

## Diel Variations in Gut Pigments of Marine Cladocerans in the Inland Sea of Japan<sup>1), 2)</sup>

Diel variations in biological processes, e. g. vertical migration, feeding, respiration, excretion, molting and spawning, have been widely known among marine planktonic crustaceans, in particular copepods (e. g. CHECKLEY et al. 1992). However, only a few such studies have been conducted for marine cladocerans, being mainly confined to diel variations in vertical migration and partheno-genetic reproduction (ONBÉ 1974, 1978, BR-YAN 1979, MULLIN & ONBÉ 1992). Except for some preliminary observations (BAINBRIDGE 1958, KLEPPEL et al. 1988), no detailed time series measurements of gut content have been made for marine cladocerans.

We investigated *in situ* feeding rhythmicity of four species of marine cladocerans by measuring the gut pigment content at intervals of 1-4 h over a 24 h period. *Podon leuckarti* and *Evadne nordmanni* were collected in Hiroshima Bay on 21 and 22 May 1992 from T & R/V *Toyoshio Maru*, and *Evadne tergestina* and *Penilia avirostris* were collected in Kure Harbor on 11 and 12 September 1992 from berthed *Toyoshio Maru*. Zooplankton was sampled by vertical tows of a NORPAC net (mesh opening: ca. 300  $\mu\text{m}$ , cod-end volume: 1  $\ell$ ) from ca. 7 m depth to the surface. Five to 15 individuals having similar body length (mean: 680  $\mu\text{m}$  for *P. leuckarti*, 460  $\mu\text{m}$  for *E. nordmanni*, 520  $\mu\text{m}$  for *E. tergestina*, 780  $\mu\text{m}$  for *P. avirostris*) were sorted as one group, rinsed with distilled water and transferred into small vials containing 6 ml of N, N-dimethylformamide (SUZUKI & ISHIMARU 1990). One to three groups of each species were prepared at each sampling time. These vials were kept at ca.  $-20^{\circ}\text{C}$  until measurement of chlorophyll and pheo-pigment contents by a fluorometer (Turner Designs).

Diel changes in gut pigment content of each species are shown in Figure 1. A one-way ANOVA showed the variation in gut pigment content with time to be significant for *P. leuckarti* ( $F_{10,3}=1892$ ,  $p<0.01$ ), *E. nordmanni* ( $F_{10,4}=6.8$ ,  $p<0.05$ ) and *P. avirostris* ( $F_{20,30}=4.0$ ,  $P<0.01$ ). Among these, *P. leuckarti* showed the most remarkable variation; its gut pigment content increased rapidly before dusk, reaching a maximum, decreased after midnight, and remained at low level thereafter. The average pigment level between 1600 hr and 0200 hr was higher than that of the rest of the time by a factor of 3.0. Similarly, the gut pigment level of *P. avirostris* was higher during the nighttime (1700 hr to 0400 hr) than during the daytime, although the difference in average pigment levels between the two time periods was slight (factor: 1.2). *E. nordmanni* did not show any consistent diel feeding pattern, but its pigment level fluctuated within several hours. Its congener, *E. tergestina*, showed no significant variation in gut pigment content over the study period ( $F_{10,3}=1892$ ,  $p>0.05$ ).

In general, knowledge of feeding habits of marine cladocerans is meager. Feeding pattern is different between Podonidae (*Evadne* and *Podon*) and Sididae (*Penilia*), viz. raptorial feeding in the former (JAGGER et al. 1988) and filter feeding in the latter (LOCHHEAD 1936, PAFFENHÖFER & ORCUTT 1986). However, gut content examination of five species of cladocerans collected in the Inland Sea of Japan revealed that they feed mainly on centric diatoms in spite of the difference in their feeding mode (KIM et al. 1989). We assume that the cladocerans examined in this study to be mainly herbivorous, and hence the observed variation in gut pigment content is considered

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2) 瀬戸内海における海産枝角類の消化管内容物量の日周変動

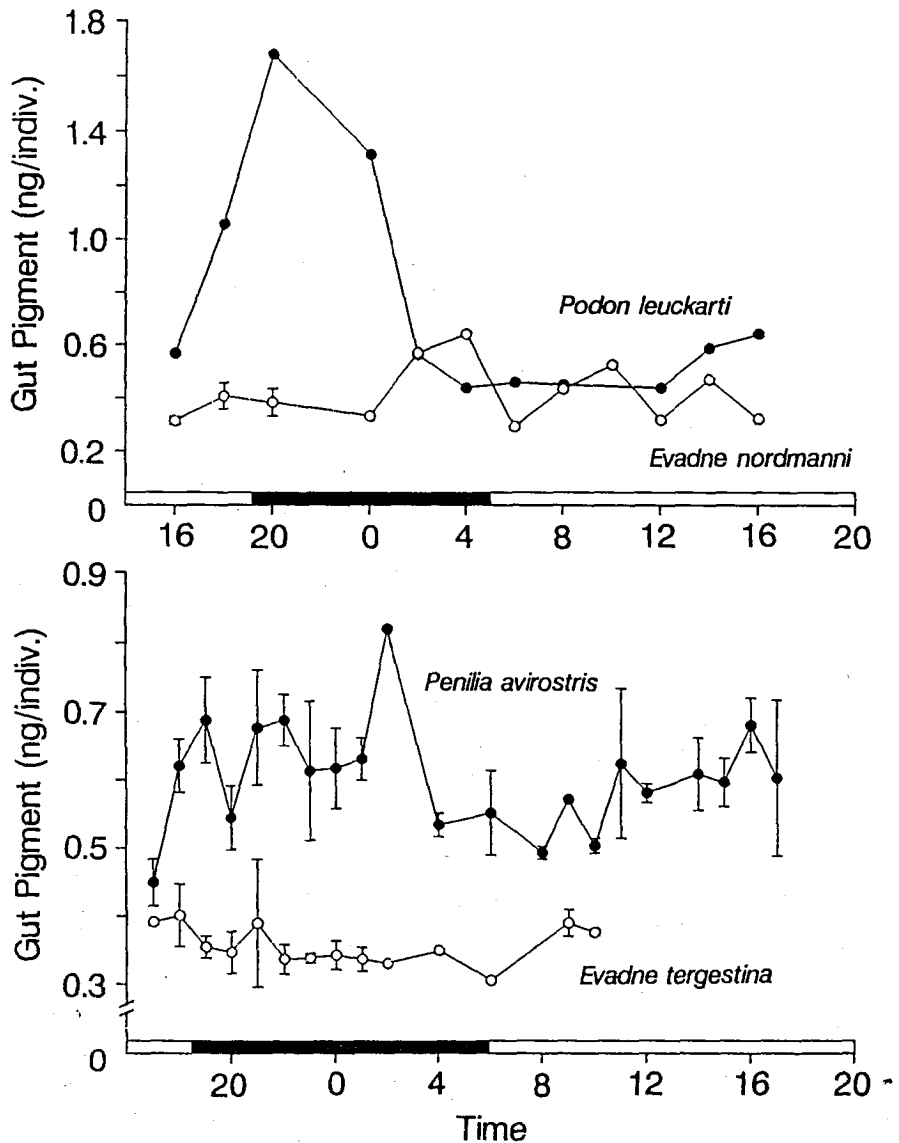


Fig. 1. Diel variations in mean gut pigment (chlorophyll + pheopigment) content of marine cladocerans. Top: *Podon leuckarti* and *Evadne nordmanni* collected in Hiroshima Bay on 21 and 22 May 1992. Bottom: *Evadne tergestina* and *Penilia avirostris* collected in Kure Harbor on 11 and 12 September 1992. Vertical bars represent SD.

directly correlated with the variation in actual feeding.

Podonid cladocerans show a pronounced reverse (shallow in daytime, deep in nighttime) diel migration, and synchronous maturation of parthenogenetic broods and neonate release

at night. Since podonids, even advanced embryos in the brood pouch, have a large, pigmented eye, the females visibility increases as the broods mature. Hence, one of the benefits of nocturnal maturation and release of broods is reduction of visual pre-dation on gravid

females (ZARET 1972, MULLIN & ONBÉ 1992). Since full gut of pigmented food also increases the body visibility, nocturnal feeding also reduces visual predation loss. In this study, apparent nocturnal feeding was found only for *P. leuckarti*, but not for *Evadne* spp. However, a midnight peak in gut pigmentation was observed for *Evadne* spp. off southern California (KLEPPEL et al. 1988). In Sididae, nocturnal maturation and release of broods are less pronounced than Podonidae (MULLIN & ONBÉ 1992). Similar less pronounced periodicity was also found in the feeding of this species.

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