Tooth replacement of tigerfish *Hydrocynus vittatus* from the Kruger National Park

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Gagiano, C.L., G.J. Steyn and H.H. du Preez. 1996. Tooth replacement of tigerfish *Hydrocynus vittatus* from the Kruger National Park. *Koedoe* 39(1): 117-122. Pretoria. ISSN 0075-6458.

Evidence of tooth replacement was observed in 14 tigerfish which had been caught during the period 1991 - 1993 in the Olifants and Letaba rivers in the Kruger National Park. Replacement of teeth is a quick process (3-5 days) and first replacement of adult conical dentition takes place at six to seven months post hatch, at a body length of 100 mm (FL). Swollen gums are evident prior to tooth replacement and newly erupted teeth are loosely embedded in the gums. Tooth replacement occurs in both the upper and lower jaws simultaneously. It was observed in the laboratory that the feeding behaviour was affected when adult conical dentition was replaced in ± 287 mm (FL) specimens.

Key word: tooth replacement, tigerfish, *Hydrocynus vittatus*, Kruger National Park, South Africa

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Introduction

Tooth replacement in characins is not an uncommon phenomenon, as it has been studied by Monod (1950), Roberts (1967), Kenmuir (1972), Gaigher (1975), Tweddle (1982) and Brewster (1986). It has been suggested by Roberts (1967) and confirmed by Kenmuir (1972) that the dentition of tigerfish is entirely conical. Conical teeth appear generally when the specimens reach 14 mm (SL), changing to tricuspid dentition at ± 22 mm (SL), followed by adult conical dentition. Fry are fully scaled by the time they reach 25 mm (SL), suggesting that development of tricuspid dentition begins when scale development has finished (Roberts 1967; Kenmuir 1972). Change to functional conical teeth occurs at about 32 mm standard length. Brewster (1986) also reported on transition from conical to tricuspid dentition at 16-25 mm (SL). A specimen of 40 mm (SL) had conical teeth anteriorly in both jaws but each tooth had lateral cusps in the form of very small, nipple-like protuberances. The posterior teeth of this specimen were all tricuspid with well-developed lateral cusps. In specimens larger than 50 mm (SL), the lateral cusps on the anterior teeth are difficult to detect but the teeth at the posterior margin of each jaw are always tricuspid (Brewster 1986). Each tricuspid replacement tooth can be separated into three conical elements, thus suggesting that such teeth are formed by fusion of three "juvenile" conical elements.

Five tooth replacement cavities are present on each side of both jaws. The anterior four each contain a single large tooth, whereas the fifth may contain one or two small, usually tricuspid, teeth (Brewster 1986).

Kenmuir (1973) reported anglers who had caught toothless tigerfish, and he himself had also caught a 300-mm toothless tigerfish in a gill net in Lake Kariba. This author also mentioned a tagged toothless tigerfish which had been recaptured several months later, still toothless. Tweddle (1982) observed a tigerfish in which the protruding teeth were not firmly embedded in their sockets, and could easily be moved by light finger pressure. It has been suggested that tooth replacement is quick and that teeth are probably shed simultaneously (Kenmuir 1973)

Kenmuir (1973) speculated further that if replacement occurs on one side of the jaw only and replacement on the other side occurs at a later stage, the teeth should show different degrees of wear on each side of the jaw. Gaigher (1975) reported a captured tigerfish with small teeth and concluded from X-ray evidence that these teeth were newly-formed replacement teeth at the time of capture. All the teeth were in the same state of development, indicating that tooth replacement in both the upper and lower jaws occurs simultaneously. A tigerfish with small teeth protruding 3 mm from the gums had been collected by Tweddle (1982). This specimen was about 400 mm long and weighed 740 gram.

Analysis of stomach contents of a number of *H. vittatus* revealed teeth in some of the samples and many teeth were found on the bottom of the aquariums in which tigerfish were raised (Begg 1973). In 1973, Begg observed that the tooth-replacement period was one month, after observing it in an aquarium. However, the frequency of tooth replacement is unknown.

Table 1
Length, age, mass, stomach contents and GSI of tigerfish (in the tooth-replacement stage) from the Olifants and Letaba rivers

Fish No.	Length (FL) (mm)	Age (y)	Mass (g)	Stomach Content	GSI	Date	River
1	256	2+	317	not dissected	RR M	10/91	Letaba
2	291	2+	405	not dissected		10/91	Letaba
3	260	2+	193	not dissected	RR M	10/91	Letaba
4	240	2+	177	not dissected		10/91	Letaba
5	304	3+	551	not dissected		06/92	Letaba
6	220	1+	150	empty	IA M	08/92	Letaba
7	261	2+	268	empty	A M	08/92	Letaba
8	262	2+	296	teeth	RR M	01/92	Olifants
9[a]	270	2+	320	fish	RR M	02/92	Olifants
10	265	2+	287	empty	RR M	02/92	Olifants
11	252	2+	231	invertebrates	RR M	02/92	Olifants
12	254	2+	252	not dissected		06/92	Olifants
13	263	2+	298	not dissected		06/92	Olifants
14	252	2+	288	invertebrates	AR M	09/93	Olifants

GSI: Gonosomatic Index (IA M = Inactive male, A M = Active male, RR M = Ripe running male)
[a] Tigerfish with no teeth protruding from the gums

During this investigation, the frequency of tooth replacement was studied in specimens taken from the Olifants and Letaba rivers which were then observed in a laboratory.

Materials and methods

Field observation

From October 1991 to September 1993 a total of 1 212 tigerfish were caught with artificial lures in the Olifants (853) and Letaba (359) rivers in the Kruger National Park. Fish were sampled at regular intervals each month to investigate the frequency of tooth replacement. The mass, standard length and gonosomatic index (GSI) were recorded and the age was determined according to the procedure of Balon (1971). The jaws of each fish were examined for any signs of tooth replacement.

Laboratory observation

Twelve adult tigerfish with a mean fork length of 287 mm ± 13 mm and with a mean mass of 180.85 g were kept in three 1000-litre aquaria at a temperature of 27 ± 1 °C for a period of seven months. They were fed on a mixed diet of live fish, beef liver and hake fillets. The sequence of events during tooth replacement and the frequency thereof was recorded.

Tigerfish were artificially bred according to the method of Steyn *et al.* (1996), and the larvae were kept and raised in a glass aquarium. Thirty of these fish were observed in a 1000-litre aquarium so that first replacement of adult conical teeth could be determined. After the fish had attained an average length (FL) of approximately 50 mm, the bottom of the aquarium was siphoned clean and filtered on a daily basis so as to detect any teeth. Some of the teeth were then prepared for scanning electron microscopic observation.

Results

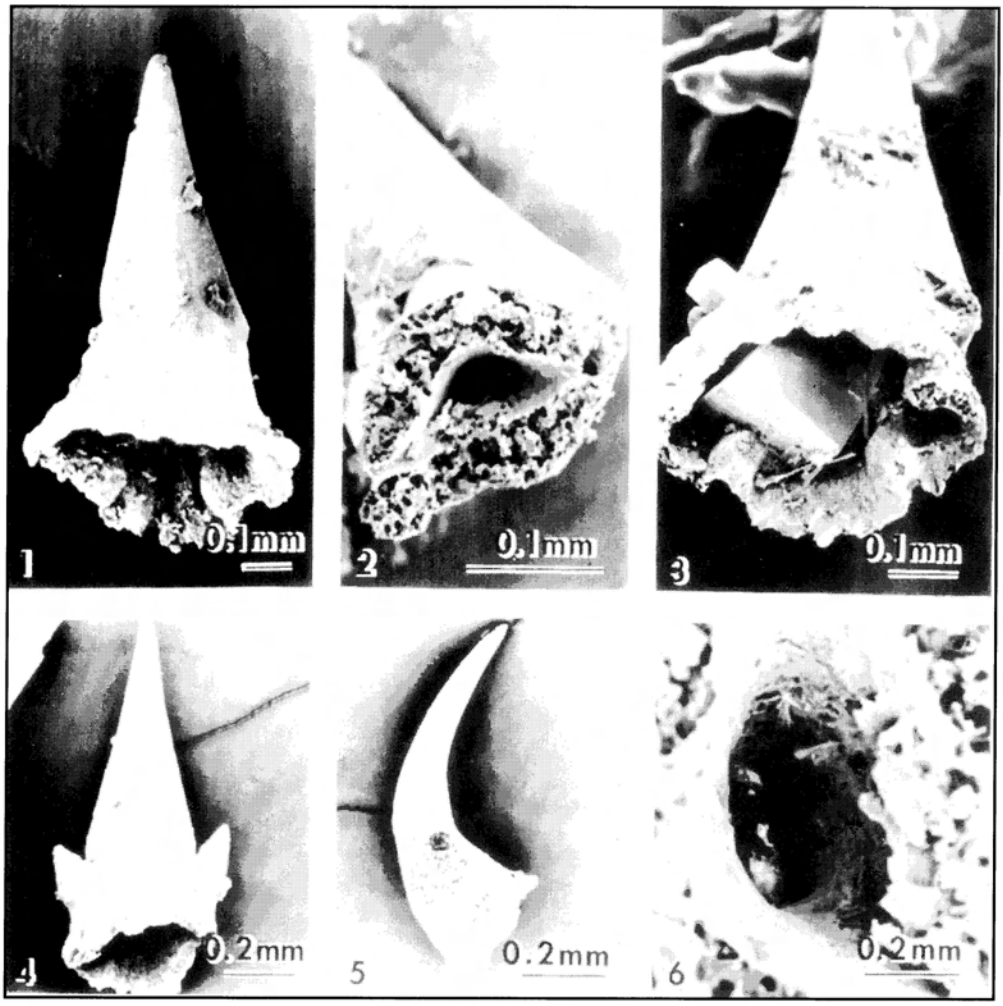
Field observation

Fourteen tigerfish, seven from the Olifants River and seven from the Letaba River, were captured during their tooth-replacement period (Table 1). Most of them had teeth in their sockets, but all the teeth were very loosely embedded and could easily be removed by hand. One tigerfish showed no teeth, while other specimens had small teeth which were hardly protruding from the gums. All the teeth were always in the same stage of development, indicating that tooth replacement was synchronised in both the upper and lower jaws. The gums of fish with loosely embedded teeth appeared swollen. Tooth replacement is apparently not restricted to a certain age and may also occur at any time during the year. The frequency of replacement was, however, slightly higher during spring and summer.

Stomach analysis revealed digested fish and invertebrates in three of these specimens. Three tigerfish teeth were also found in one specimen which had an empty stomach (Table 1). Although nine of the 14 specimens were male, a higher frequency of tooth replacement cannot be associated with a given sex due to an unequal sex ratio in both rivers (*pers. obs.*).

Laboratory observation

The 12 tigerfish in captivity progressively killed each other during fights until only three remained, one in each aquarium. During the six months observation period, two of the fish replaced their teeth twice, but both at different times. The third tigerfish replaced its teeth three times. In all three instances some of the teeth were retrieved from the bottom of the aquarium. Tooth replacement was complete and rapid and the whole process was completed in three to five days. Initially, the teeth became irregularly arranged, pointing dorsolaterally into different directions, resembling that of a ragged tooth shark. The mouth became swollen internally, appeared sensitive and the fish refused to accept food. The teeth were shed in a disorderly fashion and teeth of both jaws were lost, showing no specific pattern. The tooth-shedding process was completed in one to two days and sensitive gums persisted for approximately one day after which a complete set of teeth was visible in both



Figs. 1-3. Conical teeth displaying different angles of the hole in the centre of teeth.
Fig. 4. A tricuspid tooth. Note the difference in size as opposed to conical teeth.
Fig. 5. A hooked conical tooth situated anteriorly in the jaw.
Fig. 6. Enlargement of the centre of a tooth fragment.

jaws. Initially, the teeth were small, but had reached normal size within three days after protruding from the gums. Normal feeding behaviour returned gradually as soon as the new set of teeth was visible.

Tigerfish which were artificially bred and raised in the aquarium shed their first set of adult conical teeth after six to seven months when they had reached an average body length of ± 100 mm (FL). A total of 106 teeth were retrieved from the bottom of the aquarium during this period. Both tricuspid and adult conical teeth were found. The base of each discarded tooth had a conical hole within which the tip of the replacement tooth had probably been embedded prior to tooth replacement (Figs. 1-6).

Discussion

Tooth replacement was observed in only a small percentage (1.2 %) of tigerfish caught and examined in the Kruger National Park. Although tooth replacement was only observed in tigerfish in the age classes 1+ and 2+ years, Roberts (1967) stated that a 20-30 mm (SL) tigerfish with tricuspid teeth has similar replacement trenches to those in *Alestes*. With growth rate increments of 193-196 mm and 110-140 mm for the first and second years respectively (Balon 1971; Kenmuir 1973), one should expect tooth replacement to take place at least a couple of times during the first two years of development. This is confirmed by the fact that the third set of teeth is replaced > 6-7 months after hatching (100 mm FL). According to Kenmuir (1973), a toothless tigerfish was tagged and recaptured several months later, still toothless. This may be explained by the frequency of replacement as was observed in the aquarium. This specimen was probably recaptured while it was replacing a second or third set of teeth. Furthermore, it is hard to imagine that such a ferocious predator like the tigerfish could be without any teeth for such a long period of time. During this study it was observed that 57.1% of the tooth replacement takes place from October until February, which are the warmer months of the year. No conclusive evidence can thus be gained regarding tooth replacement and the different seasons.

Although a reluctancy to feed while replacing teeth was observed in the laboratory, it is not clear to what extent foraging behaviour is affected in nature. The presence of only 1.2 % of tooth-replacing specimens in catches done with angling gear supports the observation on suppressed foraging behaviour, especially if the frequency of tooth replacement is considered. The presence of fish in the gut of one individual is probably the result of food scarcity prior to tooth replacement. The presence of invertebrates in one stomach is also understandable, due to the small size and soft texture of the prey, which possibly does not affect the sensitive gums of tooth-replacing tigerfish. The three teeth found in one tigerfish stomach were probably its own teeth which were accidentally ingested. Roberts (1967) and Begg (1973) also found worn teeth in the stomach of some characins and made the same assumption. It appears that some teeth are accidentally swallowed while teeth are shed.

Tooth replacement is relatively quick, as was observed several times in the aquarium. Since the teeth of the tigerfish play an important role in the feeding habits of the fish, one can expect tooth replacement to be a rapid process. Begg (1973) on the other hand, said that the tooth-replacement process lasted a month. However, detail about the process itself was not given by him.

Acknowledgements

We wish to thank the National Parks Board for allowing us to collect the data within the Kruger National Park. We also wish to thank the staff of the Kruger National Park, especially A. Deacon, G. Strydom, J. van der Merwe, C. Nkuna and the two rangers, J. Steyn and L. Hare, on who's sections we have worked. Logistical support from the Rivers Research Program, and financial support from the Sanlam Research Unit for Environmental Conservation.

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