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A Comparative Study on the Biological Aspects of Shoaling

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Abstract

Shoals are unstructured groups of fish that gather together in a social, engaging manner. Various phenotypic and genotypic traits of the shoal mates are known to influence the fishes' choice of shoal. The current study categorized the various elements that affect fish shoaling behavior by analyzing the composition of fish shoals found in natural freshwater habitats. The shoals of fishes near the shallow regions of the water bodies were captured and sorted based on size of the fish shoal and length, weight, colour, sex (studying the stage of maturity of gonads), age (by counting the growth circles formed in the scales) of each individual fish were immediately examined. A randomly selected few fish from the group were kept aside for gut content analysis. Most of the collected samples were homogenous with similar food preferences. The heterogenous groups were also similar in their appearance. Understanding the importance of formation of fish shoals helps in the survival and habitat conservation of the fish species. Many species of fish that act as prey and predators are essential part of the food chain. They also aid in recycling nutrients throughout the ecosystem and managing the numbers of other aquatic organisms. Overfishing of fish shoals can lead to the depletion of total aquatic diversity, which can have significant economic and ecological consequences.

Keywords: shoal, phenotypic and genotypic traits, habitat conservation

Introduction

Living in groups is a behavioral technique used by m any animals. Fish social aggregations are a very prevalent phenomenon and provide an excellent model for examining the mechanics underlying social grouping. Shoals are unstructured groups that gather together in a social, engaging manner. According to estimates, about 25% of the roughly 36,640 fish species belonging to 5248 genera of teleost species (Fricke and Eschmeyer, 2023) form social groupings during the course of their lifetimes (Nelson, 2016). This highlights the widespread and significant role of social behavior, such as shoaling and schooling, in shaping fish ecology and survival strategies.

Various phenotypic and genotypic traits of the shoal mates are known to influence the fishes' choice of shoal. Fish in shoals must match phenotypically to the other members because of the "oddity effect," which holds that predators are more inclined to target uncommon, phenotypically unique animals within a shoal **(Peuhkuri, 1997)**. These shoaling decisions may potentially driven by both the active choice of individuals and passive mechanisms. The preference may be based on body colour, age and sex, body length, foraging behavior etc. Since "shoal-fishes" are found in groups, they have been heavily exploited. This over fishing has brought about the collapse of some commercially important fish stocks. Only in past few years has the interest of scientists shifted from how to catch these fishes to how to understand and protect them. Currently, one of the main topics of behavioral research is fish shoaling behavior. Since shoaling is an essential antipredatory activity, understanding how this specific behavior develops is

essential to comprehending fish stock fluctuations. Natural stocks are known to vary significantly from year to year, aside from fishing demands. This variation is explained by either the availability of food or predation during the so-called "critical period" of early life (Cushing, 1990). A key component of fisheries management is the quantitative evaluation of eating behaviors, and the study of fish feeding habits through stomach content analysis offers valuable insights into fish feeding patterns and subsequent shoal choices.

The current study categorized the various elements that affect fish shoaling behavior by analyzing the composition of fish shoals found in natural freshwater habitats. A deeper comprehension of fish feeding preferences and their function in shoal formation integrates a number of crucial ecological elements, such as behavior, habitat utilization, energy intake, and intra/interspecific interactions. Fish shoals should be protected as a vital survival tactic rather than being used as a convenient means of commercial fish capture.

Materials and Methods

The fish samples were collected from the freshwater bodies located in the near by areas of Biyyam Backwater, Ponnani. The shoals of fishes near the shallow regions of the water bodies were located and captured using cast net. All the fish from a single catch were brought to the lab for further analysis on the same day of capturing. The size of the fish shoal and length, weight, colour, sex (studyinging the stage of maturity of gonads), age (by counting the growth circles formed in the scales) of each individual fish were immediately examined. A randomly selected few fish from the group were kept aside for gut content analysis. The distension of stomach was judged by eye estimation and those fish whose stomachs were found $3/4^{th}$ empty were not taken for the analysis of foraging behaviour.

Ten fish with fully gorged stomach were taken representing the whole fish of a single collected sample. In the present study to avoid bias when both easily digested prey and resistant prey are present, the portion of the immediate foregut was selected. During analysis a longitudinal cut was made across the preserved portion of the stomach and the contents were transferred into a petridish. The contents then kept for five minutes to remove excess formalin and then examined under binocular microscope in order to identify the presence of following organisms which will provide some information about the feeding preferences of the fish group.

Zooplankton	Calanoid, Cyclopoid, Copepoid, Daphnia
Nekton	small juvenile fish, fish larvae, fish eggs, fish skeleton, fish scales, insects including larvae and adult forms, worms, molluscs, arthropods etc.
Phytoplankton	Diatoms, Blue green algae, Filamentous algae
Other plants	Larger aquatic plant materials
Detritus	Debris, soft sediments, particulate matter

Fish diets can be measured either qualitatively / quantitatively. The qualitative analysis consists of a complete identification of the organisms in the gut contents. Only with extensive experience and with aid of good references it is possible to identify them digested, broken, and finely comminuted material. In the present study gut contents were analysed quantitatively following the numerical method of analysis (Chipps *et al.,* 2002). In numerical method, the number of individuals of each food type in each fish sample is counted and expressed as a percentage of the total number of food items in the sample studied.

Three different set of sample was collected during the months of November, December 2012 and January 2013. In the first two months (November & December) homogenous shoals of *Puntius parrah* and *Etroplus maculates* were collected and in the third month a heterogenous shoal comprising three types of fishes (*Puntius filamentous,Parambassis thomassi and Puntius sarana*) were collected for the analysis. All three samples were analysed following the above mentioned procedure.

Result

I: Fish Identification - Shoal I: *Puntius parrah*, Shoal II: *Etroplus maculates,* Shoal III: *Puntius filamentosus, Parambassis thomassi, Puntius sarana*

II: Phenotypic Characterstics of the Fish Shoal

a) Body Colouration

All the collected samples were found to be almost homogenous in their body colouration. Sample I which is composed of *Puntius parrah* were silvery in colour while Sample II which is again composed of homogenous species *Etroplus maculates* were yellow-greyish with numerous vertical bands and dark spots. Sample III, eventhough composed of heterogenous individuals, exhibited similarity in colouring pattern. No member having an outstanding striking colouration was observed in any of the samples.

b) Age and Sex

The age of the fish were determined by noting the age bars found on the scales. The homogenous fish shoals of sample I and II were less than one year old while the heterogenous shoal of sample III were more than one year old. The shoals also exhibited variations in the male/female ratio (Fig. 3)

c) Body Length & Weight

Slight variations were observed in the overall body length of individual members of the shoal. In sample I of *P. Parrah* (n=141) Standard deviation from mean value was only ±0.89. In sample II of *E. maculates* (n=116) Standard deviation from mean value was ±1.09. In sample III

Parambassis thomassi (n=24) SD was ± 1.55, *Puntius sarana* (n=34) SD was ± 1.95 and *Puntius filamentosus* (n=35) was SD ± 2.55 was observed. The weight of the fish also exhibited some variation (Fig.1&2)

d) Foraging Behaviour

Each fish shoal exhibited astonishing similarity in their feeding habitats. All fish analysed in the present study were omnivorous (n=10 for each species). The diet consisted of Zooplankton, Nekton, Phytoplankton, Other plants and Detritus. The % of consumption of each food item was found to be different indifferent fish species but the overall fish shoal a exhibited similarities in foraging behaviour (Fig. 4)

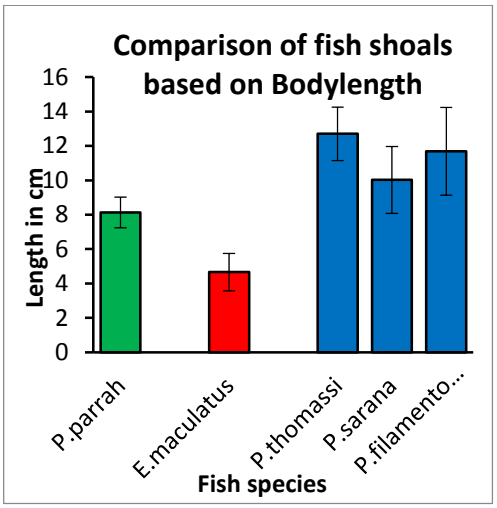


Figure 1

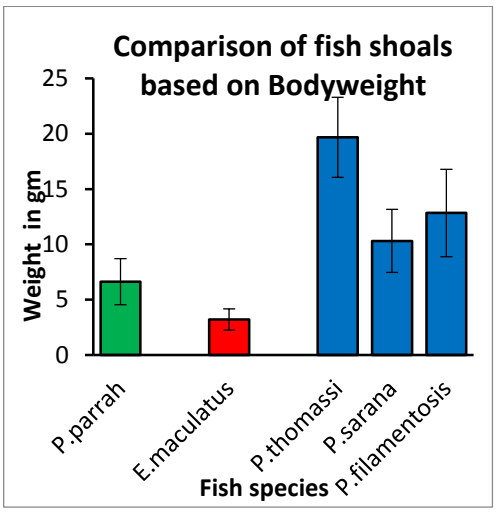


Figure 2

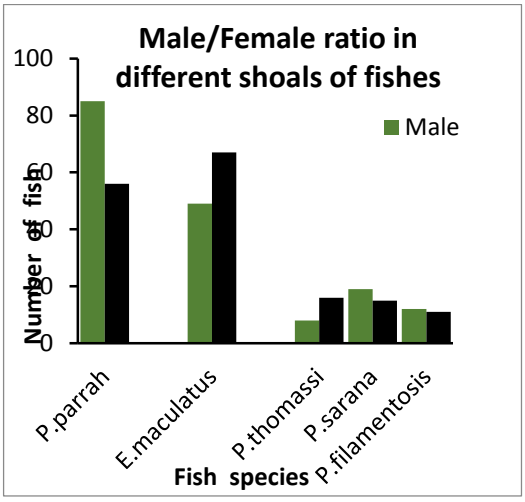
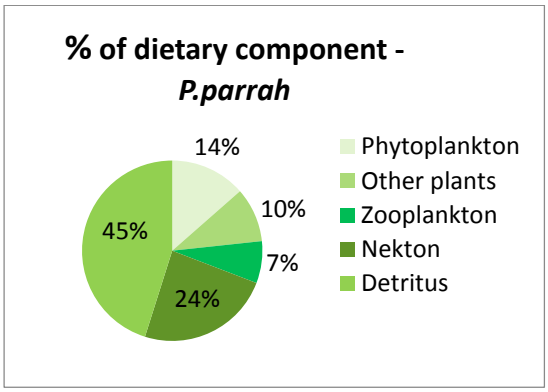
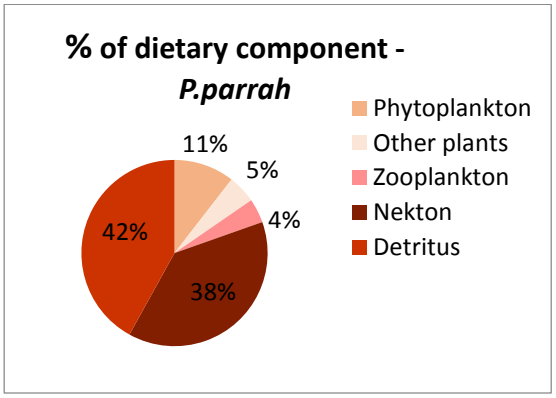
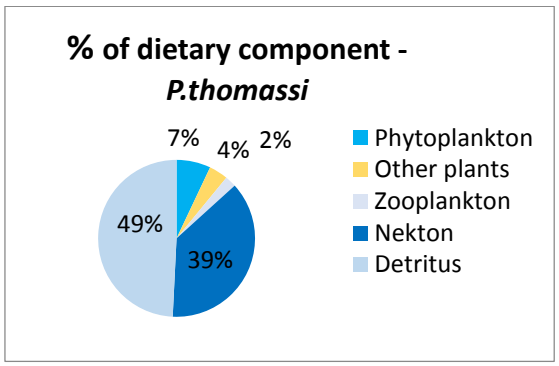
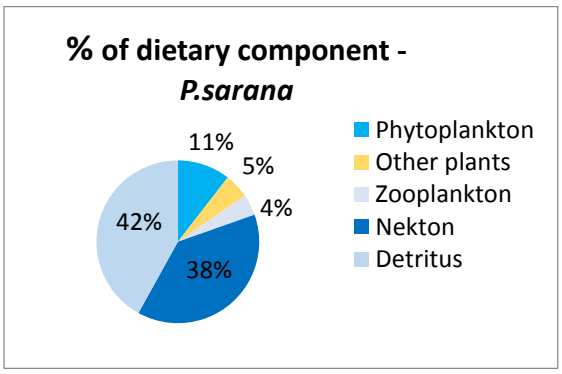


Figure 3









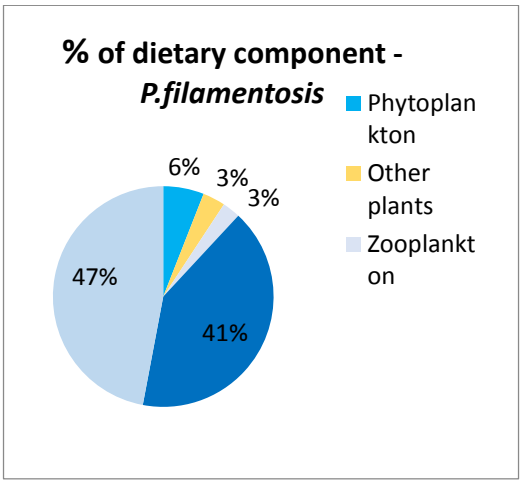


Figure 4 showing the foraging preferences of various fish shoals

Discussion

Most known fish species at some point in their lives, establish cohesive social groups. Mating, foraging, and reduction of energy expenditure have been discussed as possible advantages achieved by schooling (Domenici *et al.,* 2007). However, fish tend to school in risky situations and many established ideas include predator defense, such as safety in numbers, reduction of encounters with predators, and increased predator surveillance. Schooling has also been proposed to give confusing visual signals to predators, including visual mimicry of a large fish. Fish shoaling with individuals different from themselves are more easily spotted and large shoals are considered to be safer (Krause and Ruxton, 2002). In the present study we have found that all shoals either containing single kind of fish species or those containing different kind of fish species always kept the homogenisity in appearance.

It is well known that body colouration or hue as visible signals in fishes are associated with a variety of significant behavioural interactions, including shoaling and mate choice. Numerous studies show that shoal members obtain more benefits when the shoal is phenotypically homogeneous. Therefore, fishes have been shown to associate with individuals of similar phenotypic characteristics such as stripe pattern and body colouration (Ledesma and McRobert, 2008). This suggests that the variations in

body colouration may negatively affect the advantage of predator avoidance.

Males and females each chose to shoal rather than be alone, regardless of the strain of shoal presented. Perhaps the sex differences reflect a difference in the benefits provided by shoaling. Shoaling in males, in more natural situations, may be influenced by potential mate associations, with any shoal of zebrafish, regardless of body color or stripe pattern, providing an opportunity for increased reproductive success. Conversely, females may be making shoaling decisions based primarily on maximizing predator defense, and thus choose to associate with phenotypically similar fish. Previous studies on guppies indicate similar trends, with male strategies seemingly directed toward reproduction and females strategies toward increased foraging efficiency and survival. However, in non-breeding seasons sex is not considered to be an important factor in shoaling decisions of a fish. Further, a homogenous group either containing either juveniles or adults alone can provide more benefits than a mixed group of size different juveniles and adults.

When shoals of fish meet, the major factors determining whether individuals will join are body length and species. The mechanisms behind such decisions are not known, but seem to take effect within a few seconds, and an active shoal choice has been shown. Fish of similar shape and size will emit similar pressure waves (and water movements), and vice versa for fish differing in size and body-shape. The ability to discriminate among sounds on the basis of frequency is present in teleost fishes, and temporal patterns of sound contribute important acoustic information. Moreover, it was suggested that water movements produced by a swimming goldfish *Carassius auratus* and three other fish species with differing swimming style (Hanke and Bleckmann, 2004) show a clear vortex structure that lasts in the order of minutes (or at least 30 s).

Shoal composition not only affected individual behavior but also generated potential foraging benefits. The results strongly suggest that similarity in foraging habitat could enhance the group forming tendency between fishes. Here, it is found that in homogenous groups of fish exploited similar kind of feeding habitat probably with an alternating pattern of predator inspection. In mixed shoals the advantage may be more crucial as it may avoid interspecific competition for food. Previous work has shown that individuals having higher shoaling tendency explore more and are more likely to discover and feed on novel food sources, whereas solitary individuals are poor in finding out new food resources (Frost et al. 2007). When foraging, the fish is at risk- especially from a suddenly attacking predator- because handling food can impair a full view around the fish for some seconds. A more profitable strategy is to increase the number of eyes looking around. The benefits of group living for individual group members are thus well established and include reduced predation risk and increased sharing of information.

Conclusion

Ethological studies allied to ecological principles will be of great benefit. Analysis of factors such as phenotypical characters and food preferences that influence growth and the population dynamics of fish helps in constructive building of a fishery management system in natural environment. The present study sorted out various factors that could influence the grouping behaviour in fish. Individuals within most animal groups do not interact with each other at random; rather, they preferentially interact with certain individuals and restrict certain social interactions to particular individuals based on phenotypic similarities (such as body colour, age, sex, body length etc.). A group either consisted of homogenous or mixed species could increase the benefits of shoaling if they are following similar phenotypic and behavioural patterns such as feeding habits. The fish shoals of the present study were strictly followed the rules of homogeneity and thus increasing the benefits of shoaling.

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