Cognitive Challenges on Nature among Ancient Seafaring Pioneers of Polynesia

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1. To the Vast Expansion of the Pacific

Homo sapiens originated in Africa moved from Sunda Land to Sahul (the landmass that consists of New Guinea and Australia) between 40,000 and 60,000 B.P., but they did not go outside Near Oceania (New Guinea, Bismarck and Solomons, except for Reef and Santa Cruz Islands). Around 5,000 and 6,000 B.P., new wave of Austonesian groups, probably originated in Taiwan and neighbor regions, started moving southward. They moved through the Philippines and Indonesian islands to Near Oceania. The first manifestation of this movement in Oceania is known as Lapita Cultural Complex that originated in Bismarck Archipelago. The Lapita groups moved eastward around 3,300 and 3,000 B.P. and reached Fiji, Tonga and Samoa.

After a hiatus, they started moving eastward again and reached Nuclear Polynesia around the 3rd and the 4th centuries. Between the 5th and the 10th centuries, their descendants expanded to the marginal zones of Polynesian Triangle, such as, Hawai'i, Rapanui (Easter Island), and Aotearoa (New Zealand) (Figure 1).

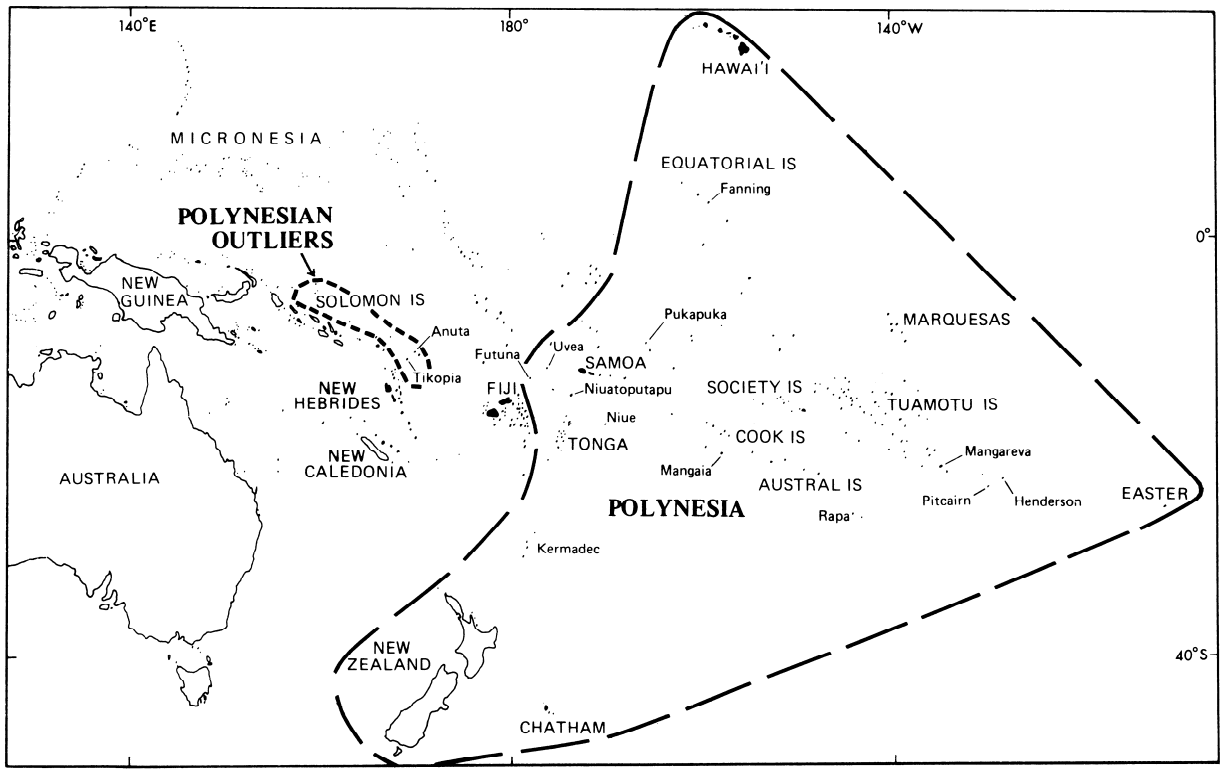

Figure 1 Map of the Pacific Islands. (Kirch 1985: Figure 13.)

There is a long argument on whether Polynesian expansion is accidental or intentional and planed. Contrary to the theory that considers Polynesian myths of ancient voyage from "*Hawaiki*" was true (e.g. Smith 1921)[i], Andrew Sharp argued that Polynesians did not know the method to

[i] *Hawaiki* is an ancestral homeland in Polynesian mythology. The name of the islands, Hawai'i and

know their position on the sea (1957). In particular, Sharp considered that the Polynesians could not estimate the position in relation to longitude, so the Polynesian migration was largely accidental[ii].

Several challenges have been made against Sharp's argument that underestimated the Polynesian navigational techniques (Golson 1962; Finney 1976). A pioneer study of computer simulation, however, clearly shows that if Polynesians' voyage was accidental, controlled by currents and winds, it is more probable that they moved from the east to the west (Levison, Ward and Webb 1973). This implies that the Polynesian voyage was largely against currents and winds, and that Polynesians had techniques to cope with winds, and their voyage was probably intentional.

Successive scientific excavation and artifact analyses started during 1960s', reinforced by historical linguistics, have led most researchers to the conclusion that the immediate origin of the Polynesians was in Eastern Melanesia (e.g. Green 1967).

In the meantime, David Lewis has extensively collected data to prove the ability of indigenous navigation techniques (1994), and Åkerblom has also disclosed the indigenous astronomical knowledge for navigation (1968). An anthropologist Ben Finney, collaborated with Herbert Kane, challenged Sharp's theory by the method of "experimental archaeology", that is, the reconstruction of Polynesian double canoe *Hokule'a*. In 1976, they succeeded a voyage of 4,000 km from Hawai'i and Tahiti (Finney 1979). It is well known that the navigator who led *Hokule'a* to Tahiti was a Carolinian (Micronesia), Mau Piailuk, since Finney could not find an appropriate navigator in any part of Polynesia.

2. Characteristics of the Pacific Environment and Bio-diversity

A. To the Diverse Environment

There are diverse forms of islands in the Pacific. They were made by a variety of geophysical processes: teconic activities, volcanic activities, coral formation, uplift/down of the land, etc. As a result, there are basically four types of the islands: (1). island--arc islands or continental islands, (2). high islands of midplate hot spot origin, (3). coral atolls on volcanic masses that have subsided beneath the ocean's surface, and (4). *makatea* islands in which coral atoll or reef formations have been uplifted or have emerged through tectonic activity (Thomas 1963). As a result, the differences of geographical and climatic factors are significantly great among Polynesian islands.

On continental and high islands (e.g. Hawaiian Islands, Mangaia in Cooks, New Zealand, etc.), one significant geographical factor to shape the subsistence is the contrast between windward and leeward of the island, known as *tonga/tokerau* contrast. The prevailing winds and currents are from the east throughout the main zone of tropical islands, and thus Pacific navigators had to develop strategies for sailing from west to east. Regular trade winds have a major environmental effect on high islands in their path. A moisture-laden winds flow from the windward side of a high island, resulting in heavy rainfall. In contrast, the leeward side remains in a rain shadow, with significantly reduced rainfall. As a result, windward rainfall causes stream erosion and the formation of board valley surrounded by steep cliffs, while leeward landforms remain relatively dry and undissected. Vegetation is also affected, with deep rainforests on windward side and dryland shrub on leeward side. These windward-leeward contrasts (e.g. wet vs. dry) were an important factor to Oceanic peoples for establishing their settlements and gardens (Kirch 2000: 52). This contrast of wet/dry is substantial not only for explaining subsistence form between windward and leeward, but also for the organization of labor, ideology and the process of social stratification (e.g. Kirch 1994; Schilt 1984).

Pacific island climates comprise the humid tropics to the temperate zones (in New Zealand),

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Savai (an island of Samoa) originated in *Hawaiki*.

[ii] Thor Heyerdahl, famous for his experimental voyage by *Kontiki* from South America to Polynesia, had a similar way of thinking, that is, underestimate of Polynesian seafaring ability, since he insisted that Polynesians migrated from the east to the west, by taking advantage of winds and currents.

but most of the islands lie within the tropical to subtropical range. On some high islands, high mountains create microclimates, as on Hawai'i and Maui Islands of Hawaiian Archipelago, where the higher elevations extends from humid temperate to alpine and tundra environments. The summits of these islands receive regular snowfalls during the winter months, and *Mauna Kea* on Hawai'i was capped by a small glacier during the late Pleistocene (Ziegler 2002: 95).

B. Decline of Bio-Diversity

In his classical paper, a biologist, F.R. Fosberg has identified several characteristic of bio-geography in the Pacific islands: (1) limitation in size (space resource), (2) limitation in, or even absence of certain other resources, (3) limitation in organic diversity, (4) reduced inter-species competition, (5) protection from outside competition and consequent preservation of archaic, bizarre, or possibly ill-adapted forms, (6) tendency toward climatic equability, (7) extreme vulnerability, or tendency toward great instability when isolation is broken down, (8) tendency toward rapid increase in entropy when change has set in (Fosberg 1965: 5).

The large archipelagoes closest to Asia and New Guinea, such as, the Solomons and Vanuatu, have much more diverse biotas in terms of the numbers of higher-order taxa represented (genera and families) than those in the central and eastern parts of the Pacific. This feature coexists with another key aspect of island biogeography, that is, a tendency for new species to evolve, especially through the process known as adaptive radiation (Fosberg 1991; Hotta 1999).

There is a clear decline of fauna and flora from the west to the east, from Asian Continent to Pacific islands. For example, more than 1,000 floral genera exist west of New Guinea, but they decrease remarkably east of the Solomons. In Fiji, Samoa and Western Carolines, more than 300 genera have reported, but only 100 to 200 genera are found east of those areas. Hawaiian Islands occupy the area five times larger than Samoa see only 230 genera. This number of genera is only half of the Fiji Islands that have almost same area with Hawai'i. The floral genera decrease into 100 to 50 taxa on most of the low islands and atolls (e.g. Merrill 1981).

A same tendency is observed on marine fauna (Figure 2). There found marked attenuation of coral fish species from the west to the east (Akimichi 2000). For instance, major families of coral water, snappers (Lutjanidae) and groupers (Serranidae) did not reach the Hawaiian Islands (Gosline and Brock 1960; Tinker 1978) [iii].

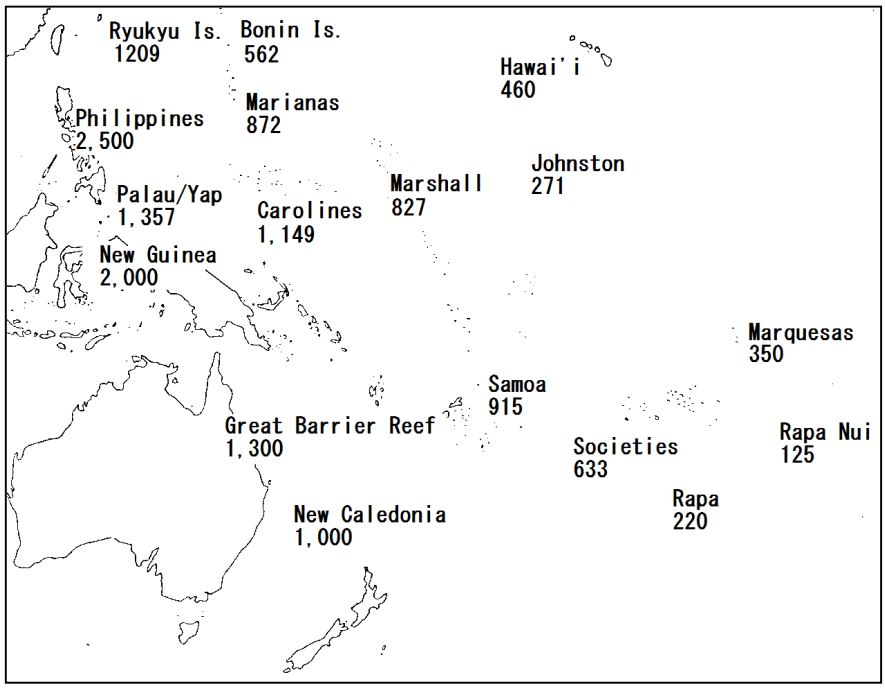

Figure 2 Number of Coral Fish Species in the Pacific. (modified from Akimichi 2000: Figure 1)

[iii] In Hawaiian water, only a few endemic species of grouper, such as, *Pikea auron* (*'u'u*) are known (Tinker 1978), but they inhabit the deep water and not seen frequently. Now in Hawaiian water, several species of grouper have been introduced from the Society Isalnds (Gosline and Brock 1960: 155-158; Tinker 1978: 191-203). Indigenous snappers that live in Hawaiian water is limited to the deep-water species, and several species of snappers (e.g. *Lutjanus kasmira*) have been introduced from the Societies,

Since groupers and snappers are major carnivores in the coral waters, the absence of these families have led to the re-formation of the fauna: in Hawaiian water other competitors, such as, wrasse (Labridae) and surgeonfish (Acanthuridae) populations have well developed (Gosline 1965; Gosline and Brock 1960).

At the level of other vertebrates, disharmony is especially apparent in the absence of native amphibians, and at the ordinal level, in lack of non-marine reptiles and land mammals except for two bat species (Zeagler 2002). Within the Pacific, mammals are limited to a few marsupials (e.g. wallabies, wombats, cuscus) and to several genera of rats (e.g. *Rattus*, *Melomys*), along with fruit bats (Pteropodidae). Of these, only fruit bats dispersed into Remote Oceania, the marsupials and rats being restricted to the Bismarck Archipelago and Solomon Islands. The large, strong-flying and blossom-eating bats that successfully expanded the range from tropical Southeast Asia to as far east as the Mariana Islands and Samoa never reached Hawai'i. The only bat species now extant in the archipelago is the smaller, insectivorous Hoary Bat, *Lasiurus cinereus* (*'ōpe'ape'a*)[iv]. Reptiles too are of fairly limited distribution, with the majority of species of snakes, frogs, diurnal lizards, and geckos being found in Near Oceania or in the larger islands.

Because of their excellent dispersal abilities, many kinds of birds succeeded in colonizing Pacific islands, where they account for the greatest diversity of vertebrates. Sea birds, such as, frigates, shearwaters, petrels, noddies, and boobies, and various kinds of land birds (e.g. megapods, pigeons, fruit dovers, rails, and parrots) were especially abundant already at the time of human arrival.

C. Transported Landscape

Current landscape of Polynesia is not same of the one that Polynesians encountered at the first colonization. One reason is that the Polynesians transformed the forest mainly for agriculture, and the secondary forest thus formed occupies a significant area of each island group. Second reason is that the most of the main crops for the Polynesians were transported from Asian continent to the Pacific: taro, yam, banana, breadfruit, and so on (Cox and Banack 1991). In addition, Polynesian brought with them domesticated animals that also originated in Asian continent: pig, dog and chicken. Polynesian rats seem to have come also with Polynesians, but their migration was not probably intentional. Thus Polynesians did not simply adapted to the untouched environment, but they did transform it by introducing crops and domesticated animals.

In the past 20 years, archaeologists have uncovered evidence of human-induced environmental change throughout Polynesia (e.g. Kirch and Ellison 1994; Kirch and Hunt 1997; Fleney 2010). Several faunal species have become extinct by direct or indirect influence of human activities, such as, forest clearance or feeding (e.g. Kirch and Hunt 2007). Famous examples are the extinct of giant bird *moa* in New Zealand (e.g. Anderson 1997) and the deforestation of the Rapanui, although there is an opinion doubting the deforestation in Rapanui (Mulrooney et al. 2010).

Thus although the interpretation of the evidence has not been settled, it is certain that Polynesian landscape was the result of long-term interaction between natural environment and human practices (Kirch and Hunt 2007).

3. Structural Transformation of Cognitive System 1: Snake and Crocodile

A. Fate of Snake

As discussed above, the Polynesian environment is characterized by the decrease of

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Marquesas and New World to the inshore sea (Tinker 1978: 217-226).

[iv] Pigs and dogs were both introduced by Polynesians. It is not a joke that the humans are the most "useful" mammals in the Polynesian islands. In Hawai'i, where the shell used for making fishhooks (e.g. pearl of mother shell) are not enough, fishhook of bone, especially human bone have developed (Emory, Bonk and Sinoto 1959).

bio-diversity in terms of genera/family. Does this phenomenon have relevance to the characteristics of Polynesian recognition of nature?

Brown has extensively argued the development of zoological and botanical life forms in Polynesia and other language groups, such as, Maya (1981, 1982, 1984): life form is a universal unit to categorize animals and plants, such as, fish, bird, snake, tree, grass and so on.

According to Brown, zoological life forms tend to develop as:

[no life form] —> [bird/fish/snake] —> [wug/mammal]

Historical linguistics of Polynesian languages indicates that life forms of fish, bird and snake are traced into the Proto-Polynesian stages[v]: * *ika*, **manu*, and **ŋata* respectively. But the life forms for neither wug or mammal has been reconstructed in Proto-Polynesian (Brown 1981). This is because there is an only limited variation of insects in Polynesian fauna and there is almost no indigenous mammal in the islands. Since the Lapita groups who were the ancestors of Polynesians have migrated through Melanesia where snakes live, it is not surprising that **ŋata* is reconstructed in Proto-Oceanic and Proto-Polynesian. But except for Samoa, snakes did not reach Polynesian islands. Thus the ancestral Polynesians who had a concept of snake must have encountered a challenge in cognitive level. What was the fate of "snake"?

Nine of the 24 Polynesian languages examined by Brown retain reflexes of the Proto-Polynesian stem that designate "snake": they are mostly in Western Polynesia including Outliers (e.g. Samoa, Tonga, Niue, Futuna, Rennel, etc.). The languages of Outlier Polynesia have been largely derived from Samoan, and the retention of “snake” in those languages is explained by the remnant of the concept. Another possibility is that there was a contact with Melanesian islands where snakes live[vi].

In Eastern Polynesia that is outside of the distribution of snake, two phenomena are found: (1) **ŋata* came to be applied to other animal, and (2) **ŋata* disappeared completely. Several languages shifted **ŋata* reflexes to other elongated creatures which are not snakes: Hawaiian *naka* "a land shall or a sea shell", Mangaian *ŋata* "sea slug", Rarotongan *ŋata* "a species of shellfish", Maori *ŋata* "slug, snail". In Tuamotuan languages, the reflex shifted to non-zoological living objects characterized by elongation, "a stem, stalk, and vine". In two languages reflexes totally lost a substantive application. In Tahitian *ʔataʔata* (reduplication) means "shocking, disgusting", and in Mangarevan *ŋatata* (partial reduplication) "to crawl". Today, some Polynesian languages have re-acquired "snake" terms, due to contact with Europeans.

B. Eel, Crocodile and Lizard.

The disappearance of the concept of snake should not be understood merely as a subtraction of one category. Animals as symbols form a complex system of opposition in mythological thought and semantic field: they do not exit independently, but they are situated each other with semantic opposition. Thus both addition and subtraction of any of these semantic elements may cause changes in the whole semantic system. This is especially true of snake that is one of the most significant animals in mythological thought of Indonesia, Australia and Melanesia (e.g. Dixon 1916; Ritter 1946; Kirtley 1980)[vii].

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[v] The concept of **ika* could include not only fish but also a wide range of aquatic animals (Brown 1981: 93). For instance, Hawaiian reflex *iʻa* included fish, octopus, squids, shell, turtle, whale and so on (Titcome 1972, 1978).

[vi] For comparison, there are many folktales on monkey in the Ryukyu Islands where monkey do not live. This is probably from the continuous contact with Japanese Archipelago or China where monkey live.

[vii] Mythological importance of snake is not limited to this area, but found world-widely (e.g. Mundkur 1983).

Some aspects of mythological role of the snake have been reflected by the eel/moral eel (e.g. *puhi/pusi*, *toke*, or *tuna*). In Polynesian myths, there was a monster eel, *tuna* who got married with goddess *Hina*. Finally *tuna* was killed, and coconut originated from his head (Kirtley 1967; Roosman 1970). Original motif of this type of tale seems to have been derived from the origin of crops and/or death concerning snakes frequently found in Melenesia[viii]. This type of mythological motif is also related to the killing of human-like-sea animals (e.d. talking fish, dugong) that causes tsunami or deluge widely found in Austronesian and Austro-Asiatic world (e.g. Walk 1949; Goto 1999a). Other aspects of mythological role of snake have been reflected by lizard (*mo'o/moko*). But the reflection is only incomplete, and a structural transformation of whole mythological system must have occurred.

Crocodile offers a similar problem. Crocodiles are often used as a symbol of kingship and political power in Indonesia and some parts of Melanesia (Lommel 1939), but they also disappear in Polynesia. These roles of the crocodile have been inherited partially by sharks in Polynesia[ix]. In Hawai'i, for example, chiefs were symbolized as the shark on land:

> A shark going inland is my chief,
> A very strong shark able to devour all on land;
> A shark of very red gills is the chief,
> He has a throat to swallow the island without choking
> (Fornander 1916-20, 6: 393-394)

In material culture of New Guinea and Melanesia, the crocodile is a frequently used motif on wood carving on various items, such as, canoe bow, paddles, war clubs, dish, split drums and so on (e.g. Bühler 1961). In Fiji, Tonga, Samoa and the Marquesas Islands, war clubs were shaped in the form of crocodile (Figure 3). Even in New Zealand that was settled after the 10th century, we can find probable relics of crocodile motif on material culture, although it is not very distinguishable from the lizard. New Zealand Maori mythology seems to retain a mythological image of crocodile and snake, or even dragon. Skinner argued "the crocodile is not, and never has been, a member of the New Zealand fauna nor the fauna of the rest of Polynesia. … Maori folk-memory has preserved its characteristics in great detail and has localized it in all parts of New Zealand " (Skinner 1964: 1). He further points out that Maori had three words designating mythical crocodile, *taniwha*, *ngarara,* and *moko*. *Taniwha* is also called *moko* (=lizard), and it is also the name of a species of shark (Skinner 1964: 2)[x].

Figure 3 War club probably symbolizing crocodile, the Marquesas Islands. (Oceanic Culture Museum, Okinawa Kaiyohaku Kinen Koen, photo by the author)

As seen above, snake and crocodile raise an interesting question concerning folk-memory. The big lizard *mo'o/moko* in Hawaiian and Maori that could be a substitute of snake might have a role of crocodile also. Thus among the Polynesians who have moved to the environment

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[viii] There are a variety of myths and folktales concerning snake in Melanesia. There is a tale type: man got married with a girl who is a daughter of snake. After she begat a baby, her mother, giant snake, comes to look after her grandchild. The snake is killed and a coconut sprung from her body. It is interesting to note that this type tends to be found in matrilineal society such as Banks Islands of Vanuatu (Fox 1924: 83)

[ix] In the Solomon Islands where both crocodile and sharks live, there is a similar association of crocodiles and sharks with ancestral spirits (Cordington 1891: 180).

[x] Hawaiian cognate *mo'o* is "lizard, reptile of any kind, dragon, serpent; water spirit" (Pukui and Elbert 1957: 253).

where neither snake and crocodile live, there occurred a complex re-structuring of semantic space and mythological thought. I argue that Polynesian mythology is characterized by the incomplete reflection and semantic shift among snakes, crocodiles, sharks, eels, and lizards.

4. Structural Transformation of Cognitive System 2: Close Encounters of the Third Kind.

A. Is Cow a Big-Pig? : Encounter with Introduced Animals.

As discussed by Brown, life form of mammals has poorly developed in Polynesia, since there is a limited range of mammals on land, both indigenous and introduced by Polynesians. How did then the Polynesians respond to a variety of livestock introduced by the Europeans? Captain George Vancouver's officer, T. Manby recorded that when Kamehameha the Great saw the cow first, he called cow a "big pig" by extending already existed category of the biggest mammal, pig:

Kamehameha had seen the animals on board the ship. The Cattle greatly delighted him, though it took some time to quiet his fears, lest they should bite him, he called them large Hogs, and after much persuasion, we prevailed on him, to go close up to them, at this instant one of the poor Animals turned his head round quickly, [which] so alarmed his Majesty that he made a speedy retreat, and run over half his retinue.' When the cattle landed 'we were a good deal diverted at seeing the terror the whole Village was thrown into, by one of the Cows, galloping along the beach, and kicking up her heels, thousands run for the Sea, and plunged in -- every Cocoa-nut Tree was full in a moment, and some jumped down precipices, others Scrambled up Rocks and houses, in short not a Man would approach for half an hour' (Vancouver 1984: 812).

Kamehameha's "proposal" to call cow as big-pig had not been adopted by Hawaiians, however, and cow came to be called "*pipi/bibi*": *pipi/bibi* came from "beef" (Tomich 1986: 170). The reason why cow was called by using sound imitation of beef is that the goat, introduced before cow, came to have been mistakenly called "*kao*" (=imitation of English sound cow)[xi]. Since the category, although mistakenly, has been already adopted, Hawaiians had to call cow by using the concept most relevant to cow, that is, beef.

Among Hawaiians, sheep is called "*hipa*" that is a sound imitation of English, sheep. The origin the name of horse, *lio* is an enigma. Tomich argues that "*lio* possibly derived from *liolio* (reduplication of *lio*) which describes a frightened person. It is of interest that *lī'ō* (which has quite a different pronunciation) means to quiver, leap away, or shay, as frightened horse" (Tomich 1986: 170).

Contrastive situation is observed in Maori and Tahitian. As shown in the Table 1, Maori

	Hawai'i	Maori	Tahiti
pig	*pua'a*	*poaka*	*pua'a*
dog	*'īlio*	*kurii*	*'uri*
rat	*'iole*	*kiore*	*'iore*
chicken	*moana*	*pii*	*moa*
cow	*pipi/bipi*	*kau*	*pua'a toro*
horse	*lio*	*hooiho*	*pua'a horofenua*
goat	*kao*	*koati/nanenane*	*pua'a niho*
sheep	*hipa*	*hipi*	*mamoe*
rabitt	*lāpaki*	*raapteti*	*rapiti*

Table 1 Comparative Lexicon of Domesticated Animals. (source: Hawaiian [Pukui and Elbert 1957]; Tahitian [Andrews and Andrews 1994]; Maori [Biggs 1990])

[xi] Captain Cook has already left goats at his first visit to Hawai'i in 1778. Cow was introduced first when G. Vancouver came in 1793. Vancouver wrote "To Kahowmoto, who had taken the greatest care of the goats I had presented him with on a former occasion, and of their produce since my last visit, I gave him a ram, two ewes, and an ewe lamb that had been born on our passage". (Vancouver 1984: 801). It indicates that when Vancouver visited Hawai'i for the second time in 1973, the domestication of goats had been well established. In the above passage, "Kahowmoto" is Keamoku who was a kind of prime minister of King Kamehameha.

names of these animals are mostly sound imitation of English name. On the contrary, Tahitians tend to extend the concept of pig, *pua'a*, to the other animals. Cow, horse, and goat are called using *pua'a* as a primary lexeme with kinds of adjective: cow as *pua'atoro* (meaning "crawling pig"), horse as *pua'ahorofenua* (meaning "land running pig"), and goat as *pua'aniho* (meaning "tusk pig"). On the other hand, sheep (Hawai'i and Maori) and rabbit (Hawai'i, Maori and Tahiti) are named by sound imitation (Table 1).

Thus there is an inconsistency in naming introduced mammals among the Polynesians. This is because the Polynesians encountered these new animals independently in each island group. Since the contact with Westerners processed rapidly, and Polynesians were often astonished with a variety of livestock as the above quotation of T. Manby shows. This is the reason why Polynesians had invented names for these animals by rather ad-hoc manner. The independent invention of a category is also observed on such natural phenomenon as snow[xii].

B. First Experience of Snow.

One of the challenges for the Polynesians who had moved to higher latitude is the adaptation or re-adaptation to the cooler climates. Ancestral Polynesians who had been migrating in lower latitude area near the equator probably did not experience snow. In two parts of Polynesia, Hawai'i and New Zealand, however, the Polynesians must have encountered snow. Although Hawaiian Islands are situated in sub-tropical zone, there are high mountains in islands of Hawai'i and Maui. In particular, there are two high mountains on Hawai'i Island, *Mauna Kea* and *Mauna Loa* whose altitude exceeds 10,000 feet or 4,000 meters. *Mauna Kea* means "white mountain" that symbolizes snow-caps on the summit. The evidence that Hawaiians not only worshiped *Mauna Kea* but actually visited the peak is given by the presence of archaeological sites (e.g. adze quarry and shrine) around the summit. *Mauna Kea* is especially known for the high quality basalt that Hawaiians needed to make adzes (Kirch 1985).

New Zealand has also high mountains covered with snow, but in the South Island it snows in the area of the lower altitude. Thus snowing must have been one of the common natural phenomena Maori experienced annually.

The lexicons concerning natural phenomena have strong similarities throughout Polynesia (Table 2). The elements of natural phenomena are expressed by primary lexeme and they are mostly cognates in these languages (Ross, Pawley and Osmond 2003). But Hawaiian term for snow does not correspond to that of Maori, and both terms are secondary lexeme: this gives us

	Hawai'i	Maori	Tahiti
sun	*lā*	*raa*	*ra*
moon	*mahina*	*marama*	*mahina*
sky	*lani*	*rangi*	*ra'i*
Pleiades	*makali'i*	*matariki*	*matari'i*
ocean	*moana*	*moana*	*moana*
sea	*kai*	*tai*	*tai*
rain	*ua*	*ua-ina*	*ti'afoa*
mountain	*mauna*	*maunga*	*mau'a*
dew	*hau*	*hau*	*hau*
foam	*hu'a*	*huka*	*'uha*
snow	*hau kea*	*huka rere*	*hiona***

Table 2. Comparative Lexicon of Natural Phenomena* "hiona" came from English word "snow." (source: Hawaiian [Pukui and Elbert 1957]; Tahitian [Andrews and Andrews 1994]; Maori [Biggs 1990])

[xii] There are many cognates among the Polynesian fish names, since Polynesians have been engaged with similar fish throughout the region (Goto 1999b). Their growth terms, however, show low percentage of cognates, and this suggests that the Polynesians developed growth terms of fish in each island after the settlement (Clerk 1985).

an impression of ad-hoc invention of the concept.

Hawaiians thus had to invent a lexicon which means snow: *hau* or *hau kea* that literally means "white dew." (*hau*=cool, iced, frost, dew; *kea*=white; cf. In Maori *hau*=dew). Maori also had to invent lexicon meaning snow: *huka* or *huka rere* (*huka*=foam, frost, froth, snow, sugar; *rere*= fly [of birds], flow [of water], and sail [of canoe; cf. In Hawaiian *hu'a*=foam]).

In addition, Hawaiian mythology has a myth of snow goddess (*poliahu*) who is never found in other Polynesian islands including New Zealand Maori. This is contrastive to the fact that Polynesian mythology has a high similarity concerning gods and goddesses (Marck 1996).

I argue that the ancestral Polynesians did not know snow, and that Hawaiians and Maori came to have experienced snow independently in each island.

5. Structural Transformation of Cognitive System 3: The Nature of Polynesian Universe.

A. North-South Movement and Polar Star

Another cognitive challenge Polynesians encountered is related to north-south movement of the Polynesians. Northward and southward movements have caused a substantial challenge to the cosmological thought that east-west movement does not. In other words, the shift in latitude leads to changes that the movement along the longitude does not. I would emphasize that the uniqueness of Polynesians is that the similar people expanded to both northern and southern hemisphere. This has rarely happened among other ethnic groups in the world, probably before the Great Exploring Period commenced by Portuguese and Spanish.

Since the Polar Star is recognized as the center of the universe and often regarded as the principle god in many cultures of northern hemisphere, whether it is visible or not is a serious problem in the cosmological thought[xiii]. The Polynesians living in the southern hemisphere could not see Polar Star, although there is an opinion that Tahitians knew Polar Star for some reason (Lewis 1994: 403) [xiv]. The Hawaiians whose habitat lies in the Northern Hemisphere were looking at different universe from many other Polynesians in the Southern Hemisphere.

Polar Star is an important index during navigation. Hawaiians called Polar Star as *kiopa'a* that means "immovable" (Beckwith 1932: 78). Hawaiian recognized that *kiopa'a* is a very large star and it marks the north side of the earth. The Hawaiians divided the stars into two classes: (1) the fixed stars and the (2) moving stars. In fixed stars there were three classes, (a) star used as a guiding star to land, *kiopa'a*; (b) the stars close to heaven called *lani* (=heaven), *lalani*; (c) the sun, the moon, and the *hoku'loa* or great star (Beckwith 1932: 74-82). In a similar way, among Carolinians of Chuuk (Truk) in Micronesia who are also living in northern hemisphere, Polar Star is a common and the most basic index in navigation using star chart (Gladwin 1970).[xv]

Most of the Polynesians do not seem to have recognized the Polar Star, since their immigration

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[xiii] Also the latitude of your habitat influences upon the recognition concerning the motion of the universe. If you are in the North Pole, the universe rotates around the Polar Star above your head. The motion of the universe is totally different to the people living around the Equator. For example, the Gilbertese islanders who live near the Equator regard the night-sky as a vast roof supported by imaginary rafters (*oka*). This is because stars rise and set almost vertically around the Equator (Grimble 1931).

[xiv] When a Hawaiian double canoe, *Hokule'a* made an experimental voyage to Tahiti in 1976, the navigator was Mau Pialuk who came from Caroline Islands that are the only place where traditional star navigation was handed down until today. Although the navigator was very skilled and experienced person, he has never sailed in the sea where Polar Star cannot be seen, since the Caroline Islands are situated in the northern hemisphere (around 8 to 10 degrees North) and the islanders' voyaging route was mainly west-east direction. They occasionally sailed northward to Saipan, but they rarely sailed southward beyond the Equator. Since the navigator and researchers have noticed this problem to occur before the voyage of *Hokule'a*, they did training in the planetarium, by learning the constellations of southern hemisphere (Finney 1979; Kyselka 1987).

[xv] In Proto-Chuuk, the name of Polar Star is reconstructed as **fitū mʷakut* that means "star not moving" (Ross et al. 2003: 168).

route from Fiji to western and central Polynesia lies in the southern hemisphere. When ancestral Polynesians migrated north from the Marquesas to the Hawaiian Islands, they must have encountered Polar Star beyond the Equator. Probably they found that immovable Polar Star was not only the index of north, but also its altitude corresponds to the latitude where you are.

B. Solstice.

In the islands that are situated close to the equator, the seasonal variation of length of daylight is not so great. In New Zealand that lies in higher latitude of southern hemisphere, however, the difference of winter and summer solstice is great enough a substantial change of way of thinking to occur.

Pacific islanders tend to regard the heaven consists of three to twelve layers formed by widely spaced concentric hemispheres (Goto in press). In a vertical direction, the celestial layers lie one above the other, but in a horizontal direction they formed circular zones on the earth's surface. An island which could be called *te pito*, the naval of the universe, was conceived of as situated at the center of a series of concentric spaces separated from one another by various sky domes which rested on the earth (Makemson 1941: 10-11).

According to Hawaiian scholar Malo, Hawaiians divided the heaven into several layers (Malo 1996: 148-150):

(1) *kahiki-moe*: the circle or zone of the earth's surface, whether sea or land, which the eye traverses in looking to the horizon; (2) *kahiki-ku*: the circle hemisphere of the sky, which bends upward from the horizon (the domain of Alpha and Beta Centauri, the Southern Cross, etc.); (3) *kahiki-ke-papa-nu'u*: border of the earth plane (roughly corresponds to winter solstice) ; (4) *kahiki-ke-papa-lani*: borders of the celestial planes (roughly corresponds to celestial equator); (5) *kahiki-kapui-hōlani-ke-kun*ia: the zone beyond *kahiki-ke-papa-lani* and directly overhead (the domain of Orion, Aldebaran, Altair, etc.) .

Usually, Polynesians differentiate between summer solstice and winter solstice, using different terms such *lua-poto* and *lua-loa*, meaning short pit and long pit which symbolize short days in winter and long days in summer. Recent analyses of the orientation of archaeological sites in Hawai'i and Mangaia indicates that solstices and the rising position of particular constellations (e.g. Pleiades) were regularly observed in relation to religious structures (Da Sylva and Johnson 1984; Johnson 1998; Meech and Warther 1996; Ruggles 1999; Chauvin 2000; Kirch 2004a, 2004b).

The Maori used the same word for both solstice, *marua-roa* (long pit), and applied the term also to the month or season during which the Sun passed through its most northerly or southerly declination. Since the summer and winter solstice came to be reverse in the southern hemisphere, there must have been produced a conceptual confusion (Makemson 1941:85-86). In addition, in the northern hemisphere and tropical zones, the heavenly god is said to be facing north toward summer (June) solstice, but among the Maori heavenly god is said to be facing south toward summer (December) solstice.

C. Pleiades.

The Pleiades rise soon after sunset around November 20 (=acronitic rising). They are on the meridian at sunset about February 20, and set in the rays of the setting Sun toward the end of April (=heliacal set). Thirty or forty days later they are visible on the eastern horizon just before dawn (=heliacal rising).

In Hawai'i, Samoa, Tonga, Societies, Marquesas, and some other islands, the new year began in late November or early December with the first new Moon after the first appearance of the Pleiades in the eastern sky in the evening twilight: commencement of a year at the acronitic rising of Pleiades.

There is another pattern in which heliacal rising corresponds to the beginning of the year. New Zealand Maori offer a famous example (Best 1922: 27). This pattern is observed in Futuna, Tikopia, Pukapuka, Mangareva, Tuamoan and some tribes of Maori (Makemson 1941: 77-78; Krich and Green 2001: Table 9.4)[xvi].

Thus there are two patterns on the commencement of the year according to Pleiades, but both of these times were important in the Ancestral Polynesian system: the transition from one *taqu* ('season') to the next. Kirch and Green argue that because of the precession of the earth, the acronitic rising of Pleiades around 500 BC was slightly earlier, late October: 500 BC corresponds to the period of Ancestral Polynesian Society. Due to the precession of the equinoxes the star-cluster is now 30° farther east of the vernal equinox than it was 2,000 years ago, when it was also 7° close to the celestial equator (Makemson 1941: 76).

Kirch and Green further argue that "the acronitic rising of the Pleiades in late October would have not just the onset of each new wet season, but also the impending harvest season of the yams, and the ritual necessity of offering first fruits to ancestors and gods" (2001: 267). The acronitic rising of the Pleiades coincides with the beginning of the wet season, while its heliacal rising signals the onset of the dry season. Among Maori who regards the heliacal rise of Pleiades as the index of new year, this time is strongly related to the horticulture of sweet potato (Orchiston 2000: 183).

Thus the risings and settings of Pleiades provided an ideal sidereal timekeeper for the major ecological rhythms of the Polynesian homeland (Kirch and Green 2001: 265)[xvii]. But the Polynesians had to modify the correlation of celestial phenomenon and the seasonality slightly during last 2,500 years, because of precession.

6. Conclusion

In this paper I have examined transformation of cognitive system of the Polynesians who have been engaged with diverse environment of the Pacific. The environment of Polynesia is a skewed representation of Asian fauna and flora in terms of the decrease of genera and family. The attenuation of fauna and flora, however, does not mean at all that the Polynesians were a poor observer of the nature. For example, Hawaiian creation chant, *Kumulipo*, enumerates hundreds of floral and faunal taxa before the emergence of gods and humans. This expresses Hawaiians' "biophilia" (Wilson 1984) and "deep ecological thought" that the humans have been rooted in the long history of biological evolution (Drengson and Inoue 1995). Polynesians are agents who have transported and created their own environment, and also have responded to continual encounter of the inexperienced natural phenomena in the last 2,000 years. I hope this paper has explicated some aspects of dynamic actor-environmental relationship in the 2,500 years' history of Polynesia.

[xvi] According to Makemson: "The Pleiades year commencing in late fall was an ancient institution in India, Sumeria, Arabia, and other parts of Asia in the northern hemisphere. A parallel with the New Zealand, Catham Islands and Pukapukan year is found in South America where the Inca sun worshipers dated the year from the June or winter solstice when their days began to lengthen (Makemson 1941: 79)."

[xvii] Makemson has also made an extensive discussion on the Rigel Year among Maori: "it is surprising to find that in the South Island and certain parts of North Island of New Zealand and the neighboring Chatham Islands, the year began with the new Moon after the early morning rising, not of the Pleiades, but of the star Rigel in Orion." She considers that this custom is a remnant of the way of thinking among the people living around 10° south of Equator where Rigel comes to the zenith (Makemson 1941: 77).

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