et al.*, 1990). Using channel catfish (*Ictalurus punctatus*), Marty and Summerfelt (1986) determined three ways in which transmitters may be expelled: trans-intestinal expulsion, via the body wall, and via the incision. We found that the incision had healed, and no exit scars were visible on the body wall other than that from the original incision. This suggests that transmitters may be expelled via the incision within several days of the surgery, or via the anus. While there is no indication of the proportion of fish from which the transmitter was expelled, transmitters remained in the peritoneal cavity of at least some fish for approximately 2 months.

All fish showed relatively high growth rates during the experimental period (Table 1). While individual variation in

growth rate was observed, the results indicate that all fish were able to feed in captivity, including those with transmitters in the peritoneal cavity. Individual variation in growth rate may have resulted in part because of the formation of dominance hierarchies.

In summary, we examined the external attachment and surgical implantation techniques for transmitters and found that the latter technique was more suitable than the former for long-term monitoring of Mekong giant catfish. The surgical implantation procedure was also considered appropriate because all fish were able to survive and grow during the experimental period. The development of this transmitter attachment technique is expected to contribute to further ecological research on Mekong giant catfish.

#### ACKNOWLEDGMENTS

We sincerely thank all the staff of the Inland Fisheries Research and Development Centers, Thailand, for their kind support of and contributions to the research in Thailand. We express our appreciation to Y. Yamagishi for her kind assistance and discussions. This study was partly supported by a Grant-in-Aid for Scientific Research (13375005, 12556032, 14560149 and 15•5686) and the Information Research Center for Development of Knowledge Society Infrastructure, the Ministry of Education, Culture, Sports, Science and Technology. We thank the editor and anonymous referees for many kind suggestions and comments.

#### REFERENCES

- Close DA, Fitzpatrick MS, Lorion CM, Li HW, Schreck CB (2003) Effect of intraperitoneally implanted radio transmitters on the swimming performance and physiology of Pacific Lamprey. *N Amer J Fish Man* 23: 1184–1192
- Hiraoka Y, Arai N, Nakamura K, Sakamoto W, Mitamura H, Mitsunaga Y, Yoneda Y (2003) Migration record of Japanese sea bass *Lateorabrax japonicus* using ultrasonic biotelemetry. *Nippon Suisan Gakkaishi* 69: 910–916
- Hogan ZS (2004) Threatened fishes of the world: *Pangasianodon gigas* Chevey, 1931 (Pangasiidae). *Env Biol Fish* 92: 210
- Hogan ZS, Moyle PB, May B, Vander Zanden MJ, Baird IG (2004) The imperiled giants of the Mekong. *Amer Sci* 92: 228–237
- Holland KN, Lowe CG, Wetherbee BM (1996) Movements and dispersal patterns of blue trevally (*Caranx melampygus*) in a fisheries conservation zone. *Fish Res* 25: 279–292
- Jepsen N, Davis LE, Schreck CB, Siddens B (2001) The physiological response of chinook salmon smolts to two methods of radio-tagging. *Trans Amer Fish Soc* 130: 495–500
- Kasai A, Sakamoto W, Mitsunaga Y, Yamamoto S (1998) Migration of immature yellowtail *Seriola quinqueradiata* in the open sea observed by an acoustic transmitter and micro data recording tags. *Nippon Suisan Gakkaishi* 64: 197–203
- Lucas MC (1989) Effects of implanted dummy transmitters on mortality, growth and tissue reaction in rainbow trout, *Salmo gairdneri* Richardson. *J Fish Biol* 35: 577–587
- Marty GD, Summerfelt RC (1986) Pathways and mechanisms for expulsion of surgical implanted dummy transmitters from channel catfish. *Tran Am Fish Soc* 115: 577–589
- Masuda R, Tsukamoto K (1998) Stock enhancement in Japan: reviewed and perspective. *Bull Mar Sci* 62: 337–358
- McCleave JD, Stred KA (1975) Effect of dummy telemetry transmitters on stamina of Atlpantic Salmon (*Salmo salar*) Smolts. *J Fish Res Board Can* 32: 559–563
- Mellas EJ, Haynes JM (1985) Swimming performance and behavior of rainbow trout (*Salmo gairdneri*) and white perch (*Morone americana*): effect of attaching telemetry transmitters. *Can J Fish Aquat Sci* 42: 488–493
- Mitamura H (2005) Studies on the Behavior of Mekong Giant Catfish Using Biotelemetry. Doctoral Thesis, Kyoto University
- Mitamura H, Arai N, Sakamoto W, Mitsunaga Y, Maruo T, Mukai Y, Nakamura K, Sasaki M, Yoneda Y (2002) Evidence of homing of black rockfish *Sebastes inermis* using biotelemetry. *Fish Sci* 68: 1189–1196
- Mitamura H, Mitsunaga Y, Arai N, Yokota T, Takeuchi H, Tsuzaki T, Itani M (2005a) Directed movements and diel burrow fidelity patterns of red tilefish, *Branchiostegus japonicus*, determined using ultrasonic telemetry. *Fish Sci* 71: 491–498
- Mitamura H, Arai N, Sakamoto W, Mitsunaga Y, Tanaka H, Mukai Y, Nakamura K, Sasaki M, Yoneda Y (2005b) Role of olfaction and vision in homing behaviour of black rockfish, *Sebastes inermis*. *J Exp Mar Biol Ecol* 322: 123–134
- Mitsunaga Y, Sakamoto W, Arai N, Kasai H (1999) Estimation of the metabolic rate of wild red sea bream *Pagrus major* in different water temperature. *Nippon Suisan Gakkaishi* 65: 48–54
- Moore A, Russell IC, Potter ECE (1990) The effects of intraperitoneally implanted dummy acoustic transmitters on the behaviour and physiology of juvenile Atlantic salmon, *Salmo salar* L. *J Fish Biol* 37: 713–721
- MRC Fisheries Programme, Hogan Z, Kong H, Zalinge N (2002) Underwater biotelemetry to study fish migrations in the Mekong River. *Catch and Culture Mekong Fisheries Newsletter* 7: 9–13
- Rainboth WJ (1996) Fishes of the Cambodian Mekong. *FAO, Rome*
- Stasko AB, Pincock DG (1977) Review of underwater biotelemetry, with emphasis on ultrasonic technique. *J Fish Res Board Can* 34: 1261–1285
- Takai N, Sakamoto W, Maehata M, Arai N, Kitagawa T, Mitsunaga Y (1997) Settlement characteristics and habitats use of Lake Biwa Catfish *Silurus biwaensis* measured by ultrasonic telemetry. *Fish Sci* 63: 181–187

(Received July 5, 2005 / Accepted December 4, 2005)