South Pacific Study Vol. 23, No. 2, 2003

Effect of Wave Action on Shell Shape of Marine Snail *Nerita plicata* and Oil Spill on Marine Coastal Environment

Kei KAWAI[1]

Abstract

Effects of wave action on shell shape of marine intertidal snail *Nerita plicata* and oil spill on marine coastal environment were investigated in Ulthi Atoll, Yap State, Federation of States of Micronesia. Twenty species of marine snails were identified in the intertidal areas in Ulthi Atoll. Aperture mouth size of *N. plicata,* which was the most common snail in Ulithi Atoll was significantly different between small snails and large snails but not between wave exposed area and sheltered area. However, shell shape was significantly different between small snails and large size ones and between wave exposed area and sheltered area. These results suggested that shell shape and aperture size of *N. plicata* were affected by different factors.

Six Polycyclic Aromatic Hydrocarbons (PAHs) components (fluorine, phenanthrene, anthracene, fluoranthene, pyrene and chrysene) in surface seawater, sand and marine snails *N. plicata* in Ulthi Atoll where oil spill had happened from a sunken ship in August 2001 showed low values. Although concentration of benzo (a) pyren in surface seawater and sand showed lower values, that of marine snails showed extremely higher concentration than snails in non-polluted area. I discussed the possibility of the effects by oil spill to the lives in coastal area.

Key words: benzo (a) pyren, Micronesia, *Nerita plicata,* oil spill, Ulthi Atoll, wave action

Introduction

Environmental conditions in intertidal areas are rapidly changing and making it harsh for animals and plants to inhabit the areas. However, many animals and plants adapt to these environmental conditions and many of them inhabited these area. Many researchers have studied the mechanisms and systems of their adaptation on these environmental conditions such as wave action, predators, temperature, desiccation, light, etc (ex. LITTLE and KITCHING 1996; RAFFAELLI and HAWKINS, 1996). Wave action is one of the important factors that influence the shell shape of the snails and their shape was highly correlated to the strengths of the wave (ex. ETTER, 1988).

Environmental pollution through oil spills are a big problem in the world (ex. PETERSON, 1993). An oil spill from a sunken oil tanker had happened in August 2001 near Falalap Island, Ulthi Atoll, Micronesia (SALAS, 2001). The ship was sunken by Japanese submarine "Kaiten" during World War Ⅱ. The leaking point of sunken ship was soon filled up but some amount of oil was leaking into the Atoll. Two weeks later, most of the oil spill from the ship was in the open sea beside Asor and Falalap Islands. So far,

[1] Research Center for the Pacific Islands, Kagoshima University,Korimoto 1-21-24, Kagoshima 890-8580, Japan

there is no evidence of research on the possible effects of oil pollution on the marine organisms in the area.

There are three purposes on this paper: 1) to investigate species of marine snails in intertidal area in Ulthi Atoll, 2) to study the influence of wave action on the shell shape and aperture mouth of *Nerita plicata,* which is one of the most common species in the intertidal areas, and 3) to investigate the concentration of oil in the seawater, sand, and marine snail *N. plicata.*

Materials and Methods

The research was carried out in intertidal areas of Ulthi Atoll, Yap State, Federation of States of Micronesia from 18 October to 24 October 2001. To investigate the kinds of marine snails in the intertidal areas, I walked along the shore in Mogmog, Asor, Falalap, and Fassalai Islands, to note the species name of all kinds of the observed snails and brought unknown species to the laboratory for species identification.

Nerita plicata was used as a target species of my study, because this was the most common snail in these areas (see Result). Thirty small (shell length < 15 mm) and 30 large (shell length > 15 mm) *N. plicata* were collected from wave exposed and sheltered areas of Mogmog, Asor, Falalap, and Fassalai Islands, respectively. The open seaside of the atoll was the exposed area and the inside was the sheltered area. In the laboratory, the shell length, shell width, aperture length, and aperture width of all snails were measured (Fig. 1) and calculated the following indices: 1) Relative Aperture Index (RAI) = (aperture length) x (aperture width) / (shell length)^2, and 2) Relative Shell Shape Index (RSSI) = (shell length) / (shell width). RAI is an index of the size of aperture mouth and a high value of the index means that the size of the aperture is bigger. RSSI is an index showing shell shape.

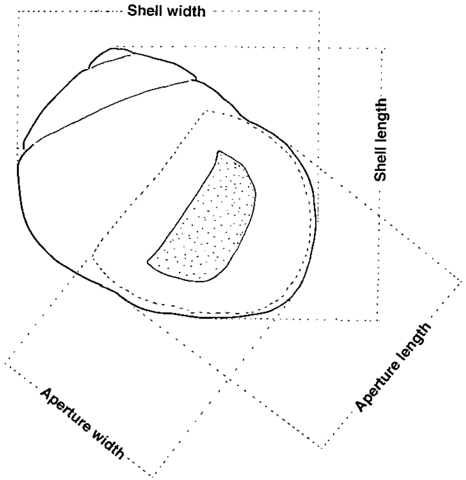

Fig. 1 Measuring method of two indices: 1) Relative Aperture Index (RAI) = (aperture length) x (aperture width) / (shell length)^2 , and 2) Relative Shell Shape Index (RSSI) = (shell length) / (shell width).

To know the impact of the pollution, I studied seven Polycyclic Aromatic Hydrocarbons (PAHs) components (fluorine, phenanthrene, anthracene, fluoranthene, pyrene, chrysene and benzo (a) pyren) in seawater, sand, and marine snail *N. plicata* in Asor Islands. Three liters of surface seawater was sampled near the shore. Two thousand seven hundred cm^3 of sand was collected from 5 cm depth under the ground surface. Ten *N. plicata* were collected from sheltered shore. I commissioned the Japan Frozen Foods Inspection Corporation to analyze these samples.

Results and Discussion

Shell Shape

Twenty species of marine snails were identified in the intertidal areas of Ulthi Atoll (Table 1). *Nerita plicata* and *Littorina undulata* were the two most common snails in these areas. I adopted *N. plicata* as a target species of the study because its density was higher than the other snails (personal observation).

Table 1. Species name which observed in intertidal area in Mogmog Island, Asor Island, Falalap Island, and Fassarai Island. 'O' indicates that the snail was observed in the island.

Species	Mogmog	Asor	Falalap	Fassarai
Nerita plicata	O	O	O	O
Cerithium nodulosum	O			
Littoraria undulata	O	O	O	O
Cypraea tigris	O			
Cypraea moneta				O
Thais marginatra		O		
Thais savignyi	O			O
Drupa ricinus	O			
Drupa ebraeus				O
Drupa grossularia				O
Mancinella hippocastanus		O		
Coralliophila neritoides				O
Vasum ceramicum	O			O
Eugina mendicaria				O
Strigatella paupercula				O
Conus ebraeus				O
Muricidae A	O			
Muricidae B				O
Muricidae C				O
Mitridae A				O

The average RSSI of large snails was significantly lower than that of small snails (two way ANOVA, $P < 0.001$) and average RSSI of snails in exposed area was significantly higher than that of sheltered area (two way ANOVA, $P < 0.001$; Fig.2, Table 2). There was an interaction effect between snail size and shore type on RSSI (two way ANOVA, P

< 0.05). These suggested that there might be a difference between exposed and sheltered areas in small snails and no significant difference in large snails. Large and small snails inhabited in the same areas (personal observation), therefore both groups received the same strength of wave force but showed different shell shapes. I do not have any data to explain these results, but this might be caused by interaction between environmental factor(s) and genetics.

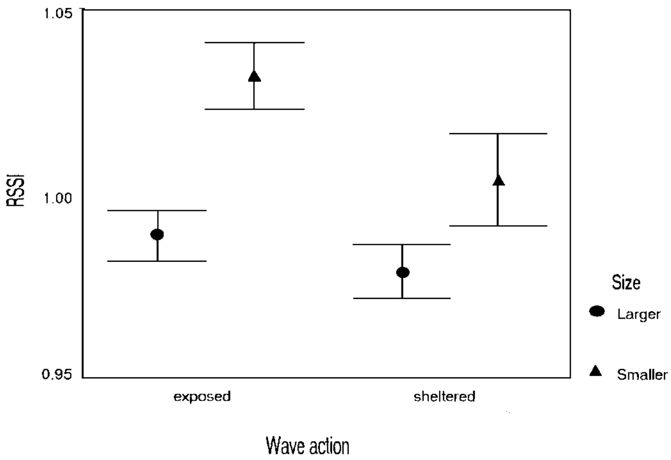

Fig. 2 Mean (± SE) relative aperture index (RSSI) of large and small snails in exposed and sheltered areas.

Table 2. Results of ANOVA on the effects of shore type and size of snail on RSSI.

Source	d.f	SS	MS	F	P
Shore type	1	0.027	0.027	17.105	0.001
Snail size	1	0.086	0.086	55.447	0.001
Interaction	1	0.006	0.006	3.961	0.047
Residual	331	0.515	0.002		

Table 3. Results of ANOVA on the effects of shore type and size of snail on RAI.

Source	d.f	SS	MS	F	P
Shore type	1	0.005	0.005	1.938	0.165
Snail size	1	1.162	1.162	422.525	0.001
Interaction	1	0.002	0.002	0.727	0.395
Residual	331	0.91	0.003		

Average RAI of small snails showed significantly higher than that of large snails (two way ANOVA, $P < 0.001$; Fig.3, Table 3). But there was no significant difference between shore types (two way ANOVA, $P > 0.05$). Shore type did not influence the aperture size but small snails had bigger size of aperture mouth than large ones. Larger aperture mouth might help to keep bigger foot and to adhere on surface of the rock, which increasing survival rate. When snails were small size, they were very sensitive on environmental conditions therefore larger aperture mouth would increase the survival rate for small snails very much.

On the other hand, both results suggested that shell shape and aperture size were affected by different factors, although I need more studies to confirm on these.

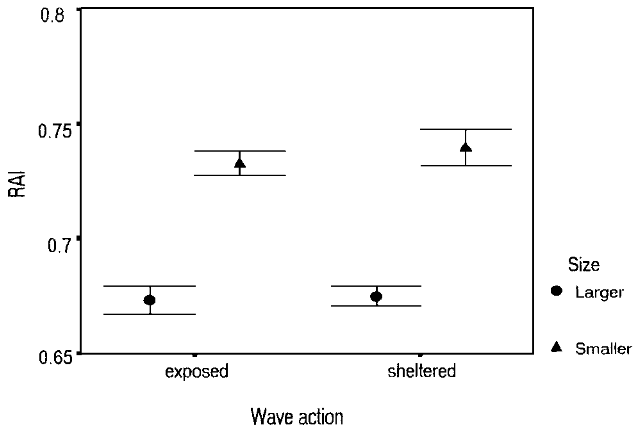

Fig. 3 Mean (± SE) relative shell shape index (RAI) of large and small snails in exposed and sheltered areas.

Oil Spill

Results of PAHs components in seawater, sand, and marine snails are shown in Table 4. PAHs components in sands were lower than these in seawater and snails. Most of PAHs components in seawater, sand, marine snail, except for the benzo (a) pyren in *N. plicata* were of similar value to non-polluted beach in Japan (FUJIMOTO, 1998). The benzo (a) pyren in marine snails was about six times higher than the concentration in snails found in non-polluted area. Another research suggested that benzo (a) pyren concentration of snails and mussels are high in oil-polluted area (NOREA-BARROSO *et al.*, 1999), suggesting the snails were affected by oil pollution. But source of the pollution was not clear in this area, although oil spill has happened from a sunken ship in August

Table 4. Results of PAHs analysis of seawater,sand,snails.

	Fluo-rene	Phenan-threne	Anthra-cene	Fluor-anthene	Pyrene	Chrysene	Benzo(a) – pyrene
Seawater(ng/g)	<0.1	3.8	<0.1	<1.4	1	<0.1	<0.1
Sand(ng/g)	<0.1	0.5	<0.1	<0.1	<0.1	<0.1	<0.1
Snails(ng/g)	3	15	<1	2	<3	<1	7

2001 in Ulthi Atoll. There are two possibilities for the source of the pollution. First possibility is oil spill from a sunken ship in August 2001 in Ulthi Atoll and the second one is oil leaking from boats, which were used for general/daily life.

Benzo (a) pyren is a chemical thought to develop cancer (SMOLAREK, 1988) and has a negative effect on mate reproduction in the mouse (REVEL *et al.*, 2001). Concentration of benzo (a) pyren in snail was high in Asor Island, suggesting a possibility that many coastal animals might develop cancer caused by benzo (a) pyren. Moreover, many marine animals are consumed as daily food by the local people. Therefore, there is a possibility that oil pollution affects the health of the local people.

To find out the source(s) of the pollution on the snails, and continuous monitoring of the concentration of PAHs are important for the conservation of the marine ecosystem and for the health of the local people in this area.

Acknowledgements

This work was carried out as part of the research project of KURCPI entitled "Social homeostasis of small islands in an island-zone" and supported by 2001 Kagoshima University Research Fund. I wish to thank the Ministry of Education, Culture, Sports, Science and Technology and Ministry of Foreign Affairs of the Japanese Government to support our project. I also wish to thank the Council of Pilung, Historic and Cultural Preservation Office, Yap State Government and Government of Federated States of Micronesia for permitting us to carry out our research. I am grateful to the staff of training vessel "Keitenmaru" of Kagoshima University for the support extended to our research, G. Koyama for his advice on the influences of oil pollution and A. S. Ilano and B. C. Prasad improving the English of this draft.

References

ETTER, R. J. 1988. Physiological stress and color polymorphism in the intertidal snail *Nucella lapillus*. Evolotion, 42: 660-680.

FUJIMOTO, K. 1998. Report of influences of oil spill by sunken ship "Nahotoka" on fisheries and ecosystem. 542pp., Department of Fisheries Agency Japan (in Japanese).

LITTLE, C. and KITCHING, J. A. 1996. The Biology of Rocky Shore. 240pp., Oxford University Press.

NOREA-BARROSO, L., GOLD-BOUCHOT, G., ZAPATA-PEREZ and SERICANO, J. L. 1999. Polynuclear aromatic hydrocarbons in American oyster *Crassostrea virginica* from the Terminos Lagoon, Campeche, Mexico. Mar. Poll. Bull., 38: 637-645.

PETERSON, C. H. 1993. Improvement of environmental impact analysis by application of principles derived from manipulative ecology: lessons from coastal marine case histories. J. Aus. Ecol., 18: 21-52.

RAFFAELLI, D and HAWKINS, S. 1996. Intertidal Ecology. 244pp., Chapman and Hall.

REVEL, A., RAANANI, H., YOUNGLAI, E., XU, J., HAN, R., SAVOURET, J. F. and CASPER, R. F. 2001. Resveatrol, a natural aryl hydrocarbon receptor antagonist, protects sperm from DNA damage and apoptosis caused by benzo (a) pyrene. Repro.Toxi., 15:479-486.

SALAS, S. 2001. Oil spill in Yap makes international headlines. In News 8 August 17 2002, http://www.kuam.com/news/story.asp?headline=1773.

SMOLAREK, T. A. 1988. Temperature-induced alterations in the metabolic activation of benzo-a-pyrene to DNA binding metabolites in the bluegill fry cell line bf-2. Aqua.Toxi.Ams., 13:89-97.