J. Mar. Biol. Ass. U.K. (2001), **81**, 979–981
Printed in the United Kingdom

Feeding behaviour of the Japanese pygmy cuttlefish *Idiosepius paradoxus* (Cephalopoda: Idiosepiidae) in captivity: evidence for external digestion?

Takashi Kasugai

Port of Nagoya Public Aquarium, Nagoya 455-0033, Japan
E-mail: t-kasugai@nagoyaaqua.or.jp

Feeding behaviour of the Japanese pygmy cuttlefish *Idiosepius paradoxus*, inhabiting sea grass beds, was observed in captivity. Pygmy cuttlefish preferred to feed on crustaceans and the feeding behaviour consisted of two phases, namely, attacking and eating. The sequence of attacking behaviour is divisible into three stages, namely attention, positioning and seizure. In the eating process, pygmy cuttlefish insert buccal mass into the exoskeleton of the captured crustacean. In this action the buccal mass elongates to a similar length to the first arm, and moves in various directions inside the exoskeleton and flesh is ingested as this behaviour proceeds. As a result, the empty exoskeleton remained intact when the pygmy cuttlefish finished feeding.

INTRODUCTION

The Japanese pygmy cuttlefish *Idiosepius paradoxus* is a small-sized cephalopod characterized by the unique habit that the animals adhere to the substrate, such as sea grass or algae, with their adhesive organ situated on the dorsal mantle (Sasaki, 1923). Sasaki (1929) described the feeding process of *I. paradoxus* on gammarids: 'the buccal mass of the squid acts almost like the introvert of some gastropods, extending as long as its first arm, and moves quite actively and freely in all directions so that the soft internal tissues may be totally eaten out without breaking the external chitinous skin'.

Since 1997 an aquarium has been set up at Port of Nagoya Public Aquarium to exhibit various small organisms living in eelgrass (*Zostera marina*) beds, in which adults of *I. paradoxus* have been maintained (Kasugai, 1998). With this facility, some aspects of *I. paradoxus* behaviour, such as mating and egg-laying (Kasugai, 2000), were observed. The present paper describes the entire process of feeding behaviour of *I. paradoxus* in captivity and discusses the possibility of external digestion in relation to the characteristic movement of the buccal mass.

MATERIALS AND METHODS

Adults of *Idiosepius paradoxus* were collected with a small dragnet from shallow eelgrass beds along the southern coast of Chita Peninsula in central Honshu, Japan (34°43′N 13°58′E) between 1998 and 2000. Living specimens were transferred to Port of Nagoya Public Aquarium and kept in the aquarium (60×45×45 cm) with a closed circulating system which was provided with eelgrass beds. Details for the system of that aquarium were already described (Kasugai, 1998; Kasugai, 2000). *Idiosepius paradoxus* were fed with live mysids *Neomysis japonica*. Other organisms which are living in eelgrass beds, such as palaemonid and hippolytid shrimp, were also kept in the aquarium as live diets for *I. paradoxus*. Body size of *I. paradoxus* and prey specimens were ∼5–15 mm (in cuttlefish mantle length) and ∼5–50 mm (in prey total length), respectively. Feeding behaviour of *I. paradoxus* was recorded with a video camera and a still photograph camera through the side panel of the aquarium.

RESULTS AND DISCUSSION

Feeding behaviour of *Idiosepius paradoxus* consisted of two phases, i.e. attacking and eating. Details for each phase are as follows:

Attacking

Once the cuttlefish noticed the prey, it approached it with its arms pointing towards the posterior tip of carapace of the prey. It continued to approach the target until it reached a particular distance to it. This distance between hunter and prey is defined as 'attacking distance' which is <1 cm. Attacking was very fast. Just after attacking, the cuttlefish seized the prey by tentacles and drew it backward to the arm crown. Then it swam to an eelgrass blade and adhered to it while feeding (Figure 1A). On several occasions, the cuttlefish attacked a prey twice its own size. In such a case, it is not able to adhere soon after it caught the prey since the prey tries to escape from its arm. Sometimes another individual attacked the same large prey which was seized by the first hunter (Figure 1B).

Eating

The cuttlefish attached its arms at the junction between carapace and first abdominal segment of the prey and then inserted its buccal mass from there into the flesh of the prey. During this process, the buccal mass was stretched and extended to a similar length to the first arm

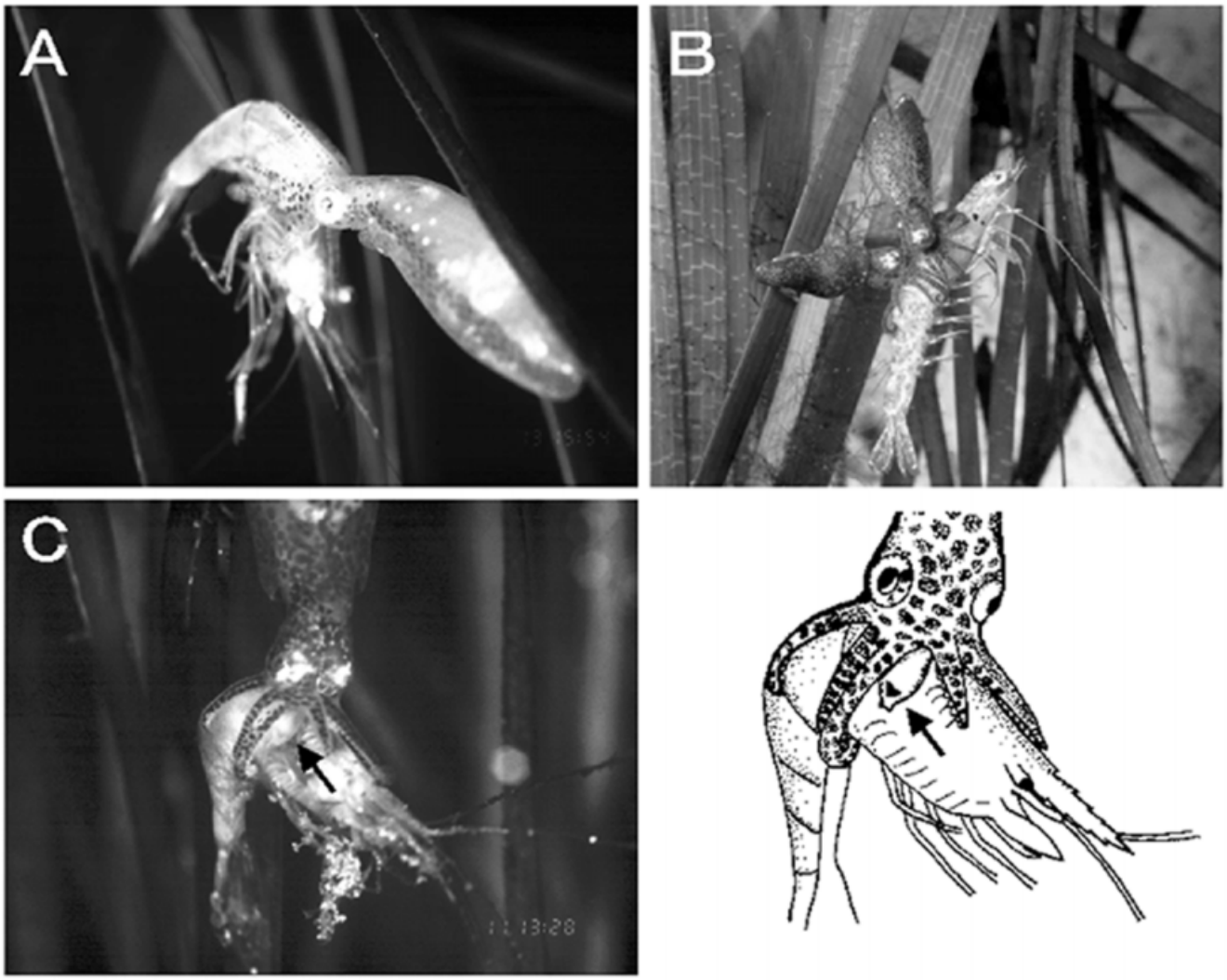

Figure 1. Feeding behaviour of the Japanese pygmy cuttlefish *Idiosepius paradoxus*. (A) The eating posture of *Idiosepius paradoxus*. Note that the cuttlefish swims back towards the eelgrass blade to adhere after catching the prey; (B) three cuttlefish are attacking the same large prey. The prey is a juvenile *Penaeus japonicus* (total length ~50 mm); (C) ingesting flesh inside the carapace of the prey (the prey is an adult *Palaemon serrifer*). Note that the squid inserts the buccal mass (arrow), which is extended as far as the first arm, into the flesh.

(Figure 1C). Movements of the buccal mass that was inserted either inside the carapace or the abdominal segments were observable through the transparent exoskeletons of the prey. Instead, the buccal mass moved around in various directions within the flesh of the prey but the exoskeleton was never chipped or eaten. The remains of the prey were discarded. In the case of small-sized prey, such as *Neomysis japonica*, almost empty exoskeletons remained and looked like a moult, the adult *Neomysis japonica* (~15 mm total length) exoskeleton being largely emptied within 15 min. While the large-sized prey, such as adult *Palaemon serrifer*, the remaining carapace and abdominal segments still retained some flesh within.

Messenger (1968) observed attacking behaviour of a juvenile cuttlefish *Sepia officinalis* on prawns, finding that behaviour consists of three stages, attention, positioning and seizure. Attacking behaviour of *I. paradoxus* under present study can be classified into the similar category.

Idiosepius paradoxus inserted the buccal mass into the flesh inside the exoskeleton of the prey. The buccal mass moved in various directions within the prey's flesh, resulting in an empty exoskeleton after eating. However, the detailed process of ingestion could not be observed. Boletzky (1974) also reported that the empty exoskeleton of the mysids remained after digestion by the young *Loligo vulgaris*. He associated this mode of ingestion with the special structure of the beaks, the lower one having a denticulated rim. *Idiosepius* also has denticles in both the upper and the lower beak (Adam, 1986). These toothed beaks may also assist in chopping up the flesh, which has become detached from the exoskeleton by enzymatic action, to be swallowed. These actions may suggest that *I. paradoxus* perform external digestion during ingestion of crustaceans.

Prey items of Idiosepiidae in nature may also offer the possibility of external digestion. The prey items of *I. paradoxus* reported are gammarids (Sasaki, 1929), and especially *Ampithoe validae* (Yamamoto, 1988) that live in seaweed areas where *I. paradoxus* occur. In captivity, *I. pygmaeus* and *I. thailandicus* respectively feed on grass shrimp *Acetes sibogae australis* (Jackson, 1989, 1992; Lewis & Choat, 1993), and the mysid *Mesopodopsis orientalis* (Nabhitabhata, 1998), that are both collected from cuttlefish habitats. In the present observation, *I. paradoxus*

https://doi.org/10.1017/S0025315401004933 Published online by Cambridge University Press

preferred to attack mysids and some crustaceans living in eelgrass beds and they never attacked fish, such as gobiidae. Preference for crustaceans, such as *Latreus acicularis*, *Crangon affinis* and *Caprella* sp. by *I. paradoxus* was also observed in eelgrass beds in the natural habitat of Chita Peninsula (T.K., personal observation). These facts suggest that crustaceans are the preferred diet of Idiosepiidae; they have hard exoskeleton, which functions as an outer wall during digesting process.

Special thanks to Professor T. Okutani, Nihon University, for his kind review of the manuscript. I am very grateful to Dr Y. Ikeda, the Institute of Physical and Chemical Research, for his kind review of the draft manuscript and assistance with the literature. Thanks are also due to Dr I. Uchida, Director of the Port of Nagoya Public Aquarium and the aquarium staff for their encouragement and support for this study.

REFERENCES

Adam, W., 1986. La radule et les mandibules de quelques espèces d'*Idiosepius* Steenstrup, 1881 (Mollusca: Cephalopoda: Decapoda). *Bulletin de l'Institut Royal des Sciences Naturelles de Belgique. Biologie*, **56**, 149–154.

Boletzky, S.v., 1974. The larvae of cephalopoda: a review. *Thalassia Jugoslavica*, **10**, 45–76.

Jackson, G.D., 1989. The use of statolith microstructures to analyze life-history events in the small tropical cephalopod *Idiosepius pygmaeus*. *Fishery Bulletin. National Oceanic and Atmospheric Administration. Washington, DC*, **87**, 265–272.

Jackson, G.D., 1992. Seasonal abundance of the small tropical sepioid *Idiosepius pygmaeus* (Cephalopoda: Idiosepiidae) at two localities off Townsville, north Queensland, Australia. *Veliger*, **35**, 396–397.

Kasugai, T., 1998. Culture and display of *Zostera marina* in the aquarium. *Bulletin of Water Plant Society, Japan*, **65**, 4–7. [In Japanese.]

Kasugai, T., 2000. Reproductive behavior of the pygmy cuttlefish *Idiosepius paradoxus* in an aquarium. *Venus (Japanese Journal of Malacolgy)*, **59**, 37–44.

Lewis, A.R. & Choat, J.H., 1993. Spawning mode and reproductive output of the tropical cephalopod *Idiosepius pygmaeus*. *Canadian Journal of Fisheries and Aquatic Sciences*, **50**, 20–28.

Messenger, J.B., 1968. The visual attack of the cuttlefish, *Sepia officinalis*. *Animal Behavior*, **16**, 342–357.

Nabhitabhata, J., 1998. Distinctive behaviour of Thai pygmy squid, *Idiosepius thailandicus* Chotiyaputta, Okutani Chaitiamvong, 1991. *Phuket Marine Biological Center. Special Publication*, **18**, 25–40.

Sasaki, M., 1923. On an adhering habit of a pygmy cuttlefish, *Idiosepius pygmaeus* Steenstrup. *Annotationes Zoologicae Japonenses*, **10**, 209–213.

Sasaki, M., 1929. Monograph of the recent dibranchiate cephalopods of the Japanese and adjacent waters. *Journal of the Faculty of Agriculture, Hokkaido Imperial University*, **29**, Supplement 10, 1–357.

Yamamoto, M., 1988. Normal embryonic stages of the pygmy cuttlefish, *Idiosepius pygmaeus paradoxus* Ortmann. *Zoological Science*, **5**, 989–998.

Submitted 4 June 2001. Accepted 1 October 2001.