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UTILIZATION OF ADULT BURROWS BY JUVENILES
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ニホンスナモグリ幼稚体による成体の巣穴利用——巣型による証拠

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Abstract: Polyester resin casts of burrows of the thalassinidean ghost shrimp, *Callianassa japonica* ORTMANN, were collected on an intertidal sand flat in west Kyushu, Japan. One burrow cast obtained in September 1989 and another, obtained in September 1990, had a thin "branch" originating from the stout adult burrow cast. Evidence pointed to such branches being inhabited by newly recruited individuals of *C. japonica*. It is believed that settling larvae and/or newly settled juveniles had entered the surface openings of the adult burrows to later branch off independently.

Introduction

After examining the distribution pattern of juveniles and adults of the thalassinidean ghost shrimp, *Callianassa japonica* ORTMANN, on an intertidal sand flat in west Kyushu, Japan, TAMAKI and INGOLE (1993) suggested that occupation of deep sediment layers by juveniles and hence their escape from mortality-causing factors near the sediment surface should be facilitated through the bioturbation of sediments by and the presence of burrows of established adults. It might therefore be expected that if juveniles utilize conspecific adult burrows in order to become established, such a utilization pattern could well be reflected by the resultant burrow shape. Although burrow morphology of *Callianassa* species has been studied

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intensively (for a recent review, see GRIFFIS and SUCHANEK, 1991), apparently only two studies have shown burrow casts in which juvenile branches led off from a stouter, adult structure, viz., FORBES (1973) (*C. kraussi*) and SWINBANKS (1981) (*C. californiensis*). The burrow structure of *C. japonica* was investigated by OHSHIMA (1967) and UTASHIRO *et al.* (1972), but a juvenile-adult burrow relationship was not detected. The present paper presents evidence for the utilization of adult burrows by juveniles of *C. japonica*.

Materials and Methods

Study area and organisms

The study area was an intertidal sand flat facing Tonioka Bay at the north-western corner of Amakusa-Shimoshima Island, west Kyushu, Japan. A rectangular area, ca. 300 m wide alongshore, was selected as the sampling site (see Fig. 1 in TAMAKI and SUZUKAWA, 1991). It was exposed for a distance of 335 m seaward at extreme low water spring tide. Almost the entire sand flat was densely populated by *Callianassa japonica*, with the densities of other burrowing decapod crustaceans being relatively low.

Females of *Callianassa japonica* attain maturity at the age of ca. one year (INGOLE *et al.*, in prep.). Ovigerous females, which spawn planktonic zoeal larvae, occur from June to October, with newly recruited juveniles appearing between July and December (INGOLE *et al.*, in prep.).

Collection of burrow casts and specimens of *Callianassa japonica*

Polyester resin casts of burrows of *Callianassa japonica* were made following HAMANO (1990), some 40–60 m seaward from the shore during low tides on two oc-

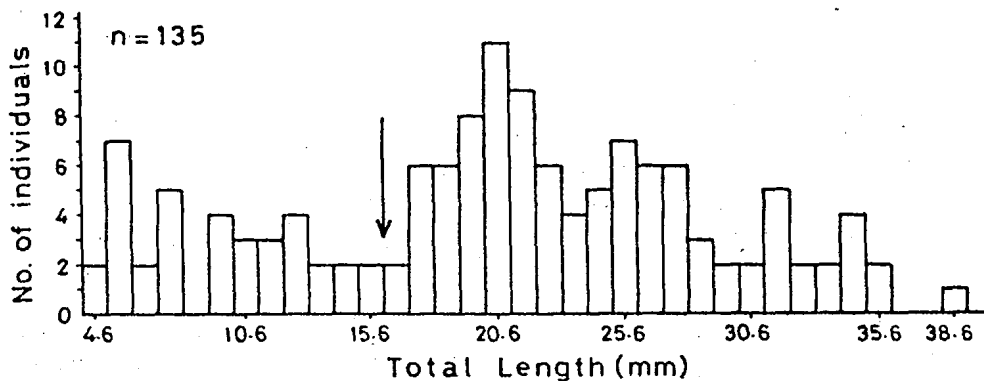


Fig. 1. Body-size (TL) histogram of *Callianassa japonica* based on core samples taken on 15 September 1989. The arrow indicates the point at which juveniles and adults are distinguished from each other. n: total number of individuals.

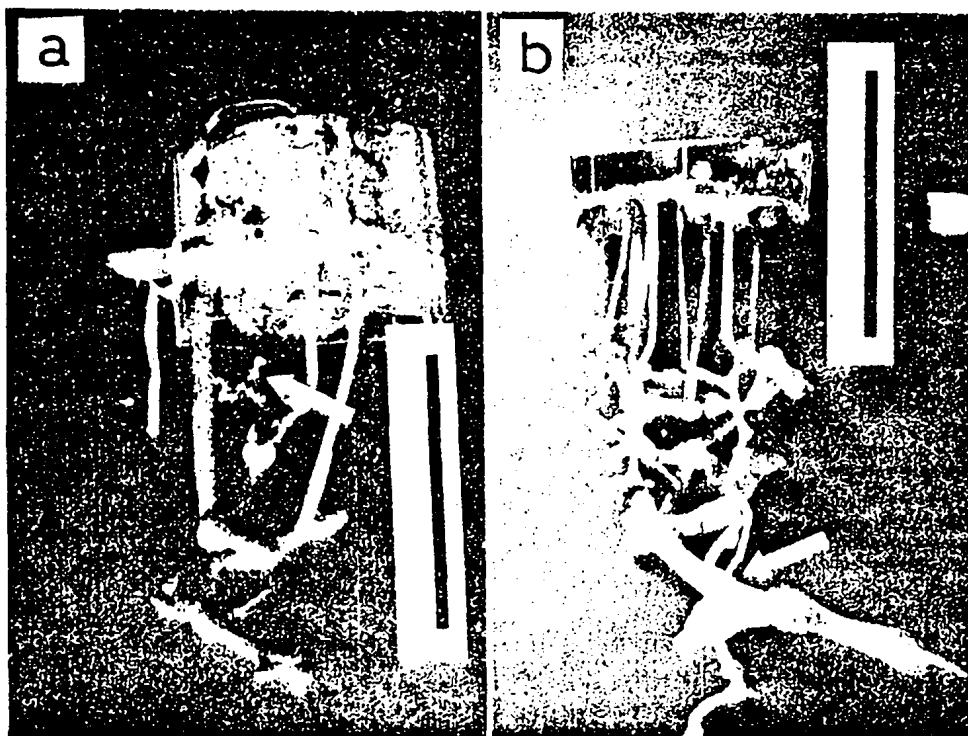


Fig. 3. Burrow casts of *Callinassa japonica* obtained on 16 September 1989 [a] and 6 September 1990 [b]. The arrow in [a] indicates a presumed juvenile burrow branching off an adult burrow. The arrow in [b] indicates the attachment point between a presumed juvenile burrow and an adult burrow. In each of [a] and [b], only one half of the paired portions above the node of the Y of the adult burrow cast was taken completely. The full range of the scale is 10 cm.

Laboratory treatments of burrow casts and specimens of *Callinassa japonica*

In the laboratory, the burrow casts were photographed. On each occasion of burrow cast collection, a single burrow cast that had a thin "branch" originating from the stout "stem" was obtained. We suspected that such branches and stems had been inhabited by newly recruited individuals and adults of *Callinassa japonica*, respectively. To determine which sizes of *C. japonica* could enter the branching sections, the following procedures were carried out: 1) Measurement of body sizes of *C. japonica*. In order to separate newly recruited individuals from adults, body-length histograms were made as follows. Among specimens collected from the core samples, those with undamaged bodies and those represented only by undamaged carapaces were measured for total length (TL: along the mid-dorsum from the tip of the rostrum to the posterior margin of the telson) and carapace length (CL: along the mid-dorsum from the tip of the rostrum to the posterior

margin of the cardiac region), respectively, under a stereomicroscope to the nearest 0.1 mm. The total lengths for the latter specimens were estimated using a linear regression equation of TL on CL obtained for specimens collected on 13-14 October 1989 as follows: $TL = 4.68 CL - 1.09$ ($n = 604$; $r = 0.99$; $p < 0.001$) (from INGOLE *et al.*, in prep.). Subsequently, a body-length histogram with 1-mm intervals was made from both directly measured and estimated TLs. This enabled recruitment cohorts to be defined, individuals being subsequently referred to as juveniles or adults, depending on body size. Secondly, for all juveniles, the maximum carapace width (CW: the width of the widest part of the body) was measured under a stereomicroscope to the nearest 0.025 mm. Although fixation and preservation might have occasionally altered the carapace dimensions to some extent, corrections were not made; 2) Measurement of the diameter of the burrow casts. The burrow casts consisted of both bulbous chambers and interconnections between them. The diameter of the interconnections was measured under a stereomicroscope to the nearest 0.025 mm for the 1989 cast at an interval of 1-1.5 mm and with a vernier caliper to the nearest 0.05 mm for the 1990 cast at an interval of 5 mm, from the proximal end (i.e., close to the "adult" stem burrows). Measurement methods differed between the two burrow casts owing to their differences in size; 3) Determination of juvenile body sizes which could move through the branching parts of the burrows. The above observations provided values of CW which were less than those of the burrow diameters. From the relationship between juvenile TL and CW, the TL of juveniles apparently inhabiting the branched sections could be determined.

Results

Definition of juveniles and adults

The total length of *Callianassa japonica* from all the core samples collected in September 1989 ranged from 4.7 mm to 38.7 mm. 6.7% of the total TL data used in the body-length (TL) histogram (Fig. 1) was estimated from CL data. Although it was impossible to conclusively identify all juveniles (individuals which were recruited in 1989) based only on histogram shape, recourse could be made to other data on temporal changes in the TL composition in this species (TAMAKI and INGOLE, 1993; INGOLE *et al.*, in prep.). Juveniles and adults could therefore be separated at the 16.05-mm TL point, with two major size-groups being recognizable within juveniles, i.e., the earlier ($9.05 \text{ mm} \leq TL \leq 16.05 \text{ mm}$) and later ($TL \leq 8.05 \text{ mm}$) recruitment cohorts.

TL-CW relationship for juveniles

The carapace width of juveniles ($TL \leq 16.05 \text{ mm}$) of *Callianassa japonica* ranged

from 0.70 mm to 3.50 mm. Fig. 2 shows the TL-CW relationship for these juveniles. The linear regression equation of TL on CW is as follows: TL (mm)=4.38 CW (mm)+2.67 (n=36; r=0.86; p<0.001).

Burrow casts

The burrow casts of *Callinassa japonica* obtained in 1989 and 1990 are shown in Fig. 3 [a] and [b], respectively. According to OHSHIMA (1967) and UTASHIRO *et al.* (1972), the burrow inhabited by one individual of *C. japonica* is basically Y-shaped with two openings on the sediment surface and the node of the Y situated some 10 to 15 cm below the sediment surface for adults. In 1990, it was found that a thin Y-shaped burrow with two openings on the sediment surface was connected to a second, stouter Y-shaped burrow. The minimum, maximum, and mean \pm SD diameters for the portion below the node of the Y of the thin burrow were 2.70 mm, 3.35 mm, and 2.97 ± 0.22 mm (n=16), respectively (the diameters of the paired portions above the node of the Y were smaller, and were not measured because those sections of the burrow were not inhabited (OHSHIMA, 1967; UTASHIRO *et al.*, 1972)). By comparison, the 1989 cast was of a thin Y-shaped burrow, which was far smaller than the thin 1990 burrow cast and had only blind ends within the sediment. It was also connected to a stout Y-shaped burrow. The minimum, maximum, and mean \pm SD diameters of the interconnection parts of this thin burrow were 0.90 mm, 1.50 mm, and 1.28 ± 0.16 mm (n=23), respectively.

Discussion

The likelihood that the "branch" burrow cast collected in 1989 (Fig. 3 [a]) was the burrow of a juvenile of *Callinassa japonica* was based on two observations: 1) The repetition of bulbous chambers and interconnections between them was typical of the burrow structure of *C. japonica* (OHSHIMA, 1967; UTASHIRO *et al.*, 1972), in which bulbous chambers are used for turning by the animal; 2) Examination of the burrow diameter and the carapace width values of juveniles (Fig. 2) indicated that the smallest-sized juveniles with at least CW \leq 0.9 mm and TL \leq 6.5 mm could move through the burrow and that juveniles with ca. 8-mm TL length, which belonged to the latest recruitment cohort (Fig. 1), conformed to the mean diameter of the interconnections in the burrow (ca. 1.3 mm).

The "branch" burrow cast collected in 1990 (Fig. 3 [b]) apparently belonged to *Callinassa japonica*, because it was Y-shaped with two openings on the sediment surface. Juveniles with ca. 16-mm TL length, which belonged to the first recruitment cohort of the year (Fig. 1), conformed to the mean diameter of the burrow (ca. 3.0 mm) (Fig. 2).

The above observations suggest the following pattern of utilization of adult bur-

rows by juveniles of *Callinassa japonica*. Settling larvae and/or newly settled juveniles enter the surface openings of adult burrows to later branch off on their own. Such branches are extended until they reach the sediment surface. The juvenile burrows eventually become separated from the adult burrows, because it is known that each adult burrow is inhabited by a single adult only (OHSHIMA, 1967; UTASHIRO *et al.*, 1972). Juveniles were observed re-entering the surface openings of adult burrows in both the field and the laboratory during the study, suggesting the common use of adult burrow openings, until such time that the juvenile burrows become completely established. For other species of *Callinassa*, FORBES (1973) showed burrow casts of juvenile shrimps radiating off an adult burrow cast of *C. kraussi*, whose larvae are non-planktonic, and SWINBANKS (1981) obtained a similar burrow cast for *C. californiensis*, which has planktonic larvae. Thus the present situation is similar to that of *C. californiensis*. On the sand flat, however, juveniles of *C. japonica* have also been found in some areas from which adults were absent (TAMAKI and SUZUKAWA, 1991; TAMAKI and INGOLE, 1993). Thus further investigations are needed to elucidate what portion of the juvenile population utilizes the adult burrows to establish itself on the sand flat.

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要 約

西九州天草の砂質干潟において、ニホンスナモグリの巣型をポリエステル樹脂を用いて採取した。1989年9月および1990年9月に得られた各一個の巣型では、太い成体の巣から細い巣が分岐していた。幾つかの証拠から、これらの分岐にはニホンスナモグリの新規加入個体が生息していたと推定された。着底期幼生あるいは着底後の幼稚体が成体の巣穴開口部から内部に入り込み、その途中で自分自身の巣を分岐させたと考えられる。