Doctoral Thesis

Ecological studies on symbiotic relationships between large-sized jellyfish and other animals in Asian waters

(Summary)

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1. In recent years, various aspects of jellyfish have been actively studied, such as their mass occurrence, application of useful compounds extracted from them, and their use as aquatic resources. Accordingly, the role of jellyfishes in the marine ecosystem has also been reviewed. It is known that various organisms associate with jellyfish. However, the information on the interaction between jellyfish and symbionts is not enough. Therefore, I investigated the fauna that associates symbiotically with the jellyfish species and their interspecific relationships in Japan, Korea, Thailand, Philippines, and Malaysia.

2. Seasonal changes in the prevalence and intensity of metacercariae of *Lepotrema clavatum, Cephalolepidapedon saba*, and *Opechona olssoni* in three species of host jellyfish, namely *Aurelia aurita* s.l., *Chrysaora pacifica*, and *Cyanea nozakii*, were examined. The prevalence and mean intensity of metacercariae in *A. aurita* s.l. and *C. pacifica* increased from late spring to early summer and decreased rapidly, thereafter. However, the prevalence of metacercariae in *C. nozakii* was high even after summer. It is presumed that metacercariae were accumulated in *C. nozakii* due to their predation by other infected jellyfish. *Cyanea nozakii* plays a role as a paratenic host rather than a second intermediate host. The adults and metacercariae of trematodes were found together with nematocysts in the guts of the Japanese butterfish, *Psenopsis anomala*, and juveniles of the black scraper, *Thamnaconus modestus*. In contrast, these were not found in the guts of the juveniles of the Japanese jack mackerel, *Trachurus japonicus*, indicating that it does not use jellyfish as a food source. The transmission of trematodes into a definitive host fish occurs *via* predation of infected jellyfish.

3. In Japan and Korea, associations of two species of fish with jellyfish were common. The juveniles of *T. japonicus* were associated with five species of jellyfish (*Aequorea macrodactyla*; *Scyphozoa*: *Aurelia aurita* s.l., *Cyanea nozakii*, *Netrostoma setouchianum*; *Cubozoa*: *Morbakka virulenta*), which were found only in Japan from June to October. The juveniles of *P. anomala* were associated with three species of jellyfish in Japan (*C.*

pacifica, *C. nozakii*, and *M. virulenta*) and Korea (*Aurelia aurita* s.l., *Nemopilema nomurai*, and *Sandria malayenisis*). These symbioses were found from May to November in Japan. The host jellyfishes of the shrimp scads, *Alepes djedaba*, were variable, with four species being the hosts in Thailand (*Acromitus flagellatus*, *Catostylus townsendi*, *Lobonemoides robustus*, *Rhopilema hispidum*), two in the Philippines (*A. maculosus* and *L. robustus*), and one in Malaysia (*Chrysaora chinensis*). All the juveniles of these three species of fish occurring in East and Southeast Asian waters were 0-year in age. The juveniles of *T. japonicus* and *A. djeaba* hatched at different times; thus, there was cycling of new recruits to the jellyfish and their departure, according to the developmental stage. On the other hand, *P. anomala* appeared to continue the relationships while exchanging various jellyfish hosts.

4. The megalopa larvae to juveniles of the Christ crab, *Charybdis feriata*, were associated with jellyfish in Thailand and the Philippines. The juveniles of the ophiuroid, *Ophiocnemis marmorata*, occurred on jellyfish in Thailand and Malaysia, and ranged from 0.8 to 8.9 mm in their disc diameter. The final stages of planktonic larvae of these organisms appeared to settle on the host jellyfish directly, and then grow during the early stages of their life cycle on the hosts. The caridean shrimp, *Latreutes anoplonyx*, was found on *R. hispidum*, *L. robustus*, and *A. flagellatus* collected from Thailand, the Philippines, and Malaysia, and seemed to breed on the host. The host jellyfish likely function in the settling, feeding, and growing spots of the crab and ophiuroids, and in the breeding spot of the shrimp.

5. The nematocysts were detected in the Foods of all the symbionts, but the frequency of their occurrence was low (14.3% in *T. japonicus*) to high (100% in *P. anomala* and *C. feriata*), depending on the taxa . It is evident that the symbionts directly fed on the hosts or stole the prey captured by them. The juveniles of *Charybdis feriata* were powerful predators and devoured not only the host jellyfish but also the other symbionts. This shows complex trophic interactions among the hosts and symbionts, as

well as among the host jellyfish, trematodes, and medusivorous fish.

6. In Thailand, two species of rhizostomes, *Rhopilema hispidum* and *Lobonemoides robustus*, were commercially harvested. These jellyfishes harbored *A. djedaba, C.feriata, L. anoplonyx*, and *O. marmorata*. The fishermen use gears, such as scoop nets and hooks, to catch these jellyfishes to avoid accidental capture of the associated fish juveniles, but they seem to pay no attention to the symbiotic invertebrates. Especially, because the ophiuroids are firmly attached to the host with specialized attachment organs, almost all the individuals are probably killed. The negative impact of jellyfish fishery on these symbionts was estimated based on my original data and the statistics from the FAO fisheries. The worst case, was determined to be for *O. marmorata*, which was estimated to be killed at the rate of 126–165 million individuals per year by the jellyfish fisheries in Thailand. It is likely that such contaminations greatly influence the benthic communities. For sustainable societies, new alternative collection methods should be proposed.