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Outline of the Biological Expedition to the Northern Mariana Islands, Micronesia

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Abstract A biological expedition to the northern Mariana Islands in the Izu–Mariana Arc was conducted in 1992 by the Natural History Museum and Institute, Chiba, in cooperation with the Department of Natural Resources (Commonwealth of the Northern Mariana Islands), and the University of Guam Marine Laboratory. The islands investigated were Anatahan, Sarigan, Guguan, Alamagan, Pagan, Agrihan, Asuncion, Maug (consisting of 3 islets), and Uracas. This expedition is considered important and significant, because 1) a close relationship of fauna and flora must exist between Japan and the northern Marianas, 2) numerous taxa and fields have not been studied, and discovery of new taxa is expected, 3) the shores of the northern Marianas are mostly volcanic and are expected to yield species different from those of raised limestone and reef flats, 4) some of the islands of the northern Marianas are good models for studies of environmental destruction, and 5) the project was expected to contribute to an understanding of the origin and evolution of the organisms of the Pacific Islands. The expedition members comprised 6 persons from the Museum, 5 persons from the Department, and 3 persons from the Marine Laboratory. The project had been prepared since 1989, and several Museum staff went to Guam, Saipan, and Hawaii to obtain information on the northern Marianas and to negotiate for permission to collect specimens with the Government of the Northern Mariana Islands. The expedition cruise was divided into two parts. In the first cruise, the expedition party visited Anatahan, Sarigan, Guguan and Alamagan, and in the second cruise, Pagan, Agrihan, Asuncion, Maug, Uracas, and again Asuncion, and Alamagan.

Key words: Northern Mariana Islands, Izu–Mariana Arc, Micronesia.

The Izu–Mariana Arc is a long chain of islands consisting of the Izu, Ogasawara (Bonin), Iwou (Volcano), and northern and southern Mariana Islands (Figs. 1 and 2). This arc, extending from temperate to tropical region, is very unique in that the fauna and flora of the islands are in some ways independent, but at the same time closely related to each other. In 1989, the Natural History Museum and Institute, Chiba, started a 5-year project on the study of the natural history of the arc in order to understand the origin and evolution of their fauna and flora. As a part of the project, the Museum carried out the expedition to the northern Mariana Islands, Micronesia, in cooperation with the Department of Natural Resources (Commonwealth of the Northern Mariana Islands) and University of Guam Marine Laboratory. We report here outline of the project.

The Northern Mariana Islands

The Mariana Islands form the southern most part of the Izu–Mariana Arc and consist of the two archipelago groups (Fig. 3); southern Mariana Islands (Guam, Rota, Tinian, Aguijan, Saipan, Farallon de Medinilla, and other miscellaneous islands) and northern Mariana Islands (Anatahan, Sarigan, Guguan, Alamagan, Pagan, Agrihan, Asuncion, Maug (consisting of 3 islets), Uracas, and other miscellaneous islands (Fig. 3). The former is constructed by raised limestone with reef flats along shore lines, while the latter is the volcanic islands, and, in particular, Pagan, Guguan, Asuncion, Agrihan, and Uracas Islands are active volcanoes. General geological description of each island is as follows, based on the data and information in Nicholson (1969), Eldredge *et al.* (1977) and Eldredge (1983).

Anatahan. Location: 16°22′N, 145°40′E.

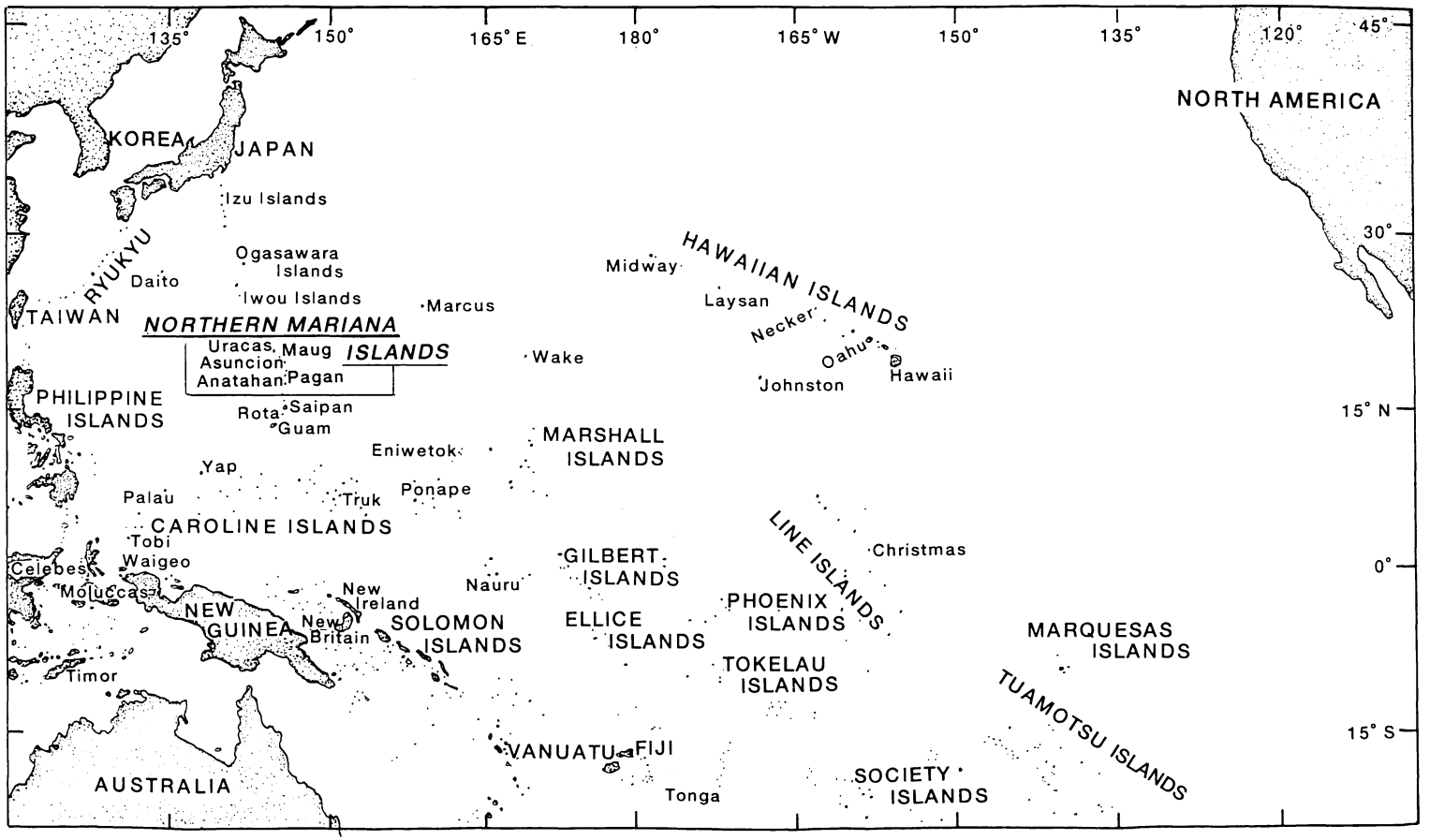

Fig. 1. Map of the Pacific Islands and locatirn of the northern Mariana Islands.

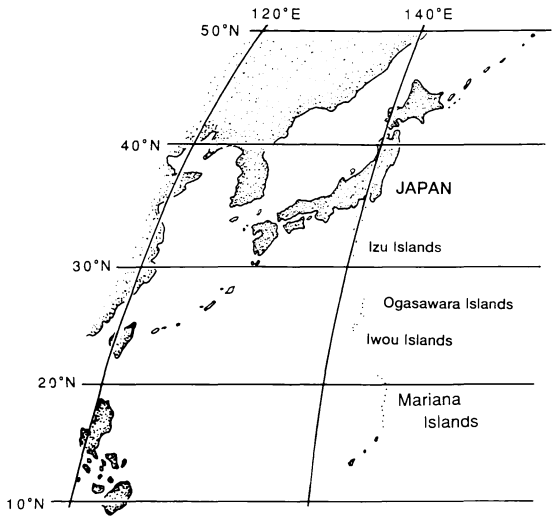

Fig. 2. Location of the Izu-Mariana Arc.

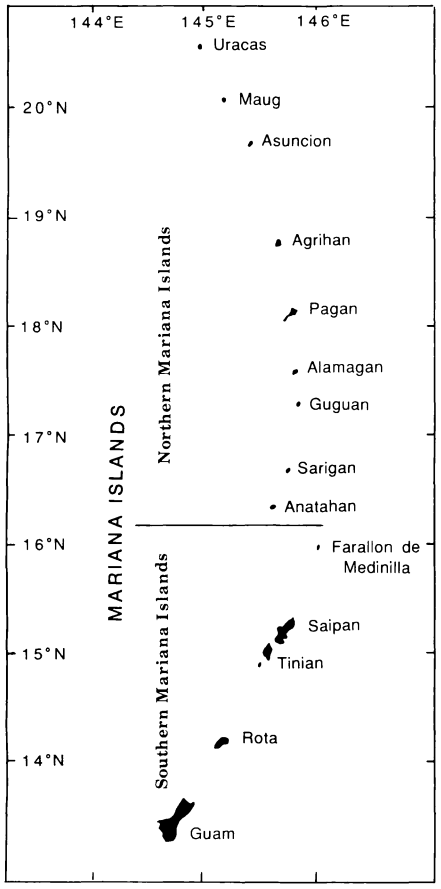

Fig. 3. Location of the southern and northern Mariana Islands.

Maximum altitude: 788 m. Area: 32.3 km^2. The shape of the island is basically rectangular with its longer axis oriented east-west. High irregularly sculpted land slopes towards the water from the craters of two extinct volcanoes. No volcanic activity has been reported during historic times. Steep cliffs and headlands outline most of the shore.

Sarigan. Location: 16°42′N, 145°47′E. Maximum altitude: 549 m. Area: 5.0 km^2. This island is an extinct volcano, but has no historically recorded volcanic activity. The shoreline is made up primarily of high cliffs and steep slopes.

Guguan. Location: 17°19′N, 145°51′E. Maximum altitude: 301 m. Area: 4.2 km^2. This island has a barren active volcano on the northern side and an old vegetation covered cone on the southern side. Volcanic activities recorded are; eruption in 1819 and 1901, minor activity in the 1860s, and explosive activity in the 1880s. There also was an observation in 1975 that steam was intermittently being emitted from the northern cone which was surrounded by a crust of yellowish sulfur-like material. Most of the shoreline is steep cliffs.

Alamagan. Location: 17°35′N, 145°51′E. Maximum altitude: 744 m. Area: 11.2 km^2. The recorded volcanic activity for the island is a minor event in the 1860s and a lava and ash eruption in 1885. The coastal area consists mainly of low headlands and steep cliffs. A boulder and cobble shore is located along the southwest coast.

Pagan. Location: 18°06′N, 145°46′E. Maximum altitude: 570 m. Area: 47.7 km^2. This is the largest island among the northern Marianas. Explosive eruption took place between 1820 to 1830 and during the last half of the 19th century. The eruption also occurred in 1909, 1917, 1923, 1925 and 1981 (Evans *et al.*, 1987). Two lakes are found, which have been formed about 200 years ago. Corwin *et al.* (1957) reported before recent volcanic eruption that the inner lake or Lagunan Sanhalom had a length of 560 m, a width of 525 m, an average depth of 15 m, and an area of 0.174 km^2, and that the outer lake or Lagunan Sanhiyong had a length of 759 m, a width of 310 m, an average depth of 12 m, and an area of 0.160 km^2. Following the

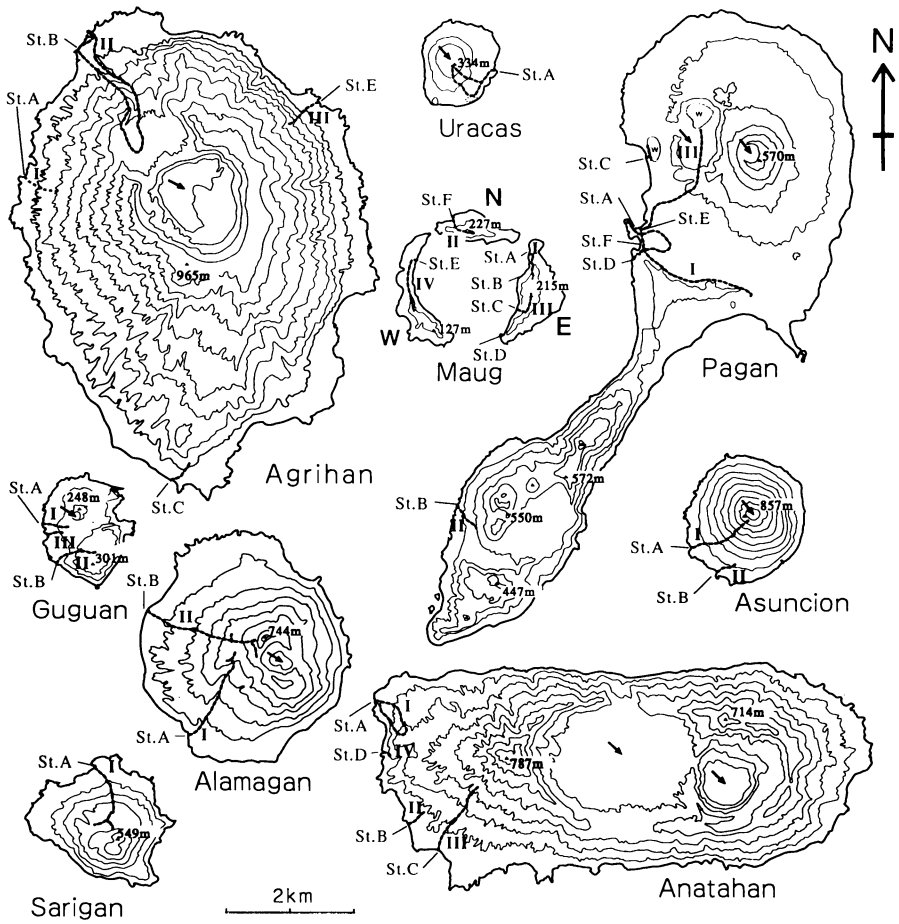

Fig. 4. Sampling routes and sites on each island. "St." means each location of a landing place and sampling site for marine invertebrates. Roman numerals indicate investigation routes for terrestrial biota.

volcanic eruption, the shore line of the inner lake was reduced by about 2 m on all side. Most of coastline is composed of near vertical headlands and steep slope. Beaches composed of fine-sized material are found along the west and southwest shore of the northern half of the island. All of the southern beaches consist of large, coarse materials. Raised reef limestone and limestone conglomerate shores are found at the north, along the east and at the west.

Agrihan. Location: 18°46′N, 145°40′E. Maximum altitude: 965 m. Area: 44.0 km^2. Its volcano has the highest elevation in the Mariana Islands and erupted ash in 1917. Elevated cliffs and steep slopes characterize the coastline. Pebble-sized black sand beaches are found along the southwestern shore.

Asuncion. Location: 19°40′N, 145°24′E. Maximum altitude: 891 m. Area: 7.3 km^2. An explosive eruption occurred in 1906 and minor eruptive activity occurred in 1920s. A small hot spring was found along the west coast. The shoreline is composed mainly of low to high steep cliffs and isolated truncated basaltic platform.

Maug. Location: 20°01′N, 145°13′E. Maximum altitude: North Island 277 m, East Island 215 m, West Island 178 m. Area: 2.1 km^2 (three islets total). Maug is comprised of three islets; North Island, East Island, and West Island, surrounding a central lagoon. On the ocean side of each islet, most of the shore is either consolidated headline or composed of small eroded materials, and at the water level, coast line is

either vertical or undercut. On the lagoon side, the islets are almost vertical in slope. The entire lagoon has been swept to a depth of 150 m.

Uracas. Location: 20°32′N, 144°54′E. Maximum altitude: 334 m. Area: 2.0 km^2. The island is round and covered with recent lava except for two promontories along the southern shore. The first recorded minor eruption was in the mid-1860s. Steaming and minor eruption have been noted almost continuously since the 1900s.

Significance of the Study on Natural History of the Northern Mariana Islands

We consider this expedition important and significant for the following reasons:

(1) *A close relationship of fauna and flora must exist between Japan and the northern Marianas*: Although the northern Marianas are located in tropical waters, some species common in temperate or subtropical Japanese waters and those evolutionary originated in Japanese waters are recorded there. For example, several species of marine molluscs (ex. *Cellana toreuma*), common in temperate Japanese waters, have been recorded from some islands of the northern Marianas (Vermeij *et al.*, 1983), as well as several other molluscs (ex. *Nipponacmea boninensis*), which were previously believed to be endemic to the Ogasawara Islands (Asakura and Kurozumi, 1991). A littorinid, *Nodilittorina* cf. *quadricintca feejeensis*, highly abundant in the Ogasawaras (Asakura *et al.*, 1990, 1991, 1993), is also recorded from the northern Marianas (Vermeij *et al.*, 1983; Asakura and Kurozumi, 1991).

(2) *Numerous taxa and fields have not been studied in the northern Marianas*: Although research on the northern Marianas was conducted by Japanese scientists before World War II, and thereafter by American scientists from Hawaii, Guam, Saipan and other areas (see Eldredge, 1983a, b for bibliography), there remain numerous unstudied taxa, such as soil animals and other invertebrates, bryophytes, and lichens. Studies on flora of higher plants, insects, and land snails are also incomplete (Fosberg *et al.*, 1975; Kondo, 1970).

(3) *The shores of the northern Marianas are mostly volcanic and are expected to yield species different from those of raised limestone and reef flats*: Most tropical islands consist of raised limestone and coral reefs, but the islands of the Izu, Bonin, Volcano, and northern Marianas are made up of volcanic substrata. Comparison of organisms between the northern and southern Marianas has shown that many species occur only in the northern Marianas, as reported by the staff of University of Guam. These include fish, marine molluscs, corals, and algae (Eldredge *et al.*, 1977; Tsuda and Tobias, 1977a, b; Vermeij *et al.*, 1983), difference being probably due to the difference in the substrata.

(4) *Some of the islands of the northern Marianas are good models for studies of the environmental destruction*: Feral goats, pigs and cows inhabit several of the northern Mariana islands and have markedly damaged the ecosystems of these small islands (Stinson *et al.*, 1991; Reichel *et al.*, 1992). The study provides the basic data on the interaction between native species and introduced species and on the environmental destruction.

(5) *The project should contribute to the understanding of the origin and evolution of the organisms of the Pacific Islands*: The highest biological diversity in marine environment is discovered in the area around the Indo–Malayan archipelago. It is considered as a source area for the fauna of the Pacific islands (Ekman, 1953; Kay, 1984). The Marianas is located at an eastern edge of the area. In addition, the project should also contribute to test the recently-proposed biogeographical hypothesis on the relationships between the island fauna and geological plates. The northern Marianas lie on the eastern edge of the Philippine Plate, separated by the deep trench from the Pacific Plate on which most of the islands of the Pacific lie. It may be one of the most suitable sites to test the hypothesis of plate endemism and others concerning the plate (Springer, 1982; Kay, 1980, 1984; Vermeij *et al.*, 1983).

Personnel

Project Officers

Makoto Numata. Director, Natural History Museum and Institute, Chiba

Nicolas M. Leon Guerrero. Director, Depart-

ment of Natural Resources, Commonwealth of the Northern Mariana Islands

The staff of the expedition party

The Museum

Tatsuyuki Ohba, Leader of the party, Vice Director (higher plants and plant sociology)

Tatsuwo Furuki (bryophytes)

Hiroshi Harada (lichens)

Shinya Miyano (insects)

Taiji Kurozumi (molluscs)

Akira Asakura, Project coordinator (crustaceans)

The Department of the Natural Resources (CNMI)

Clifford G. Rice (mammals, birds)

Derek Stinson (birds, mammals)

Ben Camacho (assist.)

Frank D. Cruz (assist.)

John Gourley (assist.)

University of Guam Marine Laboratory

Terry J. Donaldson (fish, corals)

Peter Schupp (fish)

Todd Pitlick (corals)

Log of Operation Before the Expedition

April 1989. A five-year project on the natural history of the Izu–Mariana Arc was started.

October 1989. [Guam] Asakura visited the University of Guam and met Prof. D. B. Smith (Botany Department), R. Rose-Crossly (Dean, Faculty of Science & Technology), R. T. Tsuda (Marine Laboratory), R. H. Richmond (ML), R. H. Randall (ML), S. G. Nelson (ML), R. K. Sakamoto (ML), D. H. Rubinstein (Micronesia Area Research Center), E. P. Conception (Pacific Collection, MARC), and Staff of the R. F. K. Memorial Library. Asakura obtained useful information and a large amount of literature on the natural history of the Mariana Islands from these persons. Prof. Smith and Tsuda kindly guided Asakura around the University of Guam and Guam Islands and helped him to search for a suitable vessel for the expedition to the northern Marianas.

June 1990. [Guam] Miyata, M. (Department of Plant Sciences, the Museum), Y. Kondo (Department of Earth Sciences, the Museum) and Asakura visited University of Guam Marine Laboratory and Micronesia Area Research Center, met R. T. Tsuda (ML), R. H. Richmond (ML), R. H. Randall (ML), R. K. Sakamoto (ML), and D. H. Rubinstein (Micronesia Area Research Center) and obtained information on the northern Marianas. Miyata, Kondo and Asakura examined deposited specimens at the Marine Laboratory, which had previously been collected from the northern Marianas by scientists of the University of Guam and University of Hawaii, and copied literature about the nature of the Mariana Islands in the MARC.

1991 May. [Guam] Numata (Directer, the Museum), Asakura, Kurozumi (Departmant of Zoology, the Museum), and Harada (Department of Botany, the Museum) visited the University of Guam Marine Laboratory and explained about the northern Mariana Islands expedition to Drs. R. H. Richmond, R. T. Tsuda, C. Birkeland, B. D. Smith, J. Lackson, and R. H. Randall. The 4 museum members also visited the Micronesia Area Research Center, met D. H. Rubinstein to explain about the project and copied numerous papers on the nature of the Mariana Islands. Numata and Harada visited the Herbarium of the University of Guam and examined deposited specimens of the Mariana Islands. Asakura and Kurozumi examined specimens deposited at the Marina Laboratory.

[Saipan] Numata, Asakura, Kurozumi and Harada visited the Department of the Natural Resources (Commonwealth of the Northern Mariana Islands), met Director Nicholas M. Leon Guerrero, and explained about the expedition. He kindly arranged the schedule of the Museum staff to meet leading individuals of the government of CNMI. Asakura, Kurozumi and Harada met Mr. J. F. Cool, Office of the Attorney General, and Mr. A. Ruben, Mayor of the Northern Mariana Islands, with N. M. L. Guerrero and explained about the expedition. Kurozumi and Harada visited the Saipan Central Hospital and obtained information in case of accident. Asakura, Kurozumi and Harada visited the Division of Fish and wildlife and met Arnold Palacious (Chief), Drs. T. J. Donaldson, C. G. Rice and D. W. Stinson (Researchers), explained about the expedition and after that, visited Office of the Governor, and met L. J. D. L. Guerrero (Governor) and J. Bruce (Special Counsel to the Governor) and the ex-

plained about the project. The Division proposed a Memorandum of Agreement for the expedition to the northern Mariana Islands, with which this expedition should comply.

June 1991. [Hawaii] Asakura attended the Pacific Science Congress, met Drs. L. G. Eldredge and Allison A. Kay and obtained information and literature on the northern Mariana Islands at Honolulu, Hawaii.

August 1992. [Kyoto] Asakura and Miyano negotiated with Donaldson about the contents of the Memorandum of Agreement for the expedition, proposed by the Division, and made a revised version of it.

March 1992. The Memorandum of Agreement for the expedition to the northern Mariana Islands was signed by L. J. D. L Guerrero (Governor of CNMI), Attorney General of CNMI, and M. Numata (Director of the Museum).

April 1992. Schupp and Donaldson decided to participate in the expedition as representatives of the University of Guam Marine Laboratory.

6 May 1992. [Saipan] Numata, Ohba, Asakura, Miyano, Kurozumi, Furuki, and Harada arrived at Saipan.

7 May 1992. [Saipan] Final meeting for the expedition took place at the Division of Fish and Wildlife. Attending members were N. M. L. Guerrero, Palacious, Rice, Stinson, Cruz, Camacho, Numata, Ohba, Asakura, Miyano, Kurozumi, Furuki, and Harada.

Itinerary and Daily Activity during the Expedition

The expedition was divided into two cruises. In the first cruise, we visited Anatahan, Sarigan, Guguan, and Alamagan during the period from 10 May to 19 May 1992, and the participants were Ohba, Furuki, Harada, Miyano, Kurozumi, Asakura, Stinson, Camacho, Cruz, Donaldson, and Schupp. In the second cruise, we visited Pagan, Agrihan, Asuncion, Maug, and Uracas and revisited Asuncion and Alamagan during the period from 24 May to 9 June 1992. The participants were Ohba, Furuki, Harada, Miyano, Kurozumi, Asakura, Rice, Gourley, Schupp, and Pitlick. The following is a record of daily activities of the members of the Natural History Museum and Institute, Chiba. The members of the University of Guam dived into the sea around each island 1–6 times a day and collected specimens of coral and fish. They used a motor boat stowed on the "*Stella I*", which was the expedition ship; gross tonnage: 250 t, length: 36.0 m, breadth: 7.3 m, depth: 3.4 m. The members from the Division surveyed mainly nesting sites of birds and fruit bats and damage by feral animals on vegetation on each island. Sampling sites and routes are indicated in Fig. 4.

First cruise

May 10 Sunday. [Saipan to Anatahan] The party on the ship *Stella I* left Saipan in the morning and arrived at the first investigated island, Anatahan, in the afternoon. Ohba, Furuki, Harada, Miyano, Kurozumi, and Asakura landed on the northwest shore (St. A, Fig. 4) using a rubber boat stowed on *Stella I*, made a camp near the landing place, and collected specimens around the site.

May 11 Monday. [Anatahan] Ohba, Furuki, Harada, and Kurozumi tried to climb to the top of a mountain in the north of Anatahan, but gave up because of much dense *Miscanthus* grassland. They took another route down to an abandoned village and then came back to the camp site (Route I, counterclockwise). Miyano collected insects around the camp site and at the abandoned village near the shore. Asakura investigated marine invertebrates on the shore at St. A. All members returned to *Stella I* in the evening.

May 12 Tuesday. [Anatahan] In the morning, all 6 persons landed on the southwest coast, St. B, using the rubber boat. Asakura investigated marine invertebrates on the shore around the landing point. Ohba, Furuki, Harada, Miyano, and Kurozumi went through a narrow valley in a forest (Route II). All members returned to *Stella I* in the evening.

May 13 Wednesday. [Anatahan] In the morning, all 6 persons landed on the southern coast, St. C, using the rubber boat. Asakura investigated marine invertebrates on the shore around St. C. Ohba, Furuki, Harada, Miyano, and Kurozumi went along a narrow valley, then climbed up some ridges, and reached on

altitude of about 400 m. (Route III). Miyano took the same route to the half-way point and stayed in the lowland area. All members returned to *Stella I* in the evening.

May 14 Thursday. [Anatahan in the morning, Sarigan in the afternoon] In the early morning, Ohba, Furuki, Harada, Miyano, and Kurozumi landed at St. B using the rubber boat, and Asakura landed at St. D. They collected specimens around the landing places as well as the place along the route IV and returned to *Stella I* at noon.

Stella I moved to Sarigan in the afternoon. Ohba, Furuki, Harada, Miyano, Kurozumi, and Asakura landed on the northern shore at St. A of Sarigan and made a camp in the coconut forest near the landing place. They collected specimens around there for a while.

May 15 Friday. [Sarigan] Ohba, Furuki, Harada, and Kurozumi climbed through a rocky ridge to a grassland area (Route I) and reached the north of the highest peak of Sarigan. Miyano went half way along the same route. Asakura investigated marine invertebrates on the shore at the St. A. Miyano and Furuki camped near the landing place. The others returned to *Stella I* in the evening.

May 16 Saturday. [Sarigan to Guguan] Early in the morning only Kurozumi landed at St. A, and joined Miyano and Furuki. They made the last field survey, and soon returned to *Stella I. Stella I* left Sarigan in the morning and arrived at Guguan in the afternoon. Ohba, Harada, Miyano, Kurozumi, and Asakura landed on the western shore of Guguan (St. A) using the rubber boat. They investigated the flora and fauna along Route A on the bare sandy slope of the volcano, where nesting sites of seabirds were found on the ground. All members returned to *Stella I* in the evening.

May 17 Sunday. [Guguan] In the morning, all 6 menbers landed on the southwestern shore (St. B) using the rubber boat. Miyano stayed near the shore area. Asakura investigated marine invertebrates on the shore around St. B. Others climbed up the mountain to a ridge near the peak through a forest, where there were numerous nests of birds on trees (Route II). All members returned to *Stella I* in the evening.

May 18 Monday. [Guguan in the morning, Alamagan in the afternoon] In the morning, only Miyano and Kurozumi made the last survey on Guguan (Route III).

In the afternoon, *Stella I* moved to Alamagan. All 6 members landed on the southwestern shore (St. A of Alamagan) and made a camp on the sandy beach.

May 19 Tuesday. [Alamagan] Ohba, Furuki, Harada, and Kurozumi conducted field surveys on the way along a ravine to a ridge at about 500 m alt. (Route I). Miyano stayed near the shore (St. A). Asakura investigated marine invertebrates around St. A. In the evening, all of the members returned to *Stella I* and left Alamagan for Saipan at night.

May 20 Wednesday. Stella I arrived at Saipan in the afternoon.

Second cruise

May 23 Saturday. Stella I left Saipan for Pagan.

May 24 Sunday. [Pagan] *Stella I* arrived at Pagan very early in the morning. The all 6 persons landed on northwest coast at St. A. Asakura investigated marine invertebrates at the St. A and collected shells thrown up on the shore at Sts. E and F. The others went through abandoned plantations of fruit trees between a cliff called Gake-yama and a lava flow from Mt. Pagan in 1981 (Route I). Furuki and Miyano camped near the landing site, and collected insects by using light traps in the night. The others returned to *Stella I* in the evening.

May 25 Monday. [Pagan] In the morning, Ohba, Harada, Furuki and Kurozumi landed on the southern west coast at St.B and climbed up a steep slope in forest to a ridge with *Miscanthus* grassland and were attacked by wasps (Route III). Miyano went to the Inner Lake on the northwestern midslope of Mt. Pagan (Route II). All members returned to *Stella I* in the evening.

May 26 Tuesday. [Pagan] In the morning, all 6 members landed at northern west coast at St. C and visited the coastal lake (the Outer Lake) on the west side of Mt. Pagan. Asakura and Kurozumi investigated marine invertebrates and collected shells thrown up on the shore at St. C. All members returned to *Stella I* in the evening.

May 27 Wednesday. [Pagan] In the morning, Ohba, Furuki, Miyano, and Kurozumi landed at St. A and took Route I, visiting an abandoned airstrip, that had been used during World War II and a village abandoned at the time of the last eruption of Mt. Pagan in 1981. Kurozumi collected shells thrown up on the shore at Sts. E and F. All members returned to *Stella I* in the evening, and left Pagan for Agrihan at night.

May 28 Thursday. [Agrihan] *Stella I* arrived at Agrihan very early in the morning. All 6 persons landed at St. A. Asakura investigated marine invertebrates at St. A, and the others walked through a narrow valley in the forest (Route I). All members returned to *Stella I* in the evening.

May 29 Friday. [Agrihan] All 6 persons landed at northern coast, St. B. Asakura investigated marine invertebrates around there. Miyano stayed near the landing site. Ohba, Furuki, Harada, and Kurozumi tried to climb to the top through the forest, but gave up because of much dense bush at about 300 m alt. (Route II). All members returned to *Stella I* in the evening.

May 30 Saturday. [Agrihan] In the morning, Ohba and Harada landed on the northeast coast (St. E) and climbed the eastern side of Agrihan (Route III). Furuki, Miyano, and Kurozumi landed at the southernmost coast, St. C, and visited a village inhabited by 10 Chomorro persons. All of the Museum members returned to *Stella I* in the evening.

May 31 Sunday. [Agrihan] In the morning, Ohba and Furuki landed at St. B, climbed up nearly to the edge of the crater, going along Route II, and reached 550 m alt. (Route II). Harada, Miyano, and Kurozumi stayed in a coastal forest and an adjacent grassland near St. B and Route IV. Asakura investigated shore marine invertebrates at St. D. All members returned to *Stella I* in the evening and left Agrihan for Asuncion at night.

June 1 Monday. [Asuncion] In the morning, *Stella I* arrived at Asuncion. All 6 persons landed at southwest coast, St. A. Ohba, Furuki, and Harada made field surveys on the way up to the top of Asuncion through coastal forests, *Pandanus* thickets, fern grassland and bare ground (Route I). Miyano and Kurozumi took the same route up to just beyond the upper limit of forest at about 200 m alt. In the afternoon, just after all members returned to *Stella I*, the ship left Asuncion for Maug to avoid rough weather condition due to the approach of a cold front from the west.

June 2 Tuesday. [Maug] In the morning, all 6 persons landed on the north of the East Island (E) at St. A. Asakura investigated marine invertebrates around the landing place, and other persons climbed up through Route I and made field survey. All members returned to *Stella I* in the evening.

June 3 Wednesday. [Maug] Miyano landed at St. F on the north of the North Island (N), climbed up through Route II and made a field survey. Other members rested in *Stella I* for the whole day.

June 4 Thursday. [Maug] In the morning, Ohba, Furuki, Harada, Miyano, and Kurozumi landed at St. C on the lagoon side of the East Island and tried to climb a steep slope (Route III). In the afternoon, Kurozumi dived into the subtidal zone of St. C. Asakura landed at St. F of the North Island. All members returned to *Stella I* in the evening.

June 5 Friday. [Maug] In the morning, Ohba, Furuki, Miyano, Kurozumi, and Asakura landed at St. E of the West Island (W) and Ohba, Furuki, Miyano, and Kurozumi climbed up through Route IV. Harada conducted field surveys on a slope on the lagoon side and on the ridge of the East Island (Route I). Furuki, Miyano, and Kurozumi joined Harada in the afternoon. Ohba landed on the North Island (N) in the afternoon. All members returned to *Stella I* in the evening, and left Maug for Uracas at night.

June 6 Saturday. [Uracas] *Stella I* arrived at Uracas in the morning. All 6 persons landed at St. A. Ohba, Furuki, Harada, Miyano, and Kurozumi went through a large nesting area of seabirds at the foot of a volcano to an outcrop near the beach in the south of the island. Asakura investigated marine invertebrates at St. A. Ohba and Furuki climbed to the top of an active volcano on the way back to the landing point (Route I). In the evening, all members returned to *Stella I* and left Uracas for Asuncion at night.

June 7 Sunday. [Asuncion] Ohba, Miyano, Kurozumi and Asakura landed at St. B, and visited the southern part of Asuncion (Route II). Furuki and Harada made field surveys in a lowland forest (Route I). In the evening, all members retuned to *Stella I.*

June 8 Monday. Stella I left Asuncion for Alamagan.

June 9 Tuesday. [Alamagan] Ohba and Furuki landed at St. B and climbed up to the edge of the crater (Route I). Miyano, Kurozumi, and Harada landed at St. A, and Kurozumi and Harada made field surveys through a ravine to about 200 m alt. (Route II). Miyano stayed in the lowland area. In the evening, all of the members returned to *Stella I*, and left Alamagan for Saipan.

June 10 Wednesday. Stella I arrived at Saipan in the morning.

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References

Asakura, A., Y. Kondo, W. Sato-Okoshi and M. Miyata. 1990. Distribution patterns of animals and plants on the rocky shores of Hahajima in the Ogasawara Islands. Nat. Hist. Res. 1(1): 65–79.

Asakura, A., Y. Kondo and S. Nishihama. 1991. Distribution patterns of animals on the rocky shores of Chichijima in the Ogasawara Islands. Nat. Hist. Res. 1(2): 23–40.

Asakura, A. and T. Kurozumi. 1991. Notes on three marine molluscs from the northern Mariana Islands, Micronesia. J. Nat. Hist. Mus. Inst., Chiba 1 (2): 15–20.

Asakura, A. and S. Nishihama. 1987. Studies on the biology and ecology of intertidal animals of Chichijima Island in the Ogasawara (Bonin) Islands. II. Description, habitat, size structure in the population and allometric growth of the limpet, *Notoacmea schrenckii boninensis* n. subsp. Venus, Jap. Jour. Malac. 46: 194–201.

Asakura, A., S. Nishihama and Y. Kondo. 1993. Studies on the biology and ecology of intertidal animals of Chichijima Island in the Ogasawara (Bonin) Islands. I. List of collected species with comments on some species. Atoll Res. Bull. 383: 1–17.

Eldredge, L. G. 1983a. Summary of environmental and fishing information on Guam and the Commonwealth of the Northern Mariana Islands: Historical background, description of the islands, and review of the climate, oceanography and submarine topography. NOAA Tec. Mem. NMFS. 181 pp.

Eldredge, L. G. 1983b. Mariana's Active Arc: A bibli-

ography. Univ. Guam Tech. Rep. 82: 1–19.

Eldredge, L. G., R. T. Tsuda, P. Moore, M. Chernin and S. Neudecker. 1977. A natural history of Maug, northern Mariana Islands. Univ. Guam Mar. Lab. Tech. Rept. 43: 1–86.

Evans, W. C., T. S. Presser, L. D. White and I. Barnes. 1987. The volatiles of Mt. Pagan, northern Mariana Islands. Pac. Sci. 41: 90–103.

Fosberg, F. R., M. C. V. Falanru and M. H. Sachet. 1975. Vascular flora of the northern Mariana Islands. Smith. Contr. Bot. 22, 44 pp.

Kondo, Y. 1970. Some aspects of Mariana Island Partulidae (Mollusca, Pulmonata). Occas. Pap. B. P. Bishop Mus. 24: 73–90.

Nicholson, E. M. 1969. Draft check list of Pacific oceanic Islands. Micronesica 5: 327–463.

Reichel, J. D., G. J. Wiles and P. O. Glass. 1992. Island extinctions: the case of the endangered nightingale reed warbler. Wilson Bull. 104: 44–54.

Stinson, D. W., M. W. Ritter and J. D. Reichel. 1991. The Mariana common moorhen: decline of an island endemic. The Condor 93: 38–43.

Tsuda, R. T. and W. J. Tobias. 1977a. The marine benthic algae from the northern Mariana Islands. Chlorophyta and Phaenophyta. Bull. Japan. Soc. Phycol. 25: 19–24.

Tsuda, R. T. and W. J. Tobias. 1977b. The marine benthic algae from the northern Mariana Islands. Cyanophyta and Rhodophyta. Bull. Japan. Soc. Phycol. 25: 155–158.

Vermeij, G. J., E. A. Kay and L. G. Eldredge. 1983. Molluscs of the northern Mariana Islands, with special reference to selectivity of oceanic dispersal barriers. Micronesica 19: 27–55.