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EFFECTS OF ALGAL AND ANIMAL FOOD COMBINATIONS ON SURFACING ACTIVITY AND FOOD UTILIZATION IN THE CLIMBING PERCH *ANABAS SCANDENS*[2]

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ABSTRACT

A. scandens was fed on five different combinations of the alga *Spirogyra maxima* and goat-liver. With increasing liver supplementation, the following increases were noted: consumption of food from 31 to 152 cal/g live fish·day, assimilation efficiency from 88 to 98%, production rate from 1.5 to 45.5 cal/g. day and the efficiency from 5 to 17%. For culturing *A. scandens*, supplementation of algal food up to 22% is recommended. To exchange atmospheric air, *A. scandens* surfaced 432 and 1296 times/day, when fed on 100% *S. maxima* and 100% liver, respectively. The period of elevated surfacing frequency observed in the fish following a meal was the longest in the 100% liver-fed individuals.

1. INTRODUCTION

In tropical countries like India, where availability of freshwater is limited, air-breathing fishes may be chosen for aquaculture, as they thrive in shallow waters deficient in oxygen. However, the advantageous air-breathing habit of these fishes and the consequent need to surface more or less at regular intervals impose a considerable drain of energy, which otherwise could have been channelled for fish production. Aspects of optimizing energy drain due to surfacing activity have recently received considerable attention for a number of Indian air-breathing fishes (Pandian, Vivekanandan 1976, Vivekanandan et al. 1976, Pandian et al. 1976, Arunachalam et al. 1976). These authors have recommended culturing air-breathing fishes in shallow waters.

Unfortunately, most of these air-breathing fishes are carnivores, and hence have become less attractive for fish culture in comparison to the herbivorous cyprinids. Recently, we observed the climbing perch *Anabas scandens* to feed on algae like *Spirogyra maxima* in the laboratory. In view of the fact that the herbivorous/omnivorous fishes like *Holacanthus bermudensis* (Menzel 1959), *Lepomis macrochirus* (Kitchell, Windell 1970) and *Tilapia mossambica* (Mathavan et al. 1976), are known not to consume and utilise sufficient algae to meet the energy required for metabolism and growth, we were prompted to test how far the obligatory air-breathing *A. scandens* can consume and utilise algae to meet its energy requirements for growth and metabolism.

2. MATERIAL AND METHODS

The experimental design followed in the present study has been described in detail elsewhere (Mathavan et al. 1976, Pandian, Vivekanandan 1976). Briefly, *Anabas scandens* (4 ± 0.49 (SD) g; 6 cm body length) was acclimatized in cylindrical (10 cm diameter) glass aquaria (capacity:

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0.8 l) to the respective food combinations at 27±1°C (SD). With a view to keep the energy drain through vertical swimming involved in surfacing activity at minimum and equal level, the depth of water was kept shallow at 10 cm in all aquaria and therefore, all the test individual swam 0.2 m, when surfaced to breathe atmospheric air.

Table I. Caloric value of different food combinations, and water content and caloric value of *Anabas scandens* fed on different food combinations of *Spirogyra maxima* and goat-liver for a period of 30 days at 27±1°C; ± represents SD

Food combinations	Food		Fish	
	Water content (%)	Caloric value (cal/g dry wt.)	Water content (%)	Caloric value (cal/g dry wt.)
100% *S. maxima*	85.8±7.83	3505±254	89.3±7.96	4965±246.2
73% *S. maxima* 27% liver	82.8±4.00	4229±136	83.0±6.10	4998± 94.9
47% *S. maxima* 53% liver	80.4±3.84	4925±326	85.4±2.24	5336± 68.1
22% *S. maxima* 78% liver	77.7±1.09	5596± 95	80.6±8.16	5192±134.6
100% liver	75.0±4.36	6185±101	72.7±1.05	5691±253.5

Spirogyra maxima, a natural food of *A. scandens* (Menon, Chacko 1955), was chosen as plant food, and goat-liver served as animal food. The individuals, which received different combinations of plant and animal food (Tab. I) were offered for a period of 2 h/day during the 30 day feeding experiments. The unfed liver was collected with a pipette and the plant remains by filtering the entire aquaria with a fine sieve (diameter: 160 μm) everyday after the 2 h food supply. Faeces was collected everyday prior to aquarium water change. Since aquarium water was changed everyday, the partial pressure of oxygen (Po_2 of water) ranged between 100 and 130 mm Hg and this Po_2 level is known not to affect the surfacing frequency of *A. scandens* (Pandian et al. 1976). "Sacrifice Method" (Maynard, Loosli 1962) was used for determining the water content of the test individuals before commencement of the experiment. Caloric estimations were made using a Parr 1412 semi-microbomb calorimeter.

The experiment was conducted in a laboratory — where except for feeding and observation — there was no disturbance. Number of surfacing by each test individual was observed everyday for a known period of time (20 to 30 min) in the following six timings: 0.5, 6. 12, 15, 18 and 21 h after feeding. The distance travelled per individual was estimated by multiplying the mean number of visits per unit observation time with twice the depth of water.

3. RESULTS

A. FOOD UTILIZATION

Food combinations and feeding

Five combinations of epizoan-free *Spirogyra maxima* supplemented with different proportions (in terms of energy) of goat-liver were chosen as food source for the perch *Anabas scandens*. When the food combinations supplemented with liver were offered, the fish consumed the liver pieces immediately and the algal filaments subsequently; a few filaments were consumed intermittently during the 2 h feeding period. However, the fact that the fish consumed the maximum ration, when the liver was supplemented with 22% *S. maxima* than when totally liver was given (Tab. II) shows that the fish prefers a food combination in which animal food contributes up to 78%.

Table II. Consumption of food, rates and efficiencies of assimilation and production in *A. scandens* fed on different combinations of *Spirogyra maxima* and goat-liver. Each value represents the average performance of minimum 3 individuals (mean$\pm$SD) maintained for a period of 30 days at 27 ± 1°C

Food	Food consumption (C) (cal/g·day)	Assimilation (A) (cal/g·day)	Production (L) (cal/g·day)	Metabolism (M) (ml O_2 g·day)	Assimilation efficiency (A/C) (%)	Net production efficiency ($K_2=L/A$) (%)
100% *S. maxima*	31.3 ± 6.00	27.4 ± 5.50	1.5 ± 0.6	5.4 ± 1.14	88	5
73% *S. maxima* 27% liver	76.2 ± 5.41	72.5 ± 4.73	19.9 ± 0.95	11.0 ± 0.99	95	28
47% *S. maxima* 53% liver	121.4 ± 9.51	118.6 ± 9.55*	37.7 ± 3.4**	16.9 ± 1.99	97	32
22% *S. maxima* 78% liver	152.2 ± 12.88	148.5 ± 13.00	48.9 ± 5.4	20.8 ± 2.71	98	33
100% liver	128.0 ± 15.00	126.2 ± 14.70*	45.5 ± 5.1**	16.8 ± 3.06	98	36

* Student's $t=0.950$, $P>0.05$; ** $t=2.088$, $P>0.05$.

Caloric value of the different food combinations increased from 3.505 cal/g dry weight of the food totally consisting of *S. maxima* to 6.185 cal/g dry weight of the food containing goat-liver alone (Tab. I). Therefore, per unit dry weight of food consumed, the chosen food combinations may release significantly different quantities of energy for metabolism and growth.

Liver supplementation increased not only the caloric content of food per unit dry weight, but also the feeding of *A. scandens* from 31 to 152 cal/g live fish·day (Tab. II). However, the fish offered 100% liver consumed food equivalent to only 128 cal/g·day.

Assimilation

Liver supplementation increased not only the feeding, but also efficiency of assimilation from 88% in those fed 100% *S. maxima* to 98% in those fed 78% goat-liver+22% *S. maxima* (Tab. II). Consequently, assimilation rate significantly increased from 27 to 149 cal/g·day in the above mentioned groups.

Production

Increasing liver supplementation up to 78% also resulted in increased net production efficiency (from 5 to 17%) and rate (from 1.5 to 45.5 cal/g·day) of production. The 30 day feeding on energy-rich supplemented (6.185 cal/g dry weight) liver resulted in the increased reserve of energy per unit dry weight of *A. scandens.* Caloric value of the fish increased from 5.002 cal/g dry weight at commencement of the experiment to 5.691 cal/dry weight (Tab. I) in those receiving 100% liver, whereas those fed on 100% *S. maxima* contained only 4.965 g cal; it may be noted that the caloric value of *S. maxima* was only 3.505 cal/g dry weight.

Similarly, water content of *A. scandens*, which was initially 80.5%, also decreased to 73% in those fed on 100% liver and increased to 89% in those fed on 100% *S. maxima*, i.e. the 30 day feeding results in such changes in water content similar to that of the respective food (Tab. I). Such food induced changes in composition of fish are not uncommon in the literature (e.g. Gerking 1955).

Metabolism

Since consumption of food (C), production (P) and faeces (F) are measured, it is possible to estimate the rate, at which the fish metabolised and released energy or respiratory metabolism (M), i.e. $M = C-(P+F)$ (see Petrusewicz, MacFadyen 1970). Metabolism is expressed in terms of oxygen uptake (ml O_2/g live fish·day), considering the expense of 4.8 cal as equivalent to 1 ml of O_2 uptake (Engelmann 1966). The calculated O_2 uptake of *A. scandens* increased from 5.4 ml/g live fish·day to 20.8 ml/g·day with increasing supplementation of liver up to 78%; it decreased to 16.8 ml/g·day in those fed on 100% liver.

B. SURFACING ACTIVITY

Surfacing frequency of *A. scandens* averaged to 432 and 1.296 times/day, when fed on 100% *S. maxima* and liver, respectively (Tab. III); correspondingly, these individuals swam vertical distance of 86 and 259 m/day to exchange atmospheric air. The fact that the liver-fed *A. scandens* exhibited 3 folded increases in surfacing frequency and distance swum shows that the feeding rate definitely induced a more frequent surfacing in the liver-fed individuals.

Table III. Surfacing frequency and distance swum by *A. scandens* fed on different combinations of *Spirogyra maxima* and goat-liver. Each value represents the average performance of minimum 3 individuals (mean±SD) maintained for a period of 30 days at 27±1°C

Food	Surfacing frequency (times/day)	Distance swum (m/day)
100% *S. maxima*	432±57.6	86±11.5
73% *S. maxima* 27% liver	984±64.8	197±13.0
47% *S. maxima* 53% liver	1104±74.4	221±15.9
22% *S. maxima* 78% liver	1122±72.0	224±14.4
100% liver	1296±76.8	259±15.4

Since the observations on the surfacing frequency were made 0.5, 6, 12, 15, 18 and 21 h after feeding everyday, the respective data obtained for each observation interval after feeding were pooled for the 30 days and the average performance

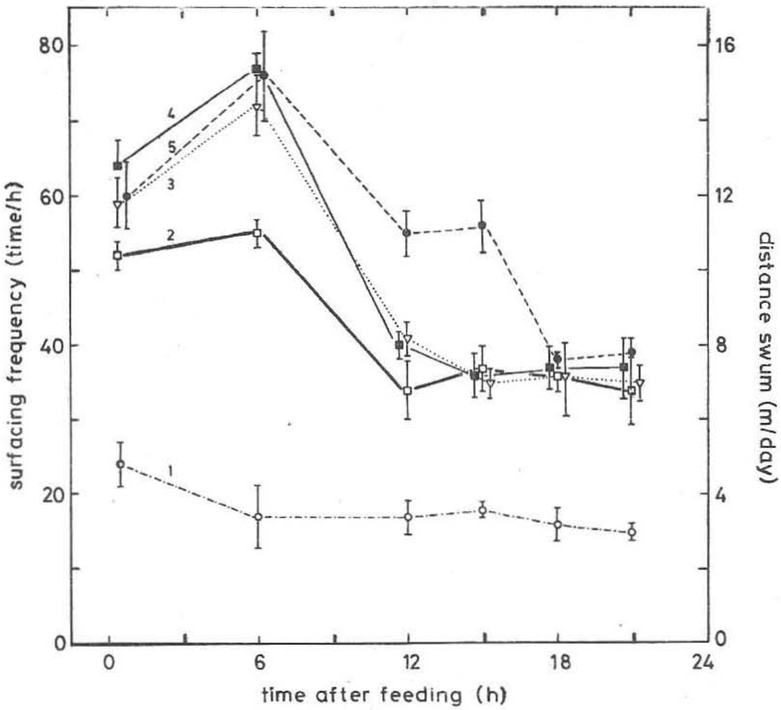

Fig) 1. Effects of different combinations of food on surfacing and swimming activities in *A. scandens* fed on 100% *Spirogyra maxima* (1), 73% *S. maxima*+27% liver (2), 47% *S. maxima*+53% liver (3), 22% *S. maxima*+78% liver (4) and 100% liver (5); vertical lines indicate SD

of surfacing and swimming activities were calculated per hour, and the data thus obtained were plotted in Fig. 1. *A. scandens* receiving 100% *S. maxima* surfaced 24 times and vertically swam 4.8 m/h, just 0.5 h after feeding; after 6 h feeding, the fish surfaced only 17 times/h involving a vertical swimming distance of 3.4 m and maintained this low level of activities for the rest of the day. Those fed on 100% liver surfaced 60 times and swam 12.0 m/h just 0.5 h after feeding; 6 h after feeding these values abruptly increased to 76 times and 15.2 m/h. These high surfacing and swimming activities lasted till the 15th h after feeding, before they reached the lowest levels of 38 times and 7.6 m/h after the 18th h of feeding. It may be noted that animal food not only induced more frequent surfacing and the consequent swimming activity, but also such induced high levels of surfacing and swimming activities lasted for a longer duration in a day, i.e. whereas those elevated level of activities lasted up to 15 h after feeding in the liver-fed individuals, the same did not last even for 6 h in the alga-fed individuals. The levels and trends obtained for the surfacing and swimming activities of *A. scandens* receiving different proportions of liver supplemented with alga were in between those obtained for the 100% alga and 100% liver-fed individuals, and confirm the conclusions made previously.

4. DISCUSSION

The observation that the epizoan-free filamentous alga *Spirogyra maxima* was not only digested with high efficiency of 88 %, but also produced at the rate of 1.5 cal/g live fish·day by *A. scandens* is interesting and unexpected. The angelfish *Holacanthus bermudensis* and the cichlid fish *Tilapia mossambica* assimilated the epizoan-free algae with an efficiency of 78 %, but lost considerable body weight (Menzel 1959, Mathavan et al. 1976). Obviously, these fishes are physiologically capable of digesting and assimilating the algae, but are incapable of eating enough algae to exhibit "true growth" in the sense of Gerking (1952). Kitchell, Windell (1970) too found that the bluegill sunfish *Lepomis macrochirus* assimilated 57 % of the plant (*Chara* sp.) energy; however, they produce evidence that the fish neither will nor can consume enough plant to meet its metabolic energy demand and growth. Contrastingly, the grass carp *Ctenopharyngodon idella* is capable of eating sufficient plant and grow optimally, though it exhibits very poor digestion and assimilation efficiency of 20 % (Fischer 1973). In view of these previous observations, the ability of *A. scandens* to consume sufficient alga, to digest and assimilate efficiently, and to exhibit growth is noteworthy. However, the food consumption (31 cal/g·day) of *S. maxima* fed *A. scandens* is only a quarter of that observed (128 cal/g·day) for the 100 % liver-fed *A. scandens*. Yet, the liver supplementation with alga up to 22 % promoted not only a still higher food consumption of 152 cal/g·day, but also resulted in maximum production rate of 49 cal/g·day. Surprisingly, Menon, Chacko (1955), who studied the feeding habits of *A. scandens* collected from different freshwaters of Madras State, found that the algae, especially filamentous ones, contributed 15 % of consumed food. Therefore, in culture farms, a supplementation of animal food up to 20 to 22 % of algal food for *A. scandens* is recommended, as this would ensure not only high assimilation and production efficiencies, but also the highest production rate.

The minor differences observed in consumption of food, the rates and efficiencies of assimilation and production among the groups receiving 100 % liver and *S. maxima* supplemented with 53 % liver were not statistically significant ($P > 0.05$; Tab. II), i.e. a combination of about 50 % animal food supplemented with 50 % algal food results in equally high efficiency and rate of production of food as those fed on 100 % liver. Where maximum growth is not given priority over cost of food material, culturing *A. scandens* with 50 % alga supplemented by animal food is advantageous.

One or more chemical constituents of *S. maxima* requiring neutralisation during digestion (see Paine, Vadas, 1969, Schroeder, 1976) appear to have significantly depressed the consumption of food, which in turn, reduced the production and metabolism. Conversely, with increasing proportion of liver supplementation and the consequent high feeding level, metabolism is elevated. Correspondingly, the magnitude in the changes of metabolism is reflected in the surfacing frequency. The observation that the surfacing frequency of *A. scandens* is directly related to the feeding rate confirms the previous report of Vivekanandan (1976), who showed that the surfacing frequency of another obligatory air-breathing fish *Ophiocephalus striatus* was directly dependent on ration.

Oxygen consumption of a number of fishes — whether passive (e.g. *Protopterus aethiopicus*; Smith 1935) or actively swimming (e.g. *Micropterus salmoides*; Beamish 1974) — are known to abruptly increase to a maximum after feeding and thereafter decrease to pre-feeding levels. Time required for such elevated O_2 consumption of *M. salmoides* following feeding to subside to pre-feeding levels increases with increasing ration size. In the obligatory air-breathing fishes like *A. scandens*, surfacing frequency may be considered as an index of oxygen consumption. The surfacing frequency, which was 38 times/h (21 h after feeding) in the fish receiving 100% liver, abruptly increased to 60 times/h, 0.5 h after feeding, and to 76 times/h, 6 h after feeding; whereas such elevated surfacing frequency lasted for over 15 h in the 100% liver-fed individuals, it lasted for less than 12 h in all other groups receiving *S. maxima* with liver supplementation. Similar observations have also been recently reported for another air-breathing fish *Polyacanthus cupanus* (Ponniah, Pandian 1976). Beamish (1974) attributed such elevated metabolic level following a meal in *M. salmoides* to what is called as Specific Dynamic Action (SDA), i.e. "an entropic tax during food conversion" (Ware 1975).

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