Asian Fisheries Science **26** (2013): *243-250*

ISSN 0116-6514
E-ISSN: 2073-3720
https://doi.org/10.33997/j.afs.2013.26.4.006

Asian Fisheries Science
The Journal of the Asian Fisheries Society

Stomach Contents of Banded Archerfish, *Toxotes jaculatrix* (Pallas 1767) (Toxotidae) from brackish waters of South Andaman, India

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Abstract

Stomach contents of banded archerfish, *Toxotes jaculatrix* (Pallas 1767) (Toxotidae) ranging from 13-24 cm total length (TL) collected from brackish waters of South Andaman, India were examined. Brachyuran crabs were the dominant prey item with an occurrence frequency (%F) of 89 followed by insects (71). Though insects were present in all length categories, their percent composition significantly decreased from 61% in the smallest to about only 3% in the largest. Ontogenetic changes in food preferences were apparent as significant decreases in number of prey categories with increasing fish size (nine, six and three prey categories from the smallest to the largest size class) were observed. The largest size class had teleosts in their stomachs, indicative of higher nutritional demands with their subsequent growth. Though known as insectivorous with specialized feeding techniques to feed upon arboreal insects, the present study suggests that *T. jaculatrix* is an opportunistic feeder, consuming a wide range of prey from various habitats.

Introduction

The members of the perciform family, Toxotidae (commonly referred to as archerfish) are well known for their remarkable hunting technique of shooting down arboreal insects from overhanging vegetation with a precisely aimed jet of water, squirted from their mouth (Lüling 1963; Dill 1977; Timmermans 2001; Schuster et al. 2006; Ben-Simon et al. 2009), where the shooter or another member of the school then summarily devours the prey (Simon et al. 2011).

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The family Toxotidae is comprised of seven species under a single genus *Toxotes,* ranging from India to Vanuatu and Northern Australia to the Philippines (Allen 2004), occurring primarily in mangrove-lined estuaries in small aggregations, but sometimes solitary, close to the surface (Froese and Pauly 2005). Two species *viz., Toxotes jaculatrix* (Pallas 1767) and *Toxotes chatareus* (Hamilton 1822) have been recorded from Andaman and Nicobar Islands so far (Rao et al. 2000), with the former being common. External markings and/or number of dorsal spines (simple descriptive statistics) have been used to differentiate these two congeneric species (Allen 2004; Simon et al. 2010b).

Globally there are several reports on hunting technique of archerfish (Lüling 1963; Dill 1977; Timmermans 2001; Rossel et al. 2002; Schuster et al. 2006; Ben-Simon et al. 2009). However, information on feeding behaviour of archerfish is scant except for reports on their congeneric species*, T. chatareus* and *T. jaculatrix* inhabiting Malaysian coastal waters with respect to their size, age and growth (Simon et al. 2008; Simon et al. 2010a; Simon et al. 2013), trophic position (Simon et al. 2009; Simon and Mazlan 2010) reproductive biology (Simon et al. 2012) and on diets of *T. chatareus* from tropical Australian estuaries (Salini et al. 1990). There are no comprehensive reports so far on stomach contents of archerfish from India. The objective of this study was to determine the dietary habits of banded archerfish from the brackish waters of South Andaman, India.

Materials and Methods

Study area

The sampling sites were three brackish water bodies (Fig. 1), *viz.,* Wandoor (11^{o}35’15.91”N 92^{o}37’ 04.29”E), Sippighat (11^{o}36’06.27”N 92^{o}41’27.33”E) and Guptapara (11^{o}35’21.56”N 92^{o}38’05.25”E) located in South Andaman, India. The vegetation of the study sites was dominated by *Rhizophora apiculata and R. mucronata* (Rhizophoraceae).

Sample collection

Specimens of *T. jaculatrix* for stomach content analysis were obtained from artisanal fishermen during April-September 2012. In this fishery, hand-lines consisting of 3-20 m long monofilament line with barbed hooks of size ranging from 1-20 are used. Formaldehyde 4% (w/v) was injected into the fish samples and these were chilled in an ice chest to prevent further digestion of the stomach contents during transit from the sampling sites to the laboratory (Simon et al. 2009).

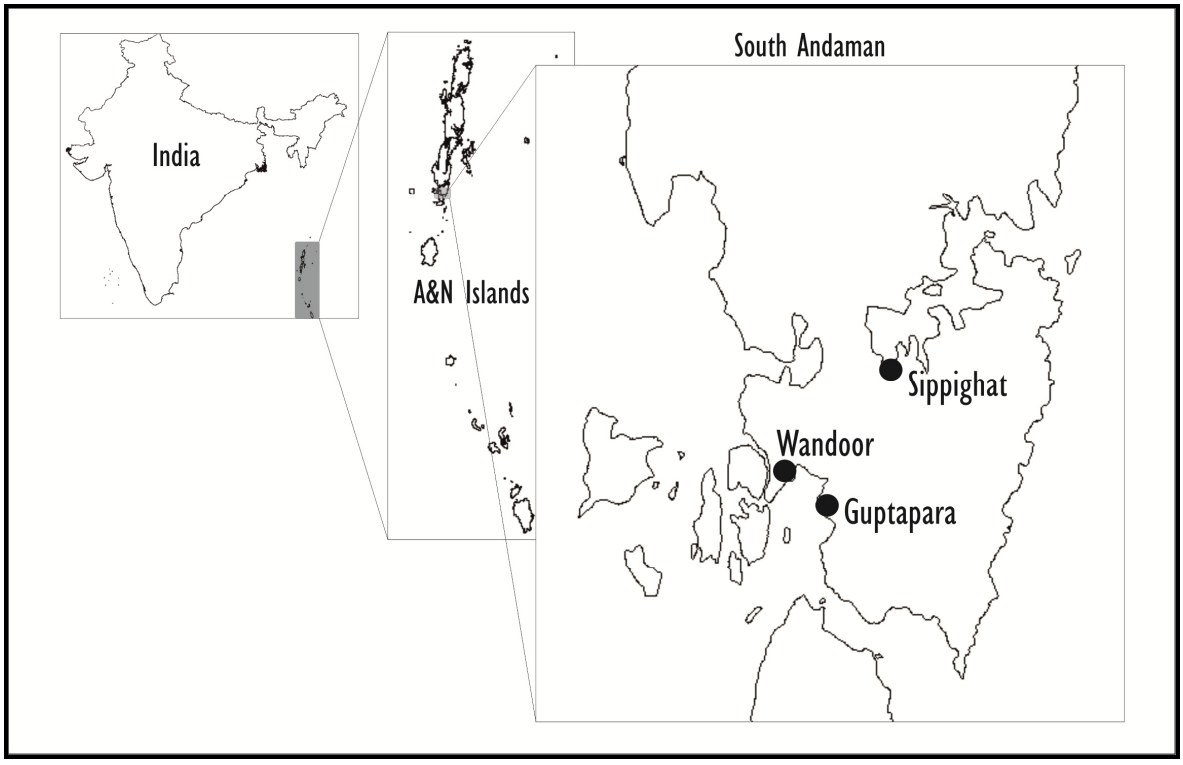

Fig. 1. Map showing study area. ● denotes sampling sites, at South Andaman, India.

Morphometrics

Total length was measured from the tip of the snout (mouth closed) to the extended tip of the caudal fin. The lengths were taken with a measuring board (BIOTECH fish scale reader) to the nearest 0.1 cm. Body weight of individual fish was measured to the nearest 0.1 g with an electric balance (Docbel BRAUN).

Stomach content analysis

Each intact stomach was slit open using a pair of fine scissors and stomach distension was categorized as (i) filled to 25% (quarter); (ii) filled to 25-50% (half); (iii) filled to 50-75% (three-quarter) and (iv) filled to 75-100% (full) modified from Chitravadivelu and Sivapalan (1984). Subsequently the contents were fixed into 4% formalin to prevent any further digestion, and the segregation of larger prey items which were visualized without the aid of a microscope was carried out using forceps. The sub-samples were then observed under a Nikon SMZ 1500 microscope and completely quantified adopting Bagenal's (1978) frequency of occurrence and Hyslop's (1980) numerical methods. In the frequency of occurrence method, the number of stomachs containing each food item is expressed as a percentage of all non-empty stomachs. Though this method is quick and requires minimal apparatus, it provides the most robust and interpretable measure of diet composition (Baker et al. 2013).

In the numerical method, the number of individuals in each prey category was recorded for all stomachs and the total expressed as percentage of the total individuals in all food categories.

Results and Discussion

A total of 88 samples of banded archerfish (size range 13-24 cm TL) were used for assessing the stomach contents. Seventy one percent of the stomachs were more than half filled. There were no empty stomachs and only 6% were filled to less than 25% which may be attributable to shorter periods of feeding, prolonged digestion and larger prey sizes (Simon and Mazlan 2010). There was no apparent relationship between stomach distension and fish size (Fig. 2).

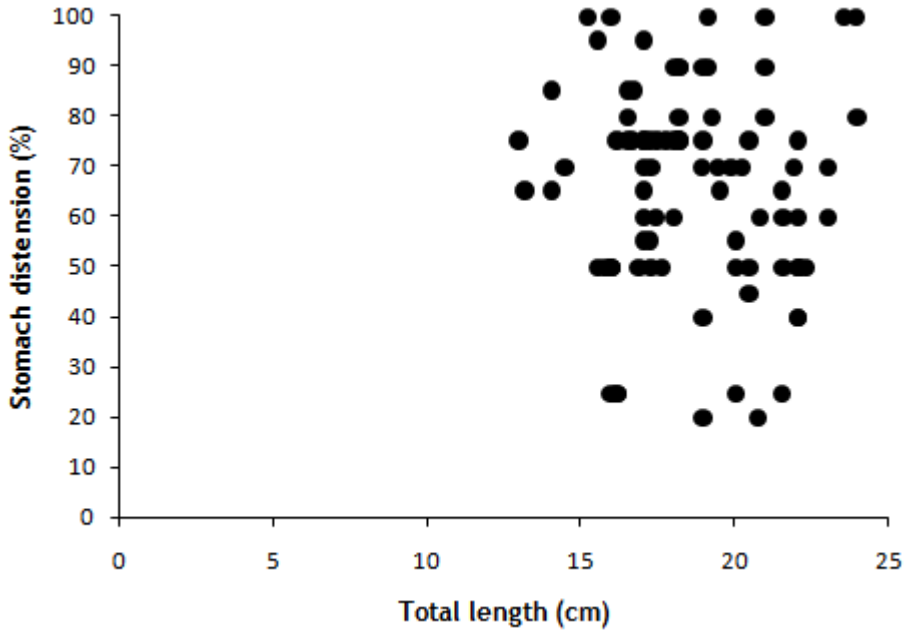

Fig. 2. Stomach distension of banded archerfish, *T. jaculatrix* in relation with total length (TL, cm); *n*=88 collected from the brackish waters of South Andaman, India. ● represents individual

A total of seven prey items were observed from the stomachs of archerfish (Table 1). Crabs and insects were observed in more than 50% of stomachs examined with an occurrence frequency (%F) of 89 and 71 respectively (Table 1). Polychaetes accounted for 23% followed by appendages of arthropods and rotifers, forming a significant diet with an occurrence frequency of 18 and 12 for arthropods and rotifers respectively. Teleosts were reported with a frequency of 18% of the diet. Other prey items included organic detritus and floating debris which were found in almost all the guts and accounted for 81% of the diet, attributing to their abundance in mangrove ecosystems (Kathiresan and Bingham 2001). Plant materials were also found in negligible quantities, indicating their occasional feeding (Blaber 2000).

Table 1. Frequency of occurrence of various food categories in the stomachs of banded archerfish, *T. jaculatrix* collected from the brackish waters of South Andaman, India.

Prey item	Frequency of occurrence (% F)
Brachyuran crabs	89
Insects	71
Polychaetes	23
Teleosts	18
Arthropods	18
Rotifers	12
Others	81

The fish samples were categorized into three length groups considering juvenile (13-16.9 cm), sub-adult (17-19.9 cm) and adult (20-24 cm) for assessing the ontogenetic changes in the diet composition. Number of prey categories decreased with increasing fish sizes *viz*., juvenile (nine prey categories) < sub-adult (six prey categories) < adult (three prey categories) (Fig. 3). Only the adult group had teleosts in their stomachs. Precise identification of the teleosts was not possible due to mastication of food. Insects were present in all life stages but their percent composition significantly decreased from 61% in juvenile to only 3% in adult length classes. Similar ontogenetic changes in food preferences have been reported previously from tropical mangrove estuaries (Blaber 2000; Nanjo et al. 2008) and this could be attributed to their energy requirements, which vary according to the developmental stage (Simon et al. 2009). Though considered as an insectivore with specialized feeding techniques, the percentage composition of insects decreased with increasing size of *T. jaculatrix*. In larger fish, brachyuran crabs and teleosts contributed greatly to the diet of archerfish.

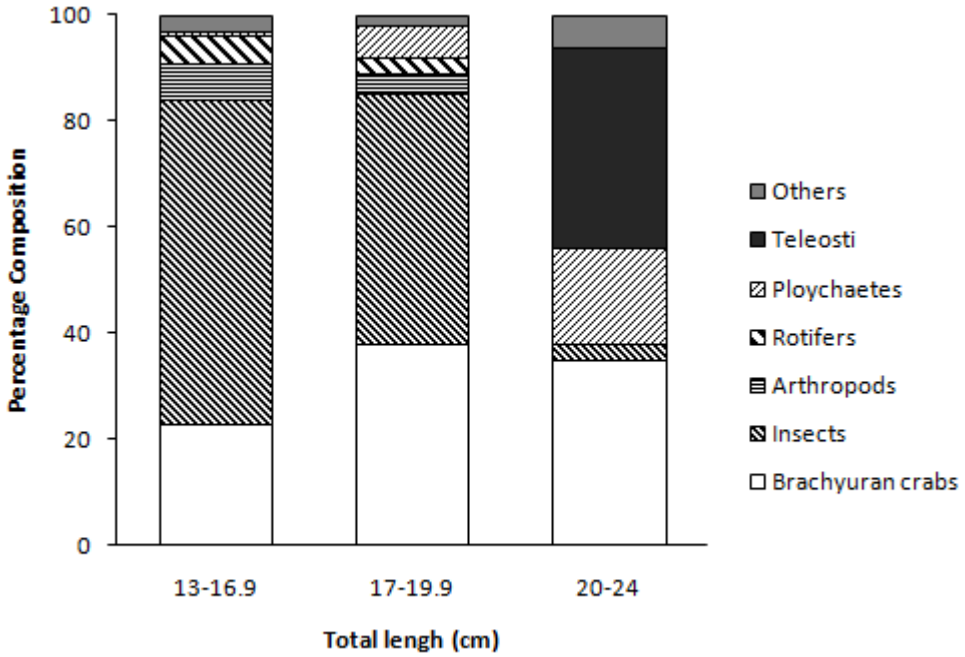

Fig. 3. Ontogenetic changes in diet composition of banded archerfish from the brackish waters of South Andaman, India. Histogram represents the percentage of prey composition.

Since mangroves provide a habitat that supports a large number of insects at different trophic levels (Nagelkerken et al. 2008), smaller archerfish might depend upon mangroves for their sustenance to a significant extent. Nanjo et al. (2008) reported that *T. jaculatrix* (20 cm standard length) fed primarily and wholly on terrestrial insects (ants) from a tropical mangrove estuary of southern Japan. On the other hand, Simon and Mazlan (2010) documented adults are known to feed upon a wide spectrum of prey species of various trophic levels in Malaysian waters. A study on its congeneric species, *T. chatareus* (maximum length 30 cm) from tropical Australian estuaries documented that these fish fed primarily on sesarmid crabs (Salini et al. 1990). Given that the average maximum length of *Toxotes* spp is 30 cm (Allen 2004), it is apparent that despite their unique hunting technique, adult archerfish are not strictly insectivores and this could be attributable to higher nutritional demands with their subsequent growth.

Conclusion

Detailed dietary studies of predators in tropical mangrove systems are surprisingly rare (Sheaves and Molony 2000). Despite the association with mangroves since the Devonian period (Gill 1909), biology and ecology of archerfish have not yet been studied comprehensively. The present study provides a preliminary report on stomach contents of archerfish from brackish water bodies of South Andaman, India. Though considered as an insectivore with specialized adaptations to feed upon arboreal insects, archerfish in our study consumed a wide range of prey including terrestrial insects, invertebrates and teleosts, suggesting their opportunistic feeding. Information derived from the present study stresses the significance of our understanding of the trophic roles of rarely studied fish species since in many cases our presumptions are based on scanty data which are not generalized across entire species range. Further, it highlights the need of extensive studies on ontogenetic changes in the diet composition of archerfish in association with their feeding ecology for determining the trophic position precisely.

Acknowledgements

The authors wish to thank the faculties of Pondicherry University for providing facilities to carry out the research. Help rendered by local fishermen during sample collection is gratefully acknowledged. The authors also wish to express their gratitude to two anonymous reviewers for their critical comments.

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Received: 18/11/2013; Accepted: 12/12/2013 (MS13-84)