The Diversity and Ecology of Mollusks in Seogundo off The Southern Jeju Island, Republic of Korea

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ABSTRACT

Seogundo is a small island adjacent to the southern coast of Jeju Island and connected to it by a boulder beach at low tide Surveys of this area were conducted from 2001 to 2009 to enumerate the mollusks there and also to examine their diversity, relative abundance, and ecological relationships. Both the boulder beach itself and several large tide pools were studied, including the coarse sand substrate and several species of seaweed and coralline algae found in the tide pools. Of the 121 species obtained or observed, there were 97 gastropods, 16 bivalves, and 8 polyplacophorans. Live specimens were obtained for about half of those species. About one third were found on rocky substrate, with the most common species being *Nodilittorina radiata* and *Nerita japonica* in the upper intertidal zone, *N. radiata* and *Littorina brevicula* in the middle intertidal, and *Turbo* (*Lunella*) *coronata coreensis* and *Acanthopleura japonica* in the lower intertidal and shallow subtidal. The seaweeds and coralline algae contained about 40% of all mollusk species. The most common mollusks in two species of brown seaweed were *Ittibittum parcum*, *Musculus nanus*, and *Euplica scripta*. In a species of red seaweed, *Komaitrochus pulcher* was the most frequent, as in the coralline algae, along with *M. nanus*. The coarse sand in the tidepools contained about 25% of the species, with the Cerithiidae having the largest number. A sample of beach drift contained 17 species, with *Bittium aleutaceum* and *Rissoina* (*Phosinella*) *pura* being most common. Most species, about 60%, were found in a variety of habitats, especially the marine flora; few species exhibited any habitat preferences. Biographically, Jeju Island is part of the Warm Temperate Northwest Pacific Province and the East China Sea ecoregion with a strong faunal affinity with southern Japan, eastern China, and northeastern Taiwan. Zonal-geographical groupings reveal that the fauna is mainly subtropical-low boreal, preferring moderately warm water, with a somewhat smaller number of tropical-subtropical species.

Key words: Mollusca, Diversity and Ecology, Species List, Seogundo, Jeju, Korea.

INTRODUCTION

Jeju Island, Korea's largest and southernmost island, is a volcanic island located about 80 km south of the mainland. The coastline is mainly rocky with several sandy beaches. Although cooler water currents exert some influence, the warm Tsushima Current flowing from the southwest, gives the island a subtropical climate. Jeju Island has a rich mollusk fauna, with over 1000 species presently recorded. The major families are the Trochidae, Muricidae, Pyramidellidae, Mytilidae, and Veneridae. This fauna is a combination of warm temperate (Central Japan to the Yellow Sea) and tropical and subtropical species (Southern Japan to Indo-West Pacific) (Noseworthy *et al*., 2007).

Seogundo (33° 13' 48" N 126° 29' 55" E) is a small island, located approximately 5 km west of Seogwipo on the south coast of the island (Fig. 1). It is surrounded by low cliffs. During low tide it is

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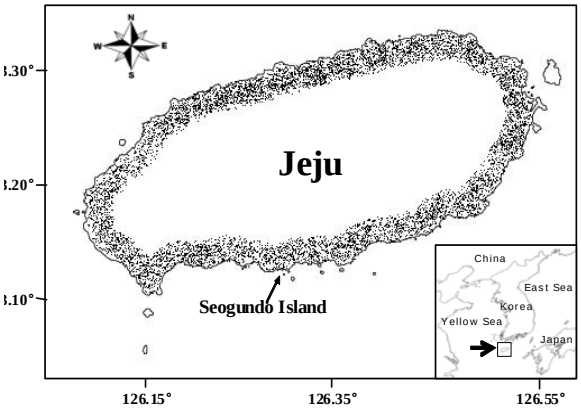

Fig. 1. Seogundo, showing its proximity to the shoreline.

connected to the mainland by a wide boulder beach, containing several large tidepools. This area is on an open coast, and is subjected to moderately wide tidal ranges (SCUBA in Korea, 1999)and strong wave action. The island shelters the shallow, rocky area which connects it to the shoreline, and contains a variety of habitats conducive to a varied population of marine organisms.

Beginning in April, 2001, three surveys of the Seogundo area were conducted and a total of 121 different species was collected. The general purpose of these surveys was to enumerate the mollusks of this area in order to examine their diversity. The study also focused on living mollusks to investigate habitat preferences. Additional sampling was also conducted in April and June 2009. The present study for the first time reports on the molluscan fauna of Seogundo surveyed in 2001 and 2009.

MATERIALS AND METHODS

The main survey was conducted in April, 2009, during an extremely low tide. According to Wells *et al*,(2008), an intensive visual search of a variety of habitats at low tide for a duration of at least one hour is sufficient to provide an effective estimate of molluscan biodiversity. The mollusks were collected using both visual searches and processing of material from various habitats. The area surveyed included the boulder beach itself as well as two large tidepools. Mollusks on the beach were obtained from the exposed surface of rocks as well as their undersides. Rocks in the tidepools were also examined. Several species, e.g., some opisthobranchs, were observed, with descriptive notes being made, but not collected. Field notes were made of the relative abundance of the more common species. Samples were also taken of the coarse sand substrate at the bottom of the tidepools. Furthermore, three types of seaweedfound in the tidepools, as well as a sample of coralline algae from the bottom of the pools, were also obtained in order to check for mollusks inhabiting these specific habitats.

The samples were separated in the field and processed separately. The seaweeds and coralline algaewere placed in fresh water overnight, then rinsed vigorously and broken apart to remove all mollusks. The material obtained was then dried. The sand from the tidepoolswas dried and then sieved through three sizes of mesh in order to remove all mollusks, the smallest-sized mesh being .75 mm. The dried material was then sorted with the aid of a 15 x magnifier, and all mollusks obtained were then identified, a stereo microscope being used for the smaller specimens. Note was also made of the number of each species, and whether the specimens were living or dead when obtained.

A variety of sources was used to identify the mollusks obtained or observed in the field based upon Okutani (2000), Min *et al*. (2004) as well as a variety of internet sources. Species lists were then prepared for each habitat for comparison purposes, and finally a total list was prepared (Table 1). The nomenclature used is based mainly on Higo, Callomon, and Goto (1999). Specimens collected are kept either at the Shellfish Aquaculture and Research Laboratory at Jeju National University or in the senior author's collection.

RESULTS

A total of 121 different species were identified, altogether a grand total of 202 species was collected from all habitats four more were identified to the genus or family level. There were 97 gastropods, 16

bivalves, and eightpolyplacophorans. The gastropod families with the largest number of species overall were the Trochidae, with nine, the Turbinidae with seven, and the Pyramidellidae and Rissoidae both with sixspecies. Among the bivalves, the Arcidae numbered four species, and the Mytilidae and Veneridae three each. The polyplacophorans belonged to the Acanthochitonidae and Chitonidae, each with three species, and the Ischnochitonidae, with two. Living mollusks comprised slightly more than half (51%) of the total number: all polyplacophorans, 50% of the gastropods, and about 40% of the bivalves.

1. Habitat Observations

The habitat preferences of living mollusks was one of the goals of this survey. The six habitats sampled contained a grand total of 87 of those species. A detailed examination was made of the mollusk diversity for each habitat, and a comprehensive list was compiled (Table 1).

2. Rocky substrate

The boulder beach was sampled over a wide area, both the exposed surface of rocks and their undersides. The rocky sides of the tidepools were also sampled. A total of 61 species, most of them including live specimens, waseither observed or collected. In the upper intertidal *Nodilittorina radiata* (Souleyet, 1852) and *Nerita* (*Heminerita*) *japonica* Dunker, 1860 were abundant. *N. japonica* and *Littorina brevicula* (Philippi, 1844) were common in the mid intertidal zone, and *Turbo* (*Lunella*) *coronata coreensis* (Recluz, 1853) was moderately common in the lower intertidal zone. The lower intertidal and shallow subtidal zones yielded eight species of Polyplacophora. The most prevalent species were *Acanthopleura japonica* (Lischke, 1873), moderately common on exposed surfaces, and *Ischnochiton comptus* (Gould, 1859) and *Onithochiton hirasei* Pilsbry, 1901, common on and under rocks in shallow water. Two opisthobranchs were observed; *Aplysia* (*Varria*) *kurodai* (Baba, 1937) was crawling on rocks in one of the tidepools, and *Chromodoris* cf. *quadricolor* (Rüppell and Leucart, 1828) occupied the underside of a small boulder. Species of Nacellidae, Lottiidae, and Siphonariidae, especially *Siphonaria* (*Anthosiphonaria*) *sirius* Pilsbry, 1894, were moderately common. Surprisingly mytilids were rarely found in this environment, but specimens of *Arca avellana* Lamarck, 1819 and *Cardita leana* Dunker, 1860 inhabited crevices in the undersides of rocks in shallow water. *Japeuthria ferrea* (Reeve, 1847), and the trochids *Monodonta australis* Lamarck, 1822 and *M. labio confusa* Tapparone-Canefri, 1874 were also common on the exposed surfaces of rocks.

3. Sand

Samples of coarse sand from the bottoms of the tidepools yielded 45 species, of which 12 included live specimens. Of those, two were bivalves, *Nucula paulula* A. Adams, 1856 and *Musculus nanus* (Dunker, 1856), and also there were two members of the Triphoridae, *Triphora turricula* (Hervier, 1897) and *T. otsuensis* (Yokoyama, 1920). The others were single species from a variety of gastropod families. Overall, the Cerithiidae had the largest number of species, five, followed by the Triphoridae with four, and the Pyramidellidae, Rissoidae, and the Turbinidae, with three each.The most common species was *Homalopoma sangarense* (Schrenck, 1857), although no live specimens were obtained. The species composition of the two tidepools was compared but the assemblages of mollusks were basically the same. *Cantharidus japonicus* (A. Adams, 1853), which usually occurs in seaweed, and *M. nanus*, which prefers rocky substrates (Okutani, 2000), were also found in this habitat.

4. Marine Flora

Specimens of the dominant species of seaweed inhabiting the tidepools were obtained in order to examine habitat preferences. Two species of brown seaweed, *Sargassum* sp. and *Padina arborescens* Holmes, 1896, one red seaweed, *Chondrus crispus* Stackhouse, 1797, and one coralline algae, *Alatocladia cf. modesta* (Yendo) Johansen, 1969 (Kang, 1968), were collected.

A sample of *Sargassum* sp. floating on the surface of the tidepool yielded 31 species, of which 11 included live specimens. Among the living species

Table 1. Species list and habits. L = living; D = dead S = *Sargassum* sp. C = *Chondrus crispus*; P. = *Padina arborescens*; A = *Alotocladia* cf. *modesta*; CS = coarse sand; R = rocks; BD = beach drift; NO. = total number; MC = moderately common; A = abundant; * = observation only; v = valves (polyplacophora)

CLASS/FAMILY/SPECIES	S	C	P	A	CS	R	BD	NO.
POLYPLACOPHORA								
Ischnochitonidae								
Lepidozona coreanica						L		2
Cf. Lepidozona coreanica					D			1(v)
Ischnochiton comptus					L	L		17
Cf. Ischnochiton comptus	D							1
Chitonidae								
Rhyssoplax.kurodai						L		1
Onithochiton hirasei						L		10
Acanthopleura japonica						L		3(MC)
Acanthochitonidae								
Acanthochitona defilippi						L		1
A. achates						L		2
Cryptoplax japonica						L		2
GASTROPODA								
Nacellidae								
Cellana nigrolineata						D		3
C. toreuma					D	L		7
Lottiidae								
Lottia. lindbergi						L		1
Lottia. cf. lindbergi					D			3
Nipponacmaea schrencki		D				L		2
N. fuscoviridis		D			D			3
N. concinna		D	D			L	D	5
Acmaeidae								
Acmaea pallida						D		1
Haliotidae								
Haliotis diversicolor						D		2
Scissurellidae								
Scissurella staminea				D				1
Fissurellidae								
Diodora sieboldi							D	1
Turbinidae								
Liotina semiclathratula			D					1
Cf. Homalopoma nocturnum					D			1
H. sangarense	D	D	D	D	D		D	25
Turbo cornutus						D		2
T. coronatus coreensis				L	L&D	L&D	D	14
Astralium haematragum						D		1
Tricolia variabilis				D				1
Trochidae								
Chlorostoma lischkei	D		D		D	L&D		12
Omphalius pfeifferi carpenteri						D		1
Granata. lyrata						D		1
Trochus sacellum rota				D		L		3
Monodonta labio confusa					D	D		3
M. australis						L&D		2
Cantharidus. japonicus	L	L			L	D		4
C. jessoensis	L							1
Komaitrochus pulcher	L	L	L	L				27

Table 1. Continued

CLASS/FAMILY/SPECIES	S	C	P	A	CS	R	BD	NO.
Skeneidae								
Teinostoma lucida					D			6
Neritidae								
Nerita albicilla						L&D		5
N. japonica						L&D		3(A)
Cerithiidae								
Cerithium kobelti	D		L	L	D	D		9
Bittium cf. glareosum					D			1
Bittium glareosum	L							1
B. aleutaceum	D	D	D	D	D		D	30
B. variegatum	D				D			3
Ittibittium parcum	L&D	L		L	L&D		D	14
Dialidae								
Diala varia	D			L	D		D	9
D. stricta					D			1
Batillariidae								
Batillaria multiformis					D	D		4
B cumingi	L				L&D	D		9
Littorinidae								
Littorina brevicula						L		1(MC)
Nodilittorina radiata	D	D	D			L	D	A
Peasiella habei	L			D				2
Assimineidae								
Angustassiminea castanea	D				D			2
Paludinellassiminea tanegashimae					D			1
Truncatellidae								
Truncatella pfeifferi						D	D	2
Rissoidae								
Alvania concinna				L				1
A. ogasawarana			L					1
Rissoina plicatula					D			5
R. costulata	D		D	D	D			11
R. pura	D		D		L&D		D	17
R. dunkeriana	D		D					2
Barleeidae								
Barleeia angustata			L	L	D			13
B. trifasciata					D			3
Vitrinellidae								
Pseudoliotia pulchella			D		D			2
Hipponicidae								
Hipponix conica						L	D	3
H. acuta					D			1
Antisabia foliacea						D		1
Vermetidae								
Serpulorbis imbricatus						L*		1
Cf. Serpulorbis imbricatus			D					1
Cypraeidae								
Cypraeidae sp.						D		1
Naticidae								
Natica gualteriana						D		7
Triphoridae								
Isotriphora kurodai					D			1

Table 1. Continued

CLASS/FAMILY/SPECIES	S	C	P	A	CS	R	BD	NO.
Triphora turricula					L			1
T. otsuensis			L		L&D			4
Cautor maculosus macmichaeli	D							1
Iniforis alba	D							1
Triphoridae sp.			D		D			3
Cerithiopsidae								
Cerithiopsis subreticulata			L					1
Cerithiopsis cf. *subreticulata*	D						D	2
C. marileutes					L			2
Eulimidae								
Melanella major	L							1
Vitreobalcis temnipleuricola				L	L			2
Muricidae								
Ergalatax contractus						D		3
Thais bronni						L&D		5
Semiricinula cf.*muricoides*						L		1
Buccinidae								
Pollia cf. *mollis*					D			1
Pollia mollis						L		2
P. subrubiginosa						L	D	3
Japeuthria ferrea						L		MC
Enzinopsis menkeana						L		1
Columbellidae								
Euplica scripta			L					8
Pyrene testudinaria tylerae						L&D		4
Mitrella bicincta						L		2
Mitrella sp.	D							1
Anachis miser	L	L		L				3
Zafra mitriformis	L							1
Nassariidae								
Hima fratercula					L			1
Costellariidae								
Cf. *Pusia aemula*	D							2
P. inermis kraussi			L		D			2
Turridae								
Haedropleura pygmaea					D			2
Guraleus kamakurana					D			1
Architectonicidae								
Heliacus variegata							D	1
Pyramidellidae								
Parthenina affectuosa							D	1
Pyrgulina pseudalveata			D					1
Cf. *Pyrgulina pseudalveata*							D	3
Miralda gemma		D						1
Pyrgiscus mumia	D		D	D	D		D	12
Cingulina cingulata			D		D			3
Paracingulina terebra					D			2
Pyramellidae sp.			D					1
Aplysiidae								
Aplysia kurodai						L*		3
Chromodorididae								
Chromodoris cf. *quadricolor*						L*		2

Table 1. Continued

CLASS/FAMILY/SPECIES	S	C	P	A	CS	R	BD	NO.
Siphonariidae								
Siphonaria japonica						L		2
S. acmaeoides				D				1
S. sirius						L		2
S. laciniosa						D		1
BIVALVIA								
Nuculidae								
Nucula paulula			L		L			2
Mytilidae								
Septifer excisus	D							1
Hormomya mutabilis			D		D			3
Musculus nanus	L	L	L	L	L			57
Arcidae								
Arca avellana						L		1
A. boucardi						D		1
Barbatia decussata						D		1
B. stearnsi				L	D			2
Noetidae								
Striarca symmetrica						L		1
Anomiidae								
Monia umbonata						L		2
Chamidae								
Chama fragum	D							1
Carditidae								
Cardita leana	D	D			D	L&D		19
Tellinidae								
Heteromacoma irus						D		1
Veneridae								
Ruditapes philippinarum						D		5
R. bruguieri	D				D	D		5
Irus irus						D		1
Freshwater								
Semisulcospira libertina		L		On silt-covered rocks in stream( )				
Radix auricularia		D		Coarse sand near stream (1)				
Hippeutis cantoni		L		Under silt-covered rock in stream (1)				
Physa acuta		L		On silt-covered rocks in stream ( )				

were three trochids, *Komaitrochus pulcher* Kuroda and IW. Taki, 1958, *Cantharidus jessoensis* (Schrenck, 1863), and *C. japonicus*, and two columbellids, *Zafra* (Zafra) *mitriformis* A. Adams, 1860 and *Anachis miser* (Sowerby II, 1844). The other species were single members of six other families. *M. nanus* was the dominant species, and *Ittibittium parcum* (Gould, 1861) was the most common live gastropod in this habitat. The Cerithiidae was the dominant family in the *Sargassum* with five species, followed by the Rissoidae with three. There were four bivalve species.

A second brown seaweed species, *Padina arborescens*, which prefers the deepest parts of the tidepools, contained 15 species, of which eight included live specimens. There was one each of eight families. Overall, there were two species of Trochidae and two of Cerithiidae, with the columbellid *Euplica scripta* Lamarck, 1822 being the most common. This species is epiphytal, grazing on seagrass and algae (Seashells of New South Wales, 2009). Four species which have been reported as preferring rock or gravel substrates, *Cerithium kobelti* Dunker, 1877, *Alvania. ogasawarana* (Pilsbry, 1904), *Cerithiopsis. subreticulata* (Dunker, 1859) and *Vexillum* (*Pusia*)

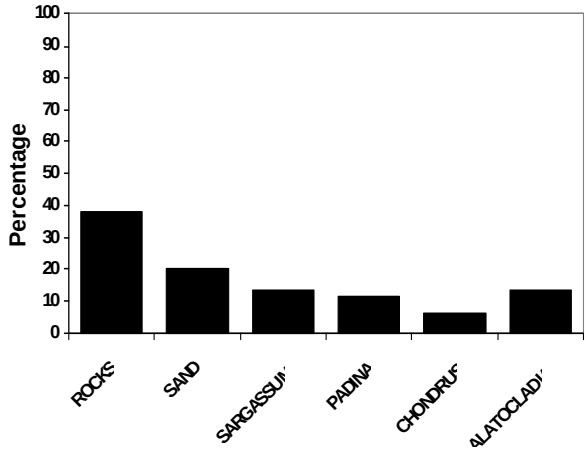

Fig. 2. Percentage of living mollusks occurring in each habitat.

inerme kraussi (Dunker, 1861) (Okutani, 2000) were also discovered in this habitat.

The red algae, *Chondrus crispus*, which occurred from relatively shallow water to the bottom of the tidepools, yielded 13 species, five of which included live specimens. *K. pulcher*, which is usually found in seaweed in the upper subtidal, was the most common species in this habitat, and M.nanus was also present.

A sample of coralline algae, *Alatocladia* cf. *modesta*, was also collected from the bottom of the tidepool, and this sample yielded 20 species, 11of which included live specimens. The most abundant species were *M. nanus* and *K. pulcher*, of which there were 32 and 13 specimens respectively. The former species was not only the most common live bivalveobtained in this survey but was alsothe most common small live species. The arcid *Barbatia* (*Ustularca*) *stearnsii* (Pilsbry, 1895), which is usually found attached to rubble in the intertidal area (Okutani, 2000) also occurred in this environment.

Lutaenko (2002) and Wells (2008), who cite several reports, suggest that dead shells should be included in biodiversity studies, as they generally reflect the distribution of live mollusks. A sample of beach drift from among rocks in the mid-tidal area was obtained in order to further examine the diversity of mollusks in this area. This sample yielded 17 species. The Pyramidellidae was most frequent with three species, and the Cerithiidae and Turbinidae had two each. *Bittium aleutaceum* Gould, 1861, in the Cerithiidae, and *Rissoina* (*Phosinella*) *pura* Gould, 1861, in the Rissoidae, had the largest number of specimens.

Most of the mollusks in this areawere found on rocky substrate and in coarse sand. Of those inhabiting the marine flora, most were on *Sargassum* and *Alatocladia*. The percentages of living mollusks found in the six habitats sampled are shown in Fig. 2.

DISCUSSION

In an island-wide study of intertidal mollusks, Lee & Jwa (1998) examined the dominant species in the upper, middle, and lower intertidal zones at twenty-five locations on Jeju Island. Two locations adjacent to Seogundo, Daepo to the west and Beophwan to the east, were included in this report. Although the surveys of the Seogundo area were not quantitative in nature, a comparison of the most common species found there with those at the above locations revealed a basic similarity, but also some significant differences (Fig. 3). With the exception of *Monodonta neritoides* (Philippi, 1849) at Beophwan,

Locality	Upper	Middle	Lower
Daepo	*N. radiata*	*M. neritoides*	*M. neritoides*
	N. japonica	*N. japonica*	*A. japonica*
			T. coronata coreensis
Seogundo	*N. radiata*	*N. radiata*	*T. coronata coreensis*
	N. japonica	*L. brevicula*	*A. japonica*
Beophwan	*N. japonica*	*M. neritoides*	*M. neritoides*
	M. neritoides	*N. japonica*	*A. japonica*
			N. concinna

Fig. 3. Intertidal dominance (nomenclature updated, adapted from Lee & Jwa, 1998).

the most common mollusks in the upper intertidal zone at all three locations were the same species. The greatest difference was in the middle intertidal zone the dominant mollusks at Beophwan and Daepo were the same but were quite different at Seogundo, with *N. radiata* and *L. brevicula* being most frequently encountered. With the exception of *M. neritoides* and *N. concinna* at Beophwan and Daepo, the other dominant mollusks at those locations were the same as those at Seogundo. An interesting feature of this comparison was the absence of *M. neritoides* at the latter location, although this species was one of the dominant ones at the other two locations.

Of the total number of mollusk species collected in the Seogundo area from various environments, those found in beach drift were not included in the habitat study because they have been washed ashore from several different habitats. About one third of the mollusks in this study, mostly live, were found on hard substrates, the prevalent habitat in this area. The Polyplacophora were almost exclusively rock dwellers, although one species, *I. comptus*, was also found in coarse sand at the bottom of one of the the tidepools. Among the astropods, the Patellogastropoda and most trochids and turbinids also preferred hard substrates. Most species of Arcidae were also found in this environment. A significant number of species, approximately 25%, were obtained from sand and/or gravel, in particular, most of the Triphoridae, Costellariidae, and Turridae, as well as all species of *Bittium*, and, among the bivalves, the Veneridae. However, only a small number were living these were mostly small species. This suggests that a significant number of dead shells may have been deposited in the tidepools at high tide. The majority of the mollusks, about 40%, such as the Dialidae, Barleeidae, and some smaller trochids, inhabited seaweed and coralline algae. Whereas the three seaweed species contained relatively few live specimens, about half the mollusks obtained from the Alatocladia were live. This suggests that more of the smaller species may prefer a coralline algae habitat.

Most species, about 60%, were found in a variety of habitats, especially the marine flora. O'Hara (2000), in a habitat study in Australia, states: "There appear to be relatively few individual species that are exclusive to a single dominant vegetation type". This was mainly confirmed by the present study, although the mollusks in the empty shells found in those habitats could have died *in situ*, or the shells could have been deposited by wave action at high tide. Among the live mollusks, the mytilid *M. nanus* and the cerithiid *I. parcum* were found in coarse sand in tide pools as well as well as the coralline algae and all three varieties of seaweed sampled. Two trochids, *C. japonicus* and *K. pulcher* inhabited several seaweed species as well as the coralline algae and sand in tide pools. The turbinid *T.* (*Lunella*) *coronatus coreenisis* exhibited a wide range of habitat preferences: the juveniles preferred coarse sand and coralline algae, while the adults were rock dwellers.

Several species merit special comment. A species of chromodorid nudibranch, *Chromodoris* cf. *quadricolor* (Rüppell and Leucart, 1828), was observed. This species has been reported mainly from the western Indian Ocean, and is one of a complex of related species (Rudman, 2004). It has also been reported from the north coast of Jeju Island (Min *et al*, 2004), but this record and the Seogundo observation may prove to be a related species. As well, a living sub-adult specimen of *Semiricinula* cf. *muricoides* (Blainville, 1832) was obtained from the underside of a rockin one of the tidepools (See Houart (1990; figs. 26-30). This Indo-West Pacific species also occurs in Southern Japan (Okutani, 2000). A careful examination of the available literature has revealed no other Korean records. More specimens will have to be obtained to verify the identification of this species if it is confirmed it will be a new record for the country.

Four specimens of the polyplacophoran *Cryoptoplax japonica* Pilsbry, 1901 were obtained or observed during the last two surveys of this area. This species appears to be rather uncommon on Jeju Island. Although there are several records in the literature (Lee & Hyun, 1992, 1997; Lee & Jwa, 1988; Lee *et al*., 1989, 1995, 2001), eight years of intensive fieldwork by the senior author have yielded only a

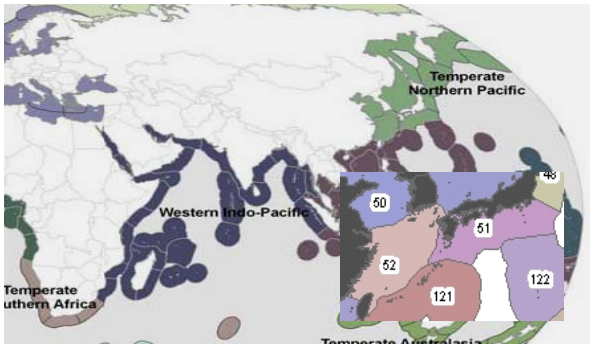

Fig. 4. Biogeography of Jeju Island (After Spalding *et al.*, 2007).

very few specimens from two localities, this survey and Songsan (Noseworthy *et al*., 2002). Another species of special interest is *Acmaea* (*Niveotectura*) *pallida* (Gould, 1859), of which a dead juvenile specimen was obtained. This species which prefers cooler water is rarely found on this island, being recorded in the available literature from only four other localities (Lee & Hyun, 1992, 1997, 2002; Lee *et al*., 1995).

Marine Ecoregions of the World (MEOW) (Spalding *et al*., 2007) is a detailed, comprehensive biogeographic system to classify coastal and continental shelf areas. According to this classification, Jeju Island is a part of the Temperate North Pacific Realm (Region) and the Warm Temperate Northwest Pacific Province. This mainly subtropical province extends from eastern Japan to the South Korean coast, then south to eastern China and Taiwan (Ecoregions 51 and 52). Jeju Island is situated in the northeastern part of the East China Sea Ecoregion (Fig. 3). Thus there is a strong affinity with the mollusk fauna of southern Japan and eastern China, and also northeast Taiwan (Noseworthy *et al* ,2007, Lee & Chao, 2003).

In order to show more specifically the faunal affinities of the Seogundo mollusk fauna, each species was assigned a zonal-geographical groupingbased on their known distribution ranges: tropical-subtropical (southward to Southeast Asia), subtropical (southward to Taiwan and the northern part of the South China Sea), and subtropical-low boreal (subtropical areas and the Yellow and East Seas) (Lutaenko *et al*. (2006). A table (Table 2) was prepared giving the zonal-geographical designations for each species recorded in the survey.

Overall, the fauna presently recorded from this area can be classed mainly as subtropical to subtropical-low boreal, preferring moderately warm water, with a somewhat smaller number of tropical-subtropical species that prefer even warmer water. (Figure 4). Among the classes, most of the Polyplacophora preferred moderately warm water with also a strong subtropical influence. The bivalves were mainly tropical-subtropical species with distribution ranges further south. Only a few were classed as subtropical-low boreal. The Gastropods are slightly more subtropical-low boreal although there is a significant warm water element. However, two, *A. pallida* and *Cantharidus jessoensis* (Schrenck, 1863), were grouped as "low boreal" species, preferring, in general, still cooler water.

The Polyplacophora has only one species, *I. comptus*, in the Ischnochitonidae, which extends to the tropical areas, while the rest prefer somewhat cooler waters. Among the Bivalvia, the main families, Mytilidae and Arcidae, exhibited strong warm water preferences. The four gastropod families with the most species showed different preferences; the Turbinidae with mainly tropical-subtropical affinities, the Trochidae divided equally between warm and moderately warm water species (subtropical-low boreal), and almost all the Rissoidae and Pyramidellidae preferring moderately warm water. With the exception of the Cerithiidae, a mainly tropical-subtropical family, the other significant families were divided between warm and moderately warm water species.

Independent of this study, a survey was made of the mollusks of Seogundo itself to determineany difference between the fauna of the boulder beach area and that of the island. In the summer and fall of 2009 five locations around the island were sampled by snorkeling at depths of two to five meters. A total of 19 species were obtained from rocky substrates, by far the main habitat on the island. The most common species encountered were the trochids *M. labio*

confusa and *Omphalius pfeifferi carpenteri* (Dunker, 1882). Of those species, only three, *Monodonta perplexa* (Pilsbry, 1889), *Isognomon ephippium* (Linnaeus, 1758), and *Chama* cf. *limbula* Lamarck, 1819, were not found at the main study area. All the rest, with the exception of the three above and *E. scripta*, also inhabited the boulder beach at the intertidal and subtidal level. The latter species was found on seaweed in the tidepools, but Okutani (2000) states that it also occurs subtidally on rocks. This was its habitat on the south side of the island.

Of special interest is the lack of *T. coronata coreensis*. This is one of the dominant species in the lower intertidal zone in the area studied, and its absence in the collections suggests that it may be uncommon on the island itself. Furthermore, *M. neritoides* was not found during the study, but it is one of the dominant species at Daepo and Beophwan. This species and *M. perplexa* are somewhat similar and confusion in identification sometimes arises, particularly in the subadult specimens. Perhaps the records of *M. neritoides* in the cited study may be a misidentification of the latter species. Furthermore, a small stream flowing to the coast adjacent to the boulder beach was searched for freshwater mollusks. Four species belonging to four different families were obtained. Those, and their respective habitats, are listed at the end of Table 1.

CONCLUSION

Generally speaking, the Seogundo area is a microcosm of Jeju Island, having a mainly rocky coastline with smaller sand and gravel areas. This locality also shares the varied habitats and rich fauna of the Island. As it the case with Jeju Island itself, as

Table 2. Zonal-geographical groupings by class

Type	Species
Low boreal	Acmaea pallida, Cantharidus jessoensis
Subtropical-low boreal	*Rhyssoplax kurodai, Onithochiton hirasei, Acanthochitona defillipi, Cryptoplax japonica, Cellana nigrolineata, Lottia lindbergi, Nipponacmaea schrencki, N. fuscoviridis, N. concinna, Turbo cornutus, T. coronatus coreensis, Chlorostoma lischkei, Omphalius pfeifferi carpenteriana, Monodonta labio confuse, Cantharidus japonicus, Teinostoma lucida, Bittium variegatum, batillariidae multiformis, B. cumingi, Angustassiminea castanea, Paludinellassiminea tanegashimae, Truncatella. pfeifferi, Alvania concinna, Rissoina plicatula, R. costulata, Barleeia angustata, B. trifasciata, Pseudoliotia pulchella, Isotriphora kurodai, Cautor maculosus macmichaeli,* Cf. *Iniforis alba, Cerithiopsis subreticulata, Vitreobalcis temnipleuricola, Pollia subrubiginosa, Enzinopsis menkeana, Pyrene testudinaria tylerae, Anachis miser, Zafra mitriformis, Pusia inermis kraussi, Haedropleura pygmaea, Guraleus kamakurana, Parthenina affectuosa, Pyrgulina pseudalveata, Miralda gemma, Pyrgiscus mumia, Cingulina cingulata, Paracingulina terebra, Siphonaria japonica, S. acmaeoides, S. sirius, Nucula paulula, A. boucardi, Chama fragum*
Subtropical	*Lepidozona coreanica, Acanthopleura. japonica, A. achates, Nodilittorina radiata, Peasiella habei, Rissoina pura, Serpulorbis imbricatus, Thais bronni, Pollia mollis, Aplysia kurodai, Monia umbonata, Heteromacoma irus, Ruditapes philippinarum*
Tropical-subtropical	*Ischnochiton comptus, C. toreuma, Haliotis diversicolor,* Cf. *Homalopoma nocturnum, H. sangarense, Astralium haematragum, Granata lyrata, Trochus sacellum rota, Monodonta australis, Komaitrochus pulcher, Nerita albicilla, N. japonica, Cerithium kobelti, Bittium glareosum, B. aleutaceum, Ittibittium parcum, Diala varia, D. stricta, Littorina brevicula, Alvania ogasawarana, R. dunkeriana, Hipponix conica, H. acuta, Antisabia foliacea, Natica gualteriana, Triphora turricula, T. otsuensis, Melanella major, Ergalatax contractus,* Cf. *Semiricinula muricoides, Japeuthria ferrea, Euplica scripta, Mitrella bicincta,* Cf. *Pusia aemula, Heliacus variegata, Chromodoris* cf. *quadricolor, Septifer excisus, Hormomya mutabilis, Musculus nanus, Arca avellana, Barbatia decussata, B. stearnsi, Striarca symmetrica, Heteromacoma irus, R. bruguieri, Irus irus*

mentioned above, the mollusk fauna of the Seogundo area has mainly subtropical affinities with a strong tropical influence, being located on the southern coast of the island in close proximity to the warm Tsushima Current.

Although there have been several surveys of the mollusk fauna of Jeju Island, there is still a need for more comprehensive comparative studies, in particular with the southern Korean mainland coast and southern Japan. This region has many species in common, and an examination of its biodiversity and biogeography would be quite informative. Also, Jeju Island shares many species with northeastern Taiwan and eastern China, being part of the same ecoregion. Comparative work here as well would be fruitful.

Furthermore, there is an increasingly urgent need for another type of comparative study, over periods of time, to examine the effects of climate change. Several tropical mollusk species have been newly reported from this island, and also several hard coral species are now known to occur, particularly along the south coast. A comparison of the older records with the most recent ones would help to ascertain both the extent and rate of climate change, and possible effects on the ecosystem.

This study is a contribution to the knowledge of the rich mollusk fauna of Jeju Island, to be added to the efforts of other researchers. Much remains to be done to fully understand the distribution, ecology, and taxonomy of the many species that inhabit our shores.

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