Zoological Studies **43**(2): 187-192 (2004)

Zoological Studies

Poecilostomatoid Copepods Associated with Bivalves in Korea and their Distribution

Il-Hoi Kim

Department of Biology, Kangnung National University, Kangnung, 210-702 Republic of Korea. E-mail: ihkim@kangnung.ac.kr

(Accepted January 8, 2004)

Il-Hoi Kim (2004) Poecilostomatoid copepods associated with bivalves in Korea and their distribution. *Zoological Studies* **43**(2): 187-192. Research carried out during the past decade on copepods associated with Korean bivalves recognized 27 species of copepods from 40 species of bivalves. These copepods consist of 14 species of the Lichomolgidae, 5 species of the Myicolidae, 4 species of the Clausidiidae, 3 species of the Anthessiidae and a single species of the Mytilicolidae. Four of these copepod species have a very broad range of hosts: *Conchyliurus quintus* Tanaka infects 12 species of bivalves; *Modiolicola bifidus* Tanaka and *Pseudomyicola spinosus* Raffaele & Monticelli each infects 11 species; and *Ostrincola koe* Tanaka infects 10 species. *Conchyliurus quintus* and *M. bifidus* inhabit all seas around southern Korea. In contrast, *O. koe* occurs mainly in the Yellow Sea, while *P. spinosus* lives in the Korea Strait and the Sea of Japan. Interestingly, although *O. koe* and *P. spinosus* infect several species of bivalves, they do not share the same host species, with the exception of a single species of bivalve *Mactra veneriformis* which acts as a host for both species.
http://www.sinica.edu.tw/zool/zoolstud/43.2/187.pdf

Key words: Copepoda, Association, Bivalvia, Distribution, Korea.

The Mollusca is one of the major phyla that serve as hosts for copepod associates (parasites or symbionts), with more than 430 recorded species of copepods (Humes 1994). Among the Mollusca, the major group with which copepods live in association is the Bivalvia. Some of these copepod associates have been known to cause considerable damage to clam cultures (Sparks 1962; Ho and Zheng 1994).

The bivalvian association with copepods has been intensively studied in Korea, particularly because of their economic importance. More than 20 species of marine bivalves are used as food, and at least 14 species are currently cultured. In 2001, the annual harvest of these cultured marine bivalves yielded 217,000 t, which was worth about US$ 150 million (Anonymous 2001).

Since Suh and Choi (1990) reported *Pseudomyicola spinosus* and *Modiolicola bifidus* as associates of the blue mussel *Mytilus galloprovincialis* (= *M. edulis* L.) for the first time in Korea, many more species of copepod associates have been recorded from bivalves living along the coasts of Korea. This paper provides a list of copepods associated with bivalves in Korea, as well as their distribution and relationship with their hosts.

MATERIALS AND METHODS

Information on the copepods associated with bivalves in Korea used in the present study was drawn from previous works published during the period from 1990 to 2002 by Suh and Choi (1990), Ho and Kim (1991, 1992), Kim and Ho (1991), Kim (1992 1993 1995 1997 1998 2000 2002), and Kim and Stock (1996). Poecilostomatoid copepods upon which those papers were based were collected from 40 species of bivalves. These bivalves came from various localities of intertidal or shallow waters in the Yellow Sea, Korea Strait, and the Sea of Japan along the coasts of South Korea.

RESULTS AND DISCUSSION

To the present, 27 species of copepods have

been recorded from 40 species of marine bivalves in Korea (Table 1). These copepods belong to the families Anthessiidae (3 species), Clausidiidae (4 species), Lichomolgidae (14 species), Myicolidae (5 species), and Mytilicolidae (1 species). Most of the 27 species seem to be endemic to Far Eastern seas (China, Japan and Korea), with only 5 species, *Pseudomyicola spinosus*, *Myicola ostreae*, *Mytilicola orientalis*, *Leptinogaster digita* and *Lichomolgus similis*, known from localities other than this area. *Pseudomyicola spinosus* has a worldwide distribution in tropical and subtropical

Table 1. List of copepods and their bivalve hosts in Korean seas (Y, Yellow Sea; K, Korea Strait; J, Sea of Japan)

ANTHESSIIDAE

1. *Anthessius atrinae* Suh & Choe, 1990 (K) from *Atrina pectinata*.
2. *Anthessius graciliunguis* Do & Kajihara, 1984 (Y, J) from *Chlamys squamata*, *Patinopecten yessoensis*, and *Solecurtus divaricatus*.
3. *Anthessius projectus* Kim, 1993 (Y) from *Solen grandis*.

CLAUSIDIIDAE

4. *Conchyliurus inchonensis* Kim, 1997 (Y) from *Dosinisca penicillata*.
5. *Conchyliurus mactrae* Avdeev, 1977 (Y, J) from *Mactra chinensis*.
6. *Conchyliurus quintus* Tanaka, 1961 (Y, K, J) from *Barnea manilensis*, *Cyclina sinensis*, *Heteromacoma irus*, *Mactra veneriformis*, *Meretrix lusoria*, *Mya arenaria oonogai*, *Nuttalia olivacea*, *Scapharca subcrenata*, *Sinonovacula constricta*, *Solen grandis*, *Solen strictus*, and *Tapes philippinarum*.
7. *Leptinogaster digita* Kim & Ho, 1991 (Y) from *Solen grandis*.

LICHOMOLGIDAE

8. *Lichomolgus bullatus* Kim, 2000 (Y) from *Striarca tenebrica*.
9. *Lichomolgus inflatus* Tanaka, 1961 (K) from *Dosinorbis japonicus*
10. *Lichomolgus similis* Ho & Kim, 1991 (Y) from *Meretrix lusoria* and *Cyclina sinensis*.
11. *Philoconcha paphiae* Yamaguti, 1936 (K) from *Dosinorbis japonicus*.
12. *Herrmannella dentata* Avdeev, 1987 (K) from *Mya arenaria oonogai*.
13. *Herrmannella hiatellai* Avdeev, 1975 (J) from *Panopea japonica*.
14. *Herrmannella hoonsooi* Kim, 1992 (K) from *Saxidomus purpuratus* and *Tapes philippinarum*.
15. *Herrmannella longicaudata* Avdeev, 1975 (K, J) from *Patinopecten yessoensis*, *Chlamys swifti*, and *Chlamys squamata*
16. *Herrmannella longichaeta* Avdeev, 1975 (K, J) from *Mactra chinensis* and *Spisula sachalinensis*
17. *Herrmannella soleni* Kim & Ho, 1991 (Y, K) from *Solen grandis*, *Mactra veneriformis*, *Solen strictus*, and *Solecurtus divaricatus*.
18. *Herrmannella exigua* Kim, 1993 (Y) from *Solen strictus*.
19. *Modiolicola bifidus* Tanaka, 1961 (Y, K, J) from *Tapes philippinarum*, *Scapharca broughtoni*, *Scapharca subcrenata*, *Mytilus edulis*, *Crenomytilus grayanus*, *Crassostrea gigas*, *Mactra veneriformis*, *Nuttallia olivacea*, *Barnea dilatata*, *Barnea manilensis*, and *Zirfaea subconstricta*.
20. *Modiolicola gracilicaudus* Avdeev, 1977 (J) from *Mytilus coruscus*.
21. *Modiolicola avdeevi* Kim, 1995 (J) from *Modiolus difficilis*.

MYICOLIDAE

22. *Myicola intumidus* Kim, 1997 (Y) from *Dosinica penicillata*.
23. *Myicola ostreae* Hoshina & Sugiura, 1953 (Y, K, J) from *Crassostrea gigas* and *Sinonovacula constricta*.
24. *Ostrincola japonica* Tanaka, 1961 (Y, K) from *Ostrea densellamellosa*.
25. *Ostrincola koe* Tanaka, 1961 (Y, K) from *Tapes philippinarum*, *Cyclina sinensis*, *Mactra veneriformis*, *Cryptomya busoensis*, *Meretrix lusoria*, *Sinonovacula constricta*, *Solen grandis*, *Solen strictus*, *Barnea dilatata*, and *Barnea manilensis*.
26. *Pseudomyicola spinosus* (Raffaele & Monticelli, 1885) (K, J) from *Crassostrea gigas*, *Scapharca broughtoni*, *Scapharca subcrenata*, *Tegillarca granosa*, *Mactra veneriformis*, *Arca boucardi*, *Barbatia virescens obtusoides*, *Mytilus edulis*, *Notochione jedoensis*, *Mya arenaria oonogai*, and *Nuttalia olivacea*.

MYTILICOLIDAE

27. *Mytilicola orientalis* Mori, 1935 (Y) from *Barnea dilatata japonica* and *Barnea manilensis*.

waters. *Mytilicola orientalis* and *Myicola ostreae*, both associates of the Pacific oyster *Crassostrea gigas*, have been artificially dispersed, along with their cultured host, to Western Europe (Holmes and Minchin 1995). Likewise, *M. orientalis* was dispersed to the eastern Pacific and transmitted to the indigenous clams in colonized areas (Odlaug 1946; Bernard 1969). *Lichomolgus similis* was originally described by Ho and Kim (1991) from the Yellow Sea as an associate of the Oriental hard clam *Meretrix lusoria* (Roding), but was afterwards also found from *M. meretrix* (L.) on the Thai coast facing the Indian Ocean (Ho and Kim, 1995). *Leptinogaster digita*, originally described by Kim and Ho (1991) from *Solen grandis* Dunker from the Yellow Sea was found in *S. corneus* Lamarck collected from West New Guinea (Stock 1995).

Twenty of the 27 species of copepods (74.1 %) in Korean seas have been found to live with only 1 or 2 species of bivalve hosts, thereby indicating high host specificity. Of the remaining 7 species, *Anthessius graciliunguis* and *Herrmannella longicaudata* each inhabit 3 species of bivalves, while *Herrmannella soleni* inhabits 4 species of bivalves. Four species of copepods have particularly low host specificities: *Conchyliurus quintus* inhabits 12 species of bivalves, *Modiolicola bifidus* and *Pseudomyicola spinosus* each inhabit 11 species, and *Ostrincola koe* inhabits 10 species.

Sixteen species of copepod associates of bivalves have been recorded from the Yellow Sea, 14 species from the Korea Strait, and 11 species from the Korean coast of the Sea of Japan. The distributions of some species are restricted to one of 3 Korean seas although their hosts occur elsewhere. For example, *Anthessius atrinae*, associated with the pen shell *Atrina pectinata*, has been found only in the Korea Strait, although its host also occurs in the Yellow Sea. *Lichomolgus similis*, an associate of the Oriental hard clam *Meretrix lusoria*, is apparently restricted to the Yellow Sea. Repeated unsuccessful examinations of the same clam species from the Korea Strait resulted in the conclusion that this copepod does not occur there. Although the mussel *Mytilus coruscus* Gould is found along all Korean coasts, the only copepod associate of this bivalve, *Modiolicola gracilicaudus*, has been found to infect mussel populations only in the Sea of Japan.

Some species of copepods are distributed along all Korean coasts. Representatives of this

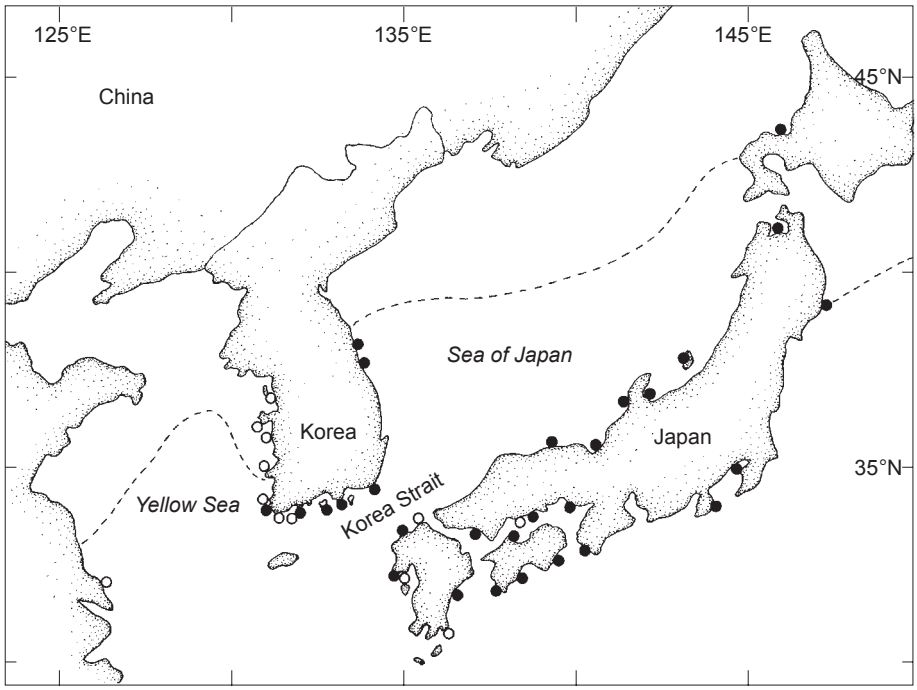

Fig. 1. Distribution of *Ostrincola koe* (open circle) and *Pseudomyicola spinosus* (black circle) in the Oriental region and the 5°C isothermal line of mean sea surface temperature in February in the period of 1961~1990 (redrawn from Kim et al. 1994). The distribution of *Pseudomyicola spinosus* in Japan is cited from Do and Kajihara (1986).

type of species include *Conchyliurus quintus* and *Modiolicola bifidus*, both of which have very low host specificities. *Conchyliurus quintus* has successfully invaded clams living in a brackish lagoon, with a salinity as low as 17‰, on the east coast of Korea (Kim 1994). *Pseudomyicola spinosus* is a well-known copepod for its extremely low host specificity, as Ho (1992) listed 51 species of bivalves as hosts of this copepod throughout the world. In addition to the reported bivalve hosts, 2 more species, *Barbatia virescens obtusoides* and *Nuttalia olivacea*, from Korea, were also found to be infected by *P. spinosus* (see Kim 1998).

Although *Pseudomyicola spinosus* and *Ostrincola koe* are the major copepod associates of Korean bivalves, these 2 copepods show a distributional difference in Korea. The occurrence of *P. spinosus* is restricted to the Korea Strait and the Sea of Japan, while *O. koe* is restricted to the Yellow Sea and the west side of the Korea Strait (Fig. 1). *Pseudomyicola spinosus* occurs in tropical and subtropical waters. In the Far East, the northern limit of its distribution roughly coincides with the 5°C isothermal line of mean sea surface temperature in Feb., the coldest month in this area (Fig. 1). *Pseudomyicola spinosus* seems unable to withstand the cold water during winter and this may be the reason why Do and Kajihara (1986) were unsuccessful in collecting this copepod from a population of *Mytilus edulis* L. on the east coast of Hokkaido, a northern Is. of Japan, as were Suh and Choi (1990) in Feb. from the same species of mussel in the southernmost area of the Yellow Sea. However, the reason for the restricted distribution of *O. koe* in Korea is unknown. Some of the bivalve hosts of *O. koe*, such as *Cyclina sinensis*, *Mactra veneriformis*, *Meretrix lusoria*, *Ruditapes philippinarum*, and *Solen grandis*, dwell in both the Yellow Sea and the Korea Strait, but none of these bivalves in the Korea Strait harbored *O. koe*. In addition to the difference in distributional patterns between *Pseudomyicola spinosus* and *O. koe*, these 2 species also show different host choices. Twenty species of Korean bivalves harbor either *P. spinosus* or *O. koe*, whereas only a single species, *Mactra veneriformis*, is infected by both species of copepods (for a similarity of host choice of 0.05) (Table 2). These differential host choices cannot

Table 2. Four prevalent species of copepods and their associations with bivalve hosts in Korea

Bivalve host	*Conchyliurus quintus*	*Ostrincola koe*	*Pseudomyicola spinosus*	*Modiolicola bifidus*
Arca boucardi			+	
Barnea dilatata		+		+
Barnea manilensis	+	+		+
Barbatia virescens obtusoides			+	
Crassostrea gigas			+	+
Crenomytilus grayanus				+
Cryptomya busoensis		+		
Cyclina sinensis	+	+		
Heteromacoma irus	+			
Mactra veneriformis	+	+	+	+
Meretrix lusoria	+	+		
Mya arenaria oonogai	+		+	
Mytilus edulis			+	+
Notochione jedoensis			+	
Nuttalia olivacea	+		+	+
Ruditapes philippinarum	+	+		+
Scapharca broughtoni			+	+
Scapharca subcrenata	+		+	+
Sinonovacula constricta	+	+		
Solen grandis	+	+		
Solen strictus	+	+		
Tegillarca granosa			+	
Zirfaea subconstricta				+
Total	12	10	11	11

be due to competition between the 2 copepods, because several clams, such as *Cryptomya busoensis*, *Cyclina sinensis*, *Meretrix lusoria*, *Ruditapes philippinarum*, and *Solen grandis*, that harbor *O. koe* in the Yellow Sea, are inhabited neither by *O. koe* nor by *P. spinosus* in the Korea Strait or the Sea of Japan.

Ho and Zheng (1994) reported *O. koe* as the primary cause of mass mortalities of the cultured hard clam *Meretrix meretrix* (L.), which occurred in 1988 and 1989 in China. Similar mass mortalities of the cultured hard clam (*M. lusoria*) occurred in the early 1970's on the Korean coast of the Yellow Sea, which devastated the industry to the extent that it has not yet recovered (the hard clams living on both sides of the Yellow Sea are probably identical species). At that time, no study was successfully able to determine the cause of the mass mortalities (Ho and Kim 1991), but 20 years later, Ho and Zheng (1995) strongly suspected that a species of parasitic copepod was the primary responsible agent.

Through research carried out by the present author during the past decade, it has been found that limited numbers of *O. koe* live in the Korean hard clam. Instead, the major copepod associate of this clam is *Lichomolgus similis*. An examination of 6 medium-sized preserved specimens collected in Aug., 1992 at Buan (located in the southern part of the Korean Peninsula facing the Yellow Sea, where the mass mortalities of the cultured hard clam occurred in the 1970's), revealed that they contained numerous individuals of *L. similis*, with 21, 51, 76, 30, 27, and 26 (mean: 38.5) individuals in each, but with only a single *O. koe* from the 6 bivalve specimens. Such a high density of *L. similis* in the hard clam has not been found in other areas, with no *L. similis* in the same species of clam from the Korea Strait, as mentioned above. According to Ho and Zheng (1994), the density of *O. koe* in China where mass mortalities of the clam have occurred, was as high as 30 individuals per hard clam. Considering these facts and the body size of *L. similis*, which is larger than that of *O. koe*, the causative agent of the mass mortalities that occurred on the Korean coast in the 1970's might have been *L. similis*. It is interesting to note that mass mortalities of cultured clams may be caused by different species of copepods and that identical species of clams may be infected by different copepod species depending on their zoogeographical locations.

Acknowledgments: This study was possible through the support from the Korea Science and Engineering Foundation (2000-1-20200-003-3).

REFERENCES

Bernard FR. 1969. The parasitic copepod *Mytilicola orientalis* in British Columbia bivalves. J. Fish. Res. Board Can. **26:** 190-191.

Do TT, T Kajihara. 1986. Studies on parasitic copepod fauna and biology of *Pseudomyicola spinosus*, associated with blue mussel. *Mytilus edulis galloprovincialis* in Japan. Bull. Ocean Res. Inst. Univ. Tokyo **23:** 1-63.

Ho JS. 1992. Phylogenetic analysis of the Myicolidae, a family of poecilostomecopepods chiefly parasitic in marine bivalve mollusks. Acta Zool. Taiwanica **3:** 67-77.

Ho JS, IH Kim. 1991. Copepod parasites of commercial bivalves in Korea. II. Copepods from cultured bivalves. Bull. Korean Fish. Soc. **24:** 369-396.

Ho, JS, IH Kim, 1992. Copepod parasites of Gastropoda from Korea. Korean J. Zool. **35:** 240-255.

Ho JS, IH Kim. 1995. Copepod parasites of a commercial clam (*Meretrix meretrix*) from Phuket, Thailand. Hydrobiologia **308:** 13-21.

Ho JS, GX Zheng. 1994. *Ostrincola koe* (Copepoda, Myicolidae) and mass mortality of cultured hard clam (*Meretrix meretrix*) in China. Hydrobiologia **284:** 169-173.

Holmes JMC, D Minchin. 1995. Two exotic copepods imported into Ireland with the Pacific oyster *Crassostrea gigas* (Thunberg). Irel. Nat. J. **25:** 17-20.

Humes AG. 1994. How many copepods? Hydrobiologia **292/293:** 1-7.

Kim IH. 1992. *Herrmannella hoonsooi*, a new species of Copepoda (Poecilostomatoida, Sabelliphilidae) associated with a bivalve from Korea. Korean J. Syst. Zool. Special Issue **3:** 77-84.

Kim IH. 1993. Two new species of poecilostomatoid Copepoda associated with razor clams (Bivalvia, Solenidae) in the Yellow Sea. Korean J. Syst. Zool. **9:** 191-202.

Kim IH. 1994. Copepodid stages of *Conchyliurus quintus* Tanaka, 1961 (Poecilostomatoida, Clausidiidae) associated with bivalve mollusks. Hydrobiologia **292/293:** 161-169.

Kim IH. 1995. *Modiolicola avdeevi*, a new sabelliphilid copepod (Poecilostomatoida) from a bivalve in the Sea of Japan. Korean J. Zool. **11:** 315-321.

Kim IH. 1997. Two new species of poecilostomatoid copepods associated with the bivalve *Dosinella penicillata* in the Yellow Sea. Korean J. Biol. Sci. **1:** 15-23.

Kim IH. 1998. Illustrated encyclopedia of fauna and flora of Korea. Vol. 38. Cirripedia, symbiotic Copepoda, and Pycnogonida. Seoul, Korea: Ministry of Education.

Kim IH. 2000. Poecilostomatoid copepods from an intertidal mud flat in the Yellow Sea. J. Nat. Hist. **34:** 367-432.

Kim IH. 2002. Redescription of two species of Copepoda (Poecilostomatoida, Lichomolgidae) associated with the bivalve *Dosinorbis japonica* from the Korea Strait. Korean J. Syst. Zool. **18:** 23-33.

Kim IH, JS Ho. 1991. Copepod parasites of commercial bivalves from Korea. I. Two new poecilostomatoid species from *Solen grandis* Dunker in the Yellow Sea. Korean J. Syst. Zool. **7:** 1-12.

Kim IH, JH Stock. 1996. A new species of Clausidiidae (Copepoda, Poecilostomatoida) associated with the

bivalve *Ruditapes philippinarum* in Korea. Cah. Biol. Mar. **37:** 1-6.

Kim YS, YH Han, SK Shin, SK Hong. 1994. Characteristics of climate in the eastern coastal regions of Korean Peninsula. Bull. Korean Fish. Soc. **27:** 314-325.

Korea statistical information system. 2001. Seoul, Korea: Korea National Statistical Office.

Odlaug TO. 1946. The effect of the copepod, *Mytilicola orientalis* upon the Olympia oyster, *Ostrea lurida*. Trans. Am. Microsc. Soc. **65:** 311-317.

Sparks, AK. 1962. Metaplasia of the gut of the oyster *Crassostrea gigas* (Thunberg) caused by infection with the copepod *Mytilus orientalis* Mori. J. Insect Pathol. **4:** 57-62.

Stock JH. 1995. Copepoda Poecilostomatoida associated with Bivalvia from New Guinea. Hydrobiologia **312:** 37-45.

Suh HL, SD Choi. 1990. Two copepodes (Crustacea) parasitic on the blue mussel, *Mytilus galloprovincialis*, from the Yongsan River Estuary in Korea. Bull. Korean Fish. Soc. **23:** 137-140.