

# Feeding behaviour and acceptance of fruit wastes by scorpion mud turtle (*Kinosternon scorpioides*) in captivity

# Comportamento e aceitação alimentar de resíduos do processamento de frutas por muçuãs (*Kinosternon scorpioides*) em cativeiro

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## ABSTRACT

The use of waste generated from the processing of human foods in the diet of turtles is an alternative for reducing production costs without compromising the development and sustainability of the animal production system. Therefore, this study aimed to evaluate the behaviour and acceptance of different food wastes from fruit processing by scorpion mud turtles (*Kinosternon scorpioides*) in captivity. We used 25 scorpion mud turtles, from which we assessed the acceptance of five different fruit processing wastes: crushed, dried coconut; orange bagasse; crushed pineapple peel; acerola bagasse; and mango bagasse. These treatments had five repetitions each, totaling 25 experimental units. Each unit was composed of one animal, and ten repetitions were performed. The nonparametric analysis of variance, Kruskal–Wallis test followed by the SNK test (5%), was used to compare the treatments. The phases of feeding behaviour observed in the animals included foraging, approach, olfactory recognition, capture, dilaceration, and ingestion. Neustophagia and head cleaning of the forelimbs after ingestion were observed. In addition, all the residues tested were accepted, with greater acceptability of mango bagasse, orange bagasse, and bagasse acerola. The results revealed 100% survival and no difference (P > 0.05) in weight gain between the experimental groups.

**Keywords:** alternative food, wildlife, kinosternon farming, nutrition, animal production, turtle farming.

## RESUMO

A utilização de resíduos oriundos do processamento de alimentos humanos na dieta dos quelônios é uma alternativa para diminuir os custos de produção, sem comprometer o desenvolvimento e sustentabilidade do sistema de produção animal. Portanto, este trabalho possuiu o objetivo de avaliar o comportamento e a aceitação alimentar de diferentes resíduos provenientes do processamento de frutas, por muçuãs (*Kinosternon scorpioides*) em cativeiro. Utilizou-se 25 muçuãs, nos quais se avaliou a aceitação de cinco diferentes resíduos de processamento de frutas: bagaço de coco seco, bagaço de laranja, casca de abacaxi, bagaço de acerola e bagaço de manga, os quais constituíram os tratamentos, com cinco repetições cada, totalizando 25 unidades



experimentais, com um animal cada, durante 10 repetições no tempo. Realizou-se a análise estatística por análise de variância não paramétrica de Kruskal-Wallis, seguido pelo teste SNK (5%) para comparação dos tratamentos. As fases de comportamento alimentar observadas nos animais foram: forrageio, aproximação, reconhecimento olfativo, apreensão, dilaceração e ingestão. Observou-se comportamentos de neustofagia e de limpeza da cabeça com os membros anteriores após a ingestão. Assim como, aceitação de todos os resíduos testados, com maior aceitabilidade do bagaço de manga, bagaço de laranja e bagaço de acerola, além de 100% de sobrevivência e ausência de diferença (P > 0,05) de ganho de peso entre os grupos experimentais.

**Palavras-chave:** alimentos alternativos, animais silvestres, kinostercultura, nutrição, produção animal, quelonicultura.

## **1 INTRODUCTION**

In the Amazon, the meat of chelonians is well appreciated by locals and by tourists, who consider it an exotic food. Therefore, restaurants in the Amazon region offer a number of culinary options in which the main ingredient is the meat of these reptiles (Moll & Moll, 2004).

Due to their widespread use, turtles are being increasingly hunted, predominantly to support illegal trade, which has led to the depletion of natural stocks due to uncontrolled exploitation (Alves et al., 2012). Therefore, incentive measures for the main species of turtles have been created by competent institutions in Brazil as a way to combat trafficking to preserve natural stocks. Among these reptiles are the scorpion mud turtle (*Kinosternon scorpioides*), which is geographically distributed from Mexico to northern South America to northern Argentina (Berry & Iverson, 2011) and is widely consumed as food in the Amazon region (Rocha & Molina, 1987).

However, despite the legislation allowing the farming of this species in captivity for commercial purposes (BRASIL, 2008), such activity is stagnant due to the lack of information that makes kinosternon farming a profitable and sustainable activity. Thus, most of the animals that are consumed come from natural stocks.

Knowledge about feeding behaviour (Monge-Nájera & Morera-Brenes, 1987) and the nutritional status of captive scorpion mud turtles (Araújo et al., 2013) is lacking, especially in relation to commercial production, in which food expenditure is highly important for ensuring the profitability of the production system. It is known that kinosternids are omnivores (Legler, 1993), and it is inferred that the diet of this species can vary depending on the sex and age of the individual since this has been observed in other Amazonian turtles, such as *Podocnemis unifilis*.



Adults are opportunistic carnivores and herbivores, while young animals have a predominantly carnivorous diet (Clark & Gibbons, 1969; Hart, 1983; Moreira & Loureiro, 1992; Terán et al., 1995).

Currently, many waste products generated from the processing of human foods are discarded, which has a great impact on both the environment and human health due to incorrect disposal. However, such waste can be incorporated into animal diets and is becoming an important factor in lowering the cost of production. However, the successful use of this waste is often limited by poor knowledge of its nutritional characteristics, economic value as a feed ingredient, and acceptance by animals and by the lack of performance data from animals fed this type of waste (Lousada Júnior et al., 2006; Meneghetti & Domingues, 2008).

Acerola (*Malpighia glabra*), mango (*Mangifera indica*), orange (*Citrus sinensis*), and pineapple (*Ananas comosus*) waste products are easily found in all Brazilian regions and stand out as sources of vitamins and energy. Chemical analysis by Gondim et al. (2005) revealed that some fruit peels generally contain more nutrients than the edible parts of the fruit. Therefore, some fruit waste may be considered an alternative source of nutrients, avoiding food waste. However, additional research is needed on the antinutritional factors present in these wastes. In addition to nutritional value, the large proportion of discarded waste is another factor that should be taken into consideration (Larrauri et al., 1996).

Several studies have investigated the recovery of mango waste (Couto Filho et al., 2007; Vieira et al., 2008; Lima et al., 2011; Aragão et al., 2012; Guzmán et al., 2012; Pereira et al., 2013), coconut waste (Braga et al., 2009; Santos et al., 2009; Omena et al., 2010), acerola waste (Ferreira et al., 2010), pineapple waste (Correia et al., 2006; Rogério et al., 2007; Lima et al., 2012), and orange waste (Tripodo et al., 2004) from animal feed. However, studies on turtles in relation to these wastes have not been conducted.

In this context, villagers will seek attitudes that reduce the costs of feeding scorpion mud turtles in captivity and that may be incorporated by producers of all sizes. Thus, alternative food wastes generated from fruit processing, such as low-value purchases and high nutritional value, are very promising, and, concomitantly, their use helps to reduce the impacts on the environment. Therefore, this study aimed to evaluate the feeding behaviour and acceptability of different food wastes from fruit processing by scorpion mud turtles (*K. scorpioides*) in captivity.



#### 2 MATERIALS AND METHODS

A total of 25 specimens of *K. scorpioides* were used, with an average weight of 281 g  $\pm$  27 g. Animals were part of the Bio-Fauna Project/Federal Rural University of Amazonia (UFRA) in Belém, Pará, Brazil.

Animals were housed in polyethylene boxes 565 mm  $\Box$  390 mm  $\Box$  190 mm in length with 60% flooded area and 40% dry area and a 20° tilt, with one animal per experimental unit, for a total of 25 boxes. The temperature of the laboratory was kept at 28 ± 2 °C through a thermostat connected to heater lamps. Timer-controlled lighting was applied, with 12 h of light and 12 h of darkness.

The acceptance of five different fruit wastes was evaluated: crushed, dried coconut (*Cocos nucifera*); orange (*C. sinensis*) bagasse; crushed pineapple (*Ananas sativus*) peel; acerola (*M. glabra*): bagasse; and mango (*M. indica*) bagasse. These wastes constituted the treatments, with five replicates each, totaling 25 experimental units, each with one animal, in ten repetitions in time.

The tested wastes were obtained by nonindustrial processing of fruits homogenized by crushing. Aggregates in units of 2 g of food were weighed on a digital scale with a precision of 0.01 g and subsequently frozen in a freezer (-18°C) until use. Food was thawed to room temperature 20 min before being offered to the animals. The time interval between the supply of the tested food and the supply of maintenance rations (extruded fish feed with 36% crude protein, provided based on 2% of the live weight of the animals) was kept constant.

The study period was 15 days of adaptation and 22 experimental days, totaling 10 observations, which were made on Mondays, Wednesdays, and Fridays. All the tests were performed at fixed times. The wastes were supplied at 15:00 at the division between the dry and flooded areas, with subsequent behavioural observation for 30 min. This was followed by assignment of codes (Table 1) for the observed level of acceptance in each experimental unit and feeding with fish food.



Table 1. Hedonic sca	le and rate of acceptability in fruit w	aste acceptability testing.		
Code	Consumption	Acceptability Index		
0	0%	0%		
1	0% > 50%	25%		
2	50%	50%		
3	50% > 100%	75%		
4	100%	100%		
	Source: Authors			

Source: Authors

To measure the food intake of each item in the acceptability test, we used a hedonic scale consisting of five points, measured by the methodology of visual estimation of leftovers (Table 1). The data were analysed statistically using a nonparametric method, the Kruskal–Wallis test. The means were subsequently compared via the Student–Newman–Keuls (SNK) test (P < 0.05). Even as measuring the weight gain and survival rate of animals. Analysis of weight gain was performed by analysis of variance (ANOVA) followed by Tukey's test (P < 0.05).

Chemical analysis of feed and waste for crude protein, ether extract, ash, and crude fibre in dry matter was performed according to the methods of the Association of Official Agricultural Chemists (AOAC 2000). Gross energy was assessed by oxygen bomb calorimetry (Parr).

## **3 RESULTS AND DISCUSSION**

The phases of feeding behaviour observed in the animals included foraging, approach, olfactory recognition, capture (Figure 1), dilaceration, and ingestion, which are successive, though not all were mandatory. The animals walked toward the nostril of the floor (foraging). They approached the food with the neck outstretched (approximation). With an outstretched neck, animals recognized the food by smell, approaching the nostrils of food. Then, they grabbed the food with their mouth and moved quickly to the deepest area of the box. When necessary, they shattered the food with their head movements and used their forelimbs and finally consumed the food. The behavioural pattern of these turtles is similar to that of other species of turtles (Molina 1990; Molina et al. 1998; Malvasio et al. 2003; Rossi et al. 2006) but with some specificity.



Figure 1. Feeding behaviour of captive scorpion mud turtles: (A) olfactory recognition and (B) capture.



Source: Authors

The preference for feeding in the flooded area was assessed after the seizure of food at the boundary between the flooded and dry areas. After the animals seized their food, they returned quickly to the deepest part of the enclosure and subsequently tore and ate it. Such a preference for feeding in water was observed by Malvasio et al. (2003) for *Podocnemis expansa*, who showed a significant difference between the consumption of food in dry and flooded areas, with the highest consumption occurring in the flooded area.

This information is extremely important since for the health of animals, food should be placed in a dry area, which facilitates the handling and cleaning of ponds and preserves the quality of water and feed. However, the observations during this work showed that scorpion mud turtles in captivity were likely to eat water.

When an animal uses an outstretched neck and open mouth to ingest particles suspended in water, Neustophagia was also observed in this study and was reported in *P. unifilis* in captivity by Malvasio et al. (2003) and Belkin and Gans (1968). Like grooming behaviour is observed after ingestion, when an animal moves one of its forelimbs first to the head and then toward the mouth to remove food debris from the mouth. Both behaviours were observed in the Amazonian turtle species *P. expansa* and *P. unifilis* by Malvasio et al. (2003). However, such observations have not been published for *K. scorpioides*. The wastes tested and the feed used during the study were analysed. The data are shown in Table 2.



*cal g <sup>-1</sup>								
Composition	Fish food	Wastes						
(%)		Mango	Coconut	Pineapple	Acerola	Orange		
Dry matter	92.94	21.07	19.65	18.98	9.75	15.70		
Crude protein	32.93	5.94	8.71	7.80	11.97	10.43		
Ether extract	6.15	2.65	35.52	1.12	5.74	4.55		
Gross energy*	4300	4208	3792	3971	3639	3892		
Mineral matter	8.28	2.47	0.91	4.10	2.89	2.94		
Crude fibre	0.02	0.03	0.16	0.09	0.15	0.08		
Source: Authors								

Table 2. Chemical composition of the rations (fish) and different waste types tested based on dry matter.

The fruit waste samples tested showed differences (P < 0.05) in acceptance by scorpion mud turtles (Table 3). Yellowish foods such as mango, orange and red waste had greater acceptance, 65%, 59.5% and 53.5%, respectively, of the total consumption, followed by green, and white foods (pineapple=51.5%, coconut=30%).

Table 3. Acceptability, weight gain, and survival rate in the different treatments (waste processing).

	Wastes					
	Mango	Orange	Acerola	Pineapple	Coconut	
Acceptability Index (%) <sup>1</sup>	65a	59.5a	53.5a	51.5ab	30.0b	
Survival (%)	100	100	100	100	100	
Weight Gain $(g)^2$	33.9a	33.1a	27.0a	37.4a	30.0a	

<sup>1</sup>Means followed by different letters in the same row indicate a significant difference according to the Kruskal– Wallis test followed by the SNK test (5%).

<sup>2</sup> Means followed by different letters in the same row indicate a significant difference according to ANOVA followed by Tukey's test (5%).

Source: Authors

This study showed variation in individual acceptance of fruit waste; for example, some individuals accepted and others rejected the same fruit waste. However, despite the total rejection by some animals, all the animals exhibited weight gain and were fed fish food. We also observed the rejection of coconut waste and pineapple waste by several animals after olfactory recognition.

It is known that some turtles have colour vision (Cunningham, 2011). However, there is no research on this topic in K. scorpioides. Monge-Nájera and Morera-Brenes (1987) emphasized vision as the primary sense used in food location and recognition by scorpion mud turtles. Therefore, based on these data, it is possible to infer the influence of food colour on the choice of food for scorpion mud turtles in captivity.

Smell is also cited as a sense involved in the search, location, and recognition processes of food in some species of *Kinosternon* (Mahmoud, 1967). Malvasio et al. (2003) reported that smell likely also plays a fundamental role in the phases of feeding behaviour in *P. expansa*, *P.* 



*unifilis*, and *Podocnemis sextuberculata*. However, olfactory verification did not occur when plant products were offered to the animals in their study, which differentiates this research in which olfactory recognition was present in the supply of all fruit waste. Other species of turtles, such as *Geochelone carbonaria* and *Geochelone denticulata*, use their senses of smell and sight to locate food in captivity (Mora & Rugeles, 1981).

Crushed, dried coconut had lower food acceptance by scorpion mud turtles in this study. However, coconut waste has already been tested for its ability to feed other species of farm animals, such as sheep (Braga et al. 2009), pigs (O'Doherty & Mckeon, 2000), poultry (Jácome et al., 2002; Braga et al., 2005), and fish (Pezzato et al., 2000; Pezzato et al., 2004).

According to Santos et al. (2009), coconut meal has the potential to be used in the diet of Nile tilapia (*Oreochromis niloticus*); considering its chemical composition and digestibility, coconut meal can serve as a protein source. Pezzato et al. (2004) studied the digestibility of several alternative ingredients in Nile tilapia feed. The authors obtained digestibility coefficients for dry matter and crude protein of 60.19% and 86.78%, respectively, for coconut meal and obtained a digestible energy of 2990 kcal kg<sup>-1</sup>. In addition, the maximum inclusion in the diet of this species was 30% (Pezzato et al., 2000), which demonstrates the feasibility of using this waste as feed for Nile tilapia. There is also the possibility of using coconut waste for the nutrition of other aquatic organisms. The inclusion of crushed dried coconut in the diet of scorpion mud turtles is interesting because of the high value of ether extract (35.52%) and the presence of medium-chain fatty acids, which are preferably used as a source of energy, allowing the targeting of protein intake for more great destinations, such as the formation of muscle mass, which becomes meat after slaughter.

Despite the difference in acceptability of the different residues tested, no difference (P > 0.05) was observed between weight gain in the different experimental groups (Table 3), with weight gain values decreasing for crushed pineapple peel (37.4 g), mango bagasse (33.9 g), orange bagasse (33.1 g), crushed dried coconut (30.0 g), and acerola bagasse (27.0 g).

During the study, there was no significant difference in the acceptance of different food items during the observation periods, except for acerola bagasse (P < 0.05). However, it was observed (Figure 2) that the acceptance of items offered mostly increased until the seventh day of observation and subsequently stabilized for mango bagasse, acerola bagasse, crushed dried coconut, and crushed pineapple peel.



Figure 2. Index of acceptability (IA). The means of each fruit waste sample on different observation days (O) are shown.



Source: Authors

The acceptability of orange bagasse, which was the second highest, remained stable until the ninth day of observation. These results demonstrated the rapid acceptance of the items by the animals. Thus, it is possible to add these items to the feed of these animals as a supplement or as a component of the ration.

## **4 CONCLUSIONS**

Therefore, this study demonstrated that scorpion mud turtles in captivity consumes, in decreasing order of predilection, mango bagasse, orange bagasse, acerola bagasse, crushed pineapple peel, and crushed dried coconut. It have a predilection for feeding in water, and their behavioural pattern of eating static food consists of six phases (foraging, approach, olfactory recognition, capture, dilaceration, and ingestion). In addition, this species contains neustophagia and cleanses after ingestion. Such waste can potentially be introduced when developing rations or even as supplemental feed in these animals. These findings form the foundation for future research aimed at the development of rations with colours, flavours, and palatants tailored to this species. However, despite these advances, it is necessary to identify the optimal amount of these



foods included in the diet of scorpion mud turtles in captivity, as well as the beneficial and harmful effects that these foods may have on the production of these species.

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## PERMISSION

This study was authorized by the Ethics Committee on Animal Use of Universidade Federal Rural da Amazônia (UFRA) through authorization n° 02/2013.



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