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Rate of Gastric Evacuation of Teleostean Prey in Two Species of Predatory Glassy Perchlets of the Genus *Chanda* Ham. (=*Ambassis* Cuv. & Val.)

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The rates of gastric evacuation of teleostean prey (yolky embryos, fry and juveniles of *Lebistes reticulatus* Peters) by two predatory species namely *Chanda commersonii* (Cuv. & Val.) and *C. thomassi* (Day), are given. Both species show an initial slow period followed by a surge in gastric activity and the trend indicates a subsequent fall in activity during the final stages. These perchlets show high degree of gastric evacuation efficiency comparable with many other larger percoid predators. The results also suggest that normal meal size, individual food particle size and texture may have relatively little effect on the rate of gastric evacuation.

Key Words: Gastric evacuation, Gastric activity, Predator, Fish prey

Introduction

Information on the time required for partial or complete gastric digestion and evacuation of the food is quite useful in understanding the structural and physiological capacity of the fish to consume food (Davis & Warren 1968). Thus, measurements of gastric digestion rates and food passage may provide useful estimates of food consumption rates (Kitchell & Windell 1968, Swenson & Smith 1973). Therefore, tests were conducted using *Chanda commersonii* (Cuv. & Val.) and *C. thomassi* (Day), both voracious carnivores with piscivorous tendencies, found in large shoals in the backwaters and culture systems of Kerala.

The digestion rate in many predatory fish of the temperate region has been well investigated. Studies concerning the digestion rate of fish in relation to different physico-chemical and biological parameters have been carried out on fishes of temperate, tropical and arctic regions (Fortunatova 1940, 1950, Hunt 1960, Molnar & Tolg 1960, 1962a, b, Windell 1966, Molnar et al. 1967, Pandian 1967, Popova 1967, Magnuson 1969, Beamish 1972, Reshetnikov et al. 1972, 1975, Noble 1973, Jacob & Nair 1981).

Materials and Methods

Healthy specimens of *C. commersonii* juveniles (35±5 mm; 450±100 mg) and *C. thomassi* immature adults (70±5 mm; 3000±500 mg) of uniform size were reared in large cement tanks in the aquarium and well-fed once or twice daily on yolky embryos, fry, juveniles and adults of guppies *(Lebistes reticulatus)*. Serial slaughter method, recommended as the most useful method (Windell 1968) was employed in this study. Preliminary experiments were carried out to find the time required for complete digestion so as to fix the slaughter intervals for the final experiment. Intervals of two hr for *C. commersonii* juveniles, and one and a half hr for *C. thomassi* immature adults were fixed as the slaughter intervals.

To make the stomach completely empty the fish were starved for one day prior to experimental feeding. Each fish was allowed to consume voluntarily a measured amount of live fish prey. The serial slaughtering was continued until the well-defined pouch-like stomach became completely empty. The tests were repeated using a different combination of yolky embryos, fry and juveniles of guppies. All experiments were carried out in duplicate and the mean value of each set was taken. Temperature of the water remained 27±1°C and the oxygen at near air saturation throughout the period of experiment.

Results

The passage of chyme from the stomach to the intestine is dependent on the rate of gastric digestion and, hence, the depletion rate of food from the stomach parallels digestion rate. Based on this, the rates of digestion (2 hr period for *C. commersonii* and 1½ hr period for *C. thomassi*) were calculated (tables 1 & 2 and figure 1). The cumulative percentage of digestion is plotted against time for computing the 50% digestion period (figure 2).

In the case of *C. commersonii* juveniles, an initial slow period of digestive activity is followed by a surge of gastric activity during the 4–6 hr period and the trend indicates a subsequent fall in activity during the final stages. The complete evacuation of the food from the stomach takes place in about 10 hr and 50% evacuation in 5.2–5.4 hr at a temperature of 27±1°C. Extrusion of faecal pellets also starts during 4–6 hr, the period of increased gastric activity.

C. thomassi immature adults also show a similar pattern of food evacuation, the 3–6 hr period showing increased gastric activity followed by a gradual fall during

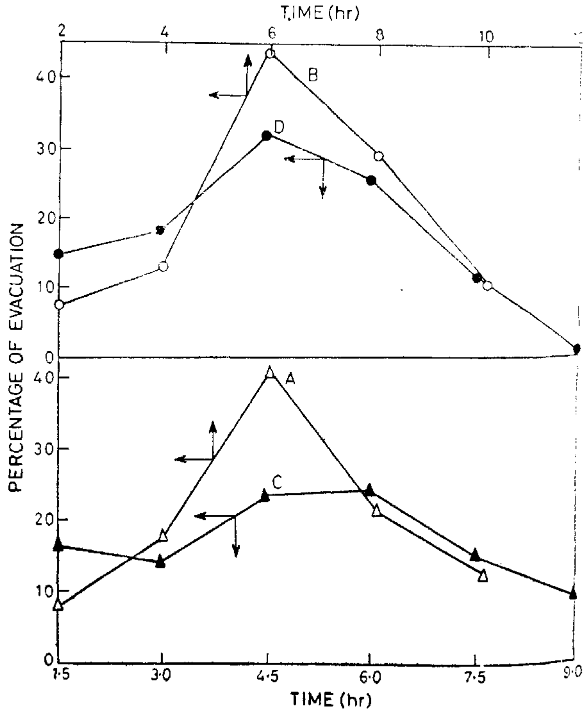

Figure 1 Rate of gastric evacuation in *C. commersonii* juveniles (curves A & B); and *C. thomassi* immature adults (curves C & D)

Table 1 *Rate of digestion (evacuation) in the predator* C. commersonii *(juveniles 35±5 mm; 450±100 mg) fed on teleostean prey*

Experiment	Duration	Amount of food in gut (mg)	% of food in the stomach	% of food digested	Rate of digestion	Remarks
No. I	Initial	33 mg (7.33% of body wt)	—	—	—	5 medium-sized fry and 3 yolky embryos each (guppy) given to 12 fish
	2 hr	30.60	92.73	7.27	7.27	Yolk of the embryos absorbed, individual prey can be easily identified
	4 hr	24.80	75.15	24.85	17.58	The embryonic larvae almost completely digested. Rest into a semi-solid mass, faecal matter formed as a long chain up to rectum
	6 hr	11.20	33.94	66.06	41.21	Starts defaccation, pellet-like up to rectum. Faecal matter—7.4 mg, i.e. 33.85% of food digested
	8 hr	04.20	12.73	87.27	21.21	Faecal matter extruded as pellets. 9.2 mg, i.e. 31.94% of food digested identifiable remains — eyes of the guppy fry
	10 hr	empty	00.00	100.00	12.73	Faecal matter in the rectum and part of the intestine. Faecal matter 11.15 mg i.e., 33.79% of digested food
No. II	Initial	22.5 mg (5% of body wt)	—	—	—	1 large, 2 medium fry and yolky embryo each (guppy) to 12 fish
	2 hr	20.9	92.89	7.11	7.11	Tail of large fry and yolk digested, individual prey identifiable
	4 hr	18.1	80.44	19.56	12.45	Food into a mass, faecal matter starts forming
	6 hr	8.5	37.78	62.22	42.66	Faecal pellets formed. Starts defaccation 4.2 mg, i.e. 30% of digested food
	8 hr	2.2	9.78	90.22	28.00	Main remains — eye of fry, faecal matter 6.3 mg, i.e. 31.03%
	10 hr	empty	—	100.0	9.78	Faecal matter remaining only in rectum 8.1 mg, i.e. 36% of digested food

Table 2 *Rate of digestion (evacuation) in the predator* C. thomassi *(immature adults (70±5 mm; 3000±500 mg) fed on teleostean prey)*

Experiment	Duration	Amount of food in the stomach	% of food in the stomach	% of food digested	Rate of digestion	Remarks
No. I	Initial	200 mg (6.67 % of body wt)	—	—	—	5 guppies each to 14 fish
	1½ hr	168.08	84.04	15.96	15.96	Tail regions digested (may be due to laceration of the caudal peduncle during swallowing)
	3 hr	140.60	70.30	29.70	13.74	2 fish – 3/4th digested, 3 fish semidigested — faecal matter starts forming
	4½ hr	94.24	47.12	52.88	23.18	The food completely acted upon and made into a semi-solid mass. Faecal matter in the intestine and rectum Faecal matter — 21.61 mg, i.e. 22.93% of digested food
	6 hr	46.24	23.12	76.88	24.00	Starts defaccation. Faecal matter in the intestine and rectum as large pellets. Only eyes of prey identifiable
	7½ hr	17.22	8.61	91.39	14.51	Only the flesh remains — semi solid
	9 hr	—	—	100.00	08.61	Faecal matter in rectum and lower reaches of intestine, 38.92 mg, i.e. 19.46% of food
No. II	Initial	160 mg (5.33% of body wt)	—	—	—	4 guppies each to 14 fish
	1½ hr	137.55	85.87	14.03	14.03	Tail region digested
	3 hr	110.21	68.88	31.12	17.09	Made soft and partly digested
	4½ hr	60.32	37.70	62.20	31.18	Into semi-solid mass and advanced digestion, starts defaccation
	6 hr	20.32	12.70	87.30	25.00	All fish up to 3/4th digested — eyes discernible
	7½ hr	1.92	1.20	98.80	11.50	Semi-solid flesh remaining
	9 hr	—	—	100.00	1.20	Faecal matters only in the lower reaches of rectum, not in the intestine

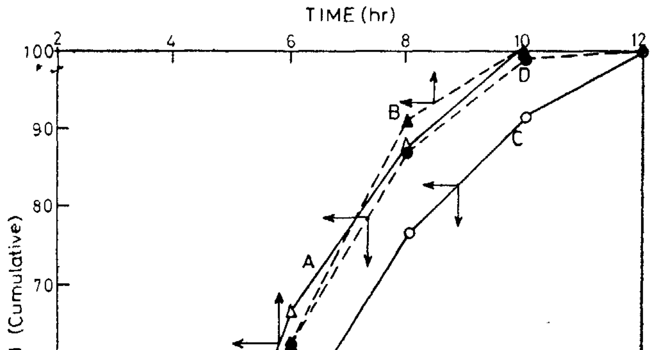

Figure 2 Percentage of gastric evacuation (cumulative) in *C. commersonii* (curves A & B) and *C. thomassi* (curves C & D) showing 50% evacuation time

the final stages. The time taken for complete gastric evacuation of food is about 9 hr and 3.9–4.3 hr for 50% evacuation at a temperature of 27±1°C. Defaccation starts towards the end of 3–4½ hr period or the beginning of 4½-6 hr period, both being periods of increased gastric evacuation.

Discussion

Present results suggest that the rates of digestion in *C. commersonii* juveniles and *C. thomassi* immature adults follow the pattern reported for other predaceous fish. Windell (1966) found that gastric digestion and evacuation of food in the stomach of *Lepomis microchirus* were characterised by three stages viz., (1) a brief initial lag, (2) a surge of gastric activity, and (3) a period of several hr when the remaining small amount of digested matter is removed into the intestine. A fish stomach may hold its contents for some time until a certain degree of liquifaction and digestion occurs, after which the digested matter is quickly moved into the intestine causing the brief initial lag followed by active gastric evacuation. The third phase suggests that gastric motility and evacuation are not efficient when a small amount of food is present in the stomach. This would lead to the gut wall being not stretched and peristalsis is either not initiated or weakly initiated. However, in the present study, even the final stage of lesser gastric activity is only as long as the initial lag period due to depleted amount of food in the stomach. Hence, peristalsis is likely to be initiated at least moderately even during the final stage of gastric evacuation of stomach, showing adaptation for more efficient digestion and evacuation of even small amounts of food present in the stomach. The state of food material in the intestine, in both the species clearly reveals that digestion takes place mainly in the stomach. The percentage of faecal matter to the amount of food digested is 30–34% (approx.) for *C. commersonii* juveniles and 20% (approx.) for *C. thomassi* immature adults, the values for unassimilated food being higher than the 15% (Winberg 1956) for high-energy diets such as for piscivorous fish (Webb 1978).

The 100% and 50% evacuation time for both species is compared with those obtained for a few other predators fed on fish prey and at temperatures between 20 and 30°C in table 3 (Windell 1978).

Table 3 *Rate of evacuation in* C. commersonii *and* C. thomassi *compared with a few other predators fed on fish prey**

No.	Predator species	Weight (g) or length (cm)	Prey given	Hours for 50% of food to pass through stomach	Hours for 100% food to pass through stomach	Water temperature (°C)	Source
1.	*Micropterus salmoides*	89 g	*Gambusia affinis*	9	—	23–26	Hunt (1960)
2.	*Chaenobrythus glusosus*	93 g	,,	14	—	23–26	,,
3.	*Lepisosteus platyrhincus*	110 g	,,	20	—	23–26	,,
4.	*Esox lucius*	40 cm	*Perch*	20	—	18–23	Seaburg & Moyle (1964)
5.	*Scomber japonicus*	29 g	*Anchoviella hepsetus*	—	21–24	20	Kariya & Takahashi (1969)
6.	*Haemulon plumieri*	19 cm	,,	—	25	24	Pierce (1936)
7.	*Stizostedion lucioperca*	400 g	*Alburnus alburnus & Acerina cernua*	—	28	25	Molnar & Tolg (1962b)
8.	*Micropterus salmoides*	25–27 cm	,,	—	19	25	,,
8 a.	*Ocyurus chrysurus*	20 cm	*Anchoviella hepsetus*	—	33	24	Pierce (1936)
9.	*Amia calva*	18 g	*G. affinis*	—	32	21	Herting & Wilt (1968)
10.	*Stizostedion vitreum vitreum*	—	Minnows	4	—	20	Swenson & Smith (1973)
11.	*S. canadense*	—	,,	4	—	20	
12.	*Micropterus salmoides*	—	Bleak & *Acerina*	—	17	25	Fabian et al. (1963)
13.	*M. salmoides* (Large size)	—	Minnows	—	12	28	Markus (1932)
	M. salmoides (Small size)	—	,,	—	16	28	,,
14.	*Perca fluviatilis*	—	Bleak & *Acerina*	—	18	25	Fabian et al. (1963)
15.	*Stizostedion lucioperca*	—	,,	—	11	25	,,
16.	*Silurus glanis*	—	,,	—	10	25	,,
17.	*Katsuwonus pelamis*	39–50 cm	Whole white bait (Omseridae)	5	—	23.3–25.7	Magnuson (1969)
18.	*Lepomis macrochirus*	64 g	Darters (*Etheostoma* sp.)	5	—	21	Windell (1967)
19.	*Micropterus salmoides*	91 g	*Notropis alternoides*	6.6	—	25	Beamish (1972)
20.	*Megalops cyprinoides*	52 g	*G. affinis*	8–9	—	28	Pandian (1967b)
21.	Glassy perchlets	3.5±0.5 cm	(Guppies)				
a.	*Chanda commersonii*	0.450±0.100 g	Yolky embryos, fry and juveniles of *Lebistes reticulatus*	5.2–5.4	10	27.0±1	Present study
b.	*C. thomassi*	7.0±0.5 cm 3.0±0.5 g	Juveniles of *Lebistes reticulatus*	3.9–4.3	9	27.0±1	Present study

* After Windell 1978

It can be seen that the predaceous glassy perchlets show a high degree of gastric evacuation efficiency comparable with many other larger percoid predators.

The similarity in the results of the two experiments (figures 1 & 3—I & II) using different amounts of fish prey (7.33 & 5.00% of predator body weight for *C. commersonii* and 6.67 & 5.33% for *C. thomassi*) suggests that the size of the given type of food may have relatively little effect on the rate of gastric evacuation in these species. Under a normal feeding regime, for a meal of normal size most data indicate relatively little effect of meal size on the periods to reach 50% and 100% stomach depletion (Hunt 1960, Windell 1966, Kitchell & Windell 1968, Magnuson 1969, Brett & Higgs 1970, Tyler 1970, Beamish 1972, McKone 1971, Elliott 1972, Steigenberger & Larkin 1974). In the rainbow trout, *Salmo gairdneri* fed 1% and 2% of its body weight, the normal meal decreased by about 60% after 12 hr of digestion at 15°C and evacuation of stomach contents was independent of the amount consumed at a single meal except at ration levels below 0.7% (abnormal meal size) of body weight (Windell & Norris 1969). These data suggest that gastric motility once initiated remains relatively constant as long as food remains in the stomach (Windell 1978).

In the present study, there is also very little effect of individual food particle size and texture (different combinations of yolky embryos, fry and juveniles of fish prey) on evacuation rate and time, as shown by *C. commersonii*. However, in the case of the walleye (*Stizostedion vitreum vitreum*) and the sauger (*S. canadense*) fed with minnows of different size, it was assumed that increased surface area and/or decreased scalation associated with smaller minnows enhanced their rate of gastric removal (Swenson & Smith 1973). Besides, the very small difference in size range of prey (2.3–9.8 mg) and scalation may be the cause for similar gastric depletion rates. Windell and Norris (1969) showed that food texture may influence the initiation of gastric juice secretion and the volume secreted.

Several reasons have been suggested for explaining the differences in the digestion rates of fishes. Whatever be the reasons, since the rate of digestion is the major factor controlling appetite (Minor 1955), the food-intake of the fish would be dependent on it, and as recognised by Ricker (1946) have an important bearing on fish production in terms of estimating the daily ration of fishes.

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