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"Sweet-Potato Washing" Revisited

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1 Introduction

Japanese monkeys (*Macaca fuscata*) on Koshima Island wash sweet potatoes. This fact is quite well known, and is often discussed as an aspect of "culture" in nonhuman animals. However, the full picture is not always entirely understood. The finding of sweet-potato washing among Koshima monkeys followed theoretical considerations of culture in nonhuman animals presented by Imanishi, and from the beginning research on Japanese monkeys has developed from anthropological concerns about human evolution. In this chapter, we would like to illustrate the history of sweet-potato washing and other characteristic behaviors shown by Koshima monkeys (for reviews, see also Itani and Nishimura 1973; Nishida 1987).

2 Prehistory of Sweet-Potato Washing

In 1948, when Kinji Imanishi, Shunzo Kawamura, and Junichiro Itani were conducting research on semiwild horses at Toi Peninsula in Miyazaki Prefecture, Japan, they happened to find a group of wild Japanese monkeys. This was the start of many studies of wild Japanese monkeys. Two points characterized these studies. The first is that they are a long-term research project which still continues after more than a half a century. The second is the individual identification of the monkeys. Each monkey was given a nickname, and not labeled like a rat or mouse in a laboratory. The researchers began to understand the cognition, behavior, and society of Japanese monkeys in the wild through long-term research with individual identification.

In November 1948, soon after their encounter with the wild Japanese monkeys at Toi Peninsula, Imanishi, Itani, and Kawamura visited Koshima Island in the same prefecture for the first time (Fig. 1). Koshima was the first, and that time the only, monkey habitat designated a natural monument in Japan. Intensive study of the Koshima troop of Japanese monkeys started since then with the success of

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Fig. 1. Koshima Island (center)

provisioning in 1952 (see Chapter 20 by Watanabe, this volume). These workers and their colleagues also began to focus their research on monkeys at several other sites in Japan. These included Takasakiyama in 1950 by Kawamura and Itani, Minoo in 1950 by Kawamura, Arashiyama in 1952 by Kawamura and Itani, Yakushima in 1952 by Kawamura and Itani, Shimokita in 1952 by Itani, Kinkazan in 1959 by Yoshiba, and Jigokudani in 1960 by Azuma, Sugiyama, and Wada.

In the meantime, in 1952, Imanishi published a landmark paper entitled "The evolution of human nature," written in Japanese. At the very beginning of the research on Japanese monkeys, or even before that, Imanishi's mind was oriented toward anthropology. The paper is rather an imaginary theoretical one, as only a little was known about nonhuman primates at that time. The paper takes the form of fantasy, with some imaginary characters debating on several subjects. It goes as follows:

Evolutionist "First of all, I think it's good to start with a commonplace topic. Well, people say, animals live only by instinct, while humans have culture."
Layman "To be a human means to have a culture."
Evolutionist "... Instinct is inherited through a genetic channel, while culture is transmitted through a nongenetic channel. Culture is acquired through learning and teaching, so that the model and the pedagogy are necessary. Therefore, a group life is inevitably required for the establishment of a culture. Thus, to maintain a culture as culture, the group life must be a perpetual one."
Layman "If the condition for the establishment of a culture is just like you described, then culture may be seen not only in humans but also in other animals that live in a perpetual social group. How is it in monkeys? Do you have culture, Monkey?"
Monkey " We live in a perpetual social group... but it is not made clear yet how much of our behavior is determined by instinct and how much is determined by culture..."

In the subsequent discussion, Imanishi let Monkey say "a change in food habits can be considered as a change in culture," and Evolutionist say "when an experience of an individual is transmitted to the next generation, it is called a culture."

The above hypothesis by Imanishi was later corroborated by colleagues in the field. The first discussion about the culture of Japanese monkeys that had a basis in actual field observations was proposed by Kawamura in "On a new type of feeding

habit which developed in a group of wild Japanese monkeys" (1954), a paper written in Japanese. Kawamura later published three related papers: "Prehuman culture" (1956), "The process of subculture propagation among Japanese macaques" (1959), and "Subculture in Japanese monkeys" (1965); the first and third were written in Japanese, and the second in English. In these papers, Kawamura gave examples of possible cultural behavior in Japanese monkeys, such as the repertoire of foods (e.g., monkeys in some troops eat bird eggs, while monkeys in other troops do not), the nomadism of the troop (i.e., the maintenance of a home range by a group, and also the moving pattern within the home range, which is inherited over generations), social behavior (e.g., many adult males of one troop show paternal care towards infants, while males in other troops do not), and social structure (e.g., males are tolerant of each other in some troops, while males in other troops become much more aggressive when approached by other members). Kawamura attempted to probe the cultural behavior of monkeys by checking on the variability of the behavior across troops. He said that: "The life of higher animals closer to humans are in the mist at present. We should not dispose of the question by considering whether or not they have language or productions, but we must keep our outlook broad and explore untouched areas to shed light on the buried evolutionary path" (Kawamura 1965); "Our purpose is not to go into an endless argument about the definition of the term, but to conduct concrete research about in what way a simple behavioral mechanism has developed into a higher complex one in animals. ..., isn't it possible to cast a completely different light on human culture by carefully tracing each step and by arriving at the evolutionary perspective?" (Kawamura 1956).

The first of the four above-mentioned papers by Kawamura was the first report on the sweet-potato washing behavior of Koshima monkeys. He briefly described the invention of sweet-potato washing by a 1.5-year-old female and its propagation to three other members by 1954. Later, Kawamura, Kawai, and colleagues conducted a follow-up study of this behavior, and Kawai (1965) wrote about the process of propagation in detail, along with reports of three other newly acquired behaviors. This paper is an extremely detailed record of these well-known behaviors based on systematic data collection. We invite readers to revisit Kawai's original 1965 paper in the following sections.

3 Revisit to Kawai (1965): "Newly Acquired Precultural Behavior of the Natural Troop of Japanese Monkeys on Koshima Islet"

Before going to the paper itself, one may wonder why Kawai used a coined word "preculture." Let us first give an explanation (Kawai 1964). Imagine the following example: Japanese people eat sea cucumbers, but people in Western countries do not. Such a phenomenon can be labeled the "culture" of food. Culture can be loosely defined as a mode of life that is invented in a group, shared by group members, and transmitted to subsequent generations through social media. However, when we say "culture," its substances and levels are, of course, different in monkeys and

humans. The word "culture" often reminds us of literature, art, music, pictures, academe, religion, etc. It cannot be denied that there is a big gap between human culture and monkey culture. In the case of monkeys, they do not have the ability to teach something. The way infant monkeys acquire a behavior is that they somehow become familiar with a certain behavior while being with their mothers, and acquire it in some way. In the case of humans, those who do not follow the culture of their own community will be treated as unorthodox and will be socially punished; human culture has the power to restrict or constrain the behavior of a person who belongs to that society. Thus, human culture of any kind is systematized in some way. On the other hand, a monkey who does not follow a culture will not be blamed, and no social restriction works against a violation. We must not overestimate the situation and say that "monkeys have culture," and then confuse it with human culture. Cultural behavior in monkeys must always be discussed in the light of evolution. This is the reason why the term "preculture," which takes such differences into consideration, was used in Kawai's paper. An abridged edition of the paper follows.

3.1 Sweet-Potato Washing (SPW) Behavior

3.1.1 Acquisition of SPW Behavior

Sweet-potato washing (SPW) is a behavior in which monkeys take a sweet potato to the edge of the water and wash the sand off the potato with water (Fig. 2). This behavior was begun in September 1953 by a female named Imo, who was one and a half years old at that time.

This behavior gradually spread to other monkeys. Table 1 shows the process of propagation during the period from 1953 to March 1958. In 1958, the acquisition rate in adults was 18.1%: i.e., 2 out of 11 animals (6 males and 5 females). The rate in monkeys aged between 2 and 7 years was 78.9%: i.e., 15 out of 19 (10 males and 9 females). After that, most newborns began to show this behavior. In August 1962, 36 out of 49 monkeys over 2 years old showed SPW behavior (73.4%). There were 13 monkeys who did not show SPW behavior. Out of 11 monkeys over 12 years old, i.e., those born before 1950, only two females showed SPW behavior (Eba and Nami). On the other hand, among the monkeys born after 1951, only 4 individuals did not perform this behavior. Interestingly, they were all Nami's children.

3.1.2 Process of Propagation

The acquisition of SPW behavior could be divided into two periods: before and after 1958. The author calls them the first and second period, respectively.

3.1.2.1 The First Period (The Period of Individual Propagation)

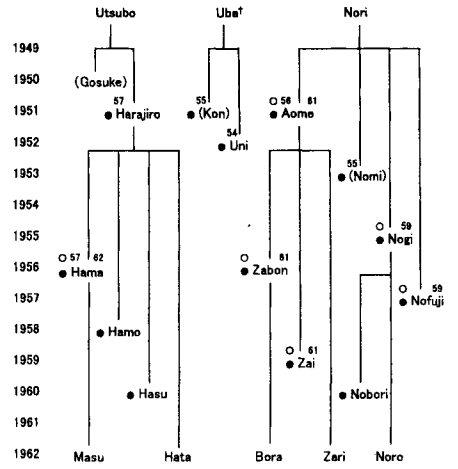
This is the period when monkeys born before 1956 acquired SPW behavior. The times and processes of acquisition were diverse. Adult monkeys who did not acquire the behavior during this period could not acquire it later.

Figure 3 and Table 1 show us the importance of age, sex, and kinship. Most

Fig. 2. Sweet-potato washing (SPW) behavior

Table 1. The year and age when the monkeys acquired SPW behavior

	Age					
Year	1–1.5	2–2.5	3	5	6	Adult
1953	Imo ♀	Semushi ♂				Eba ♀
1954	Uni ♂					
1955	Ei ♂	Nomi ♂	Kon ♂			
1956		Jugo ♂		Sango ♀, Aome ♀		
1957	Hama ♀, Enoki ♀				Harajiro ♀	Nami ♀
1958		Zabon ♀, Nogi ♀	Sasa ♀			



Males born before 1949: Kaminari, Akakin, Mobo, Hiyoshimaru, (Hanakake)

●: SPW monkey
○: WPM monkey
( ): Solitary monkey
†: Died

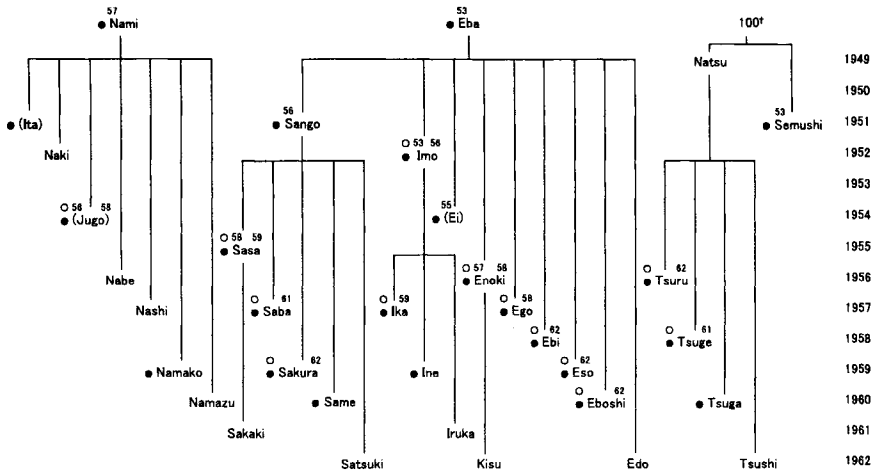


Fig. 3. The lineages of the Koshima troop and the acquisition of SPW and WPM behavior as of 1962. Individuals who died after 1949 are not included. Numerals to the left above the names indicate the year when the monkeys acquired SPW behavior. Numerals to the right above the names indicate the year when the monkeys acquired WPM behavior (snatching behavior is not included)

competent in acquiring SPW behavior were juveniles between 1 and 2.5 years old. Males older than 4 years had great difficulty in acquiring this behavior. Females, on the other hand, could acquire SPW behavior even if they were older than 4 years, but judging by the fact that only 2 females out of 11 born before 1950 did acquire the behavior, old age was obviously a great obstacle in both sexes for the acquisition of this behavior.

What causes the difference between males and females in the acquisition of this behavior? In order to acquire SPW behavior, a close social interaction with monkeys engaging in it (SPW-monkey) at feeding time seemed to play an important role. In this lies a difference between males and females which is due to their social status. When a male becomes 4 years old, he generally begins to move from the center to the periphery of the troop. Therefore, the social interactions of adolescent and adult males with females and juveniles in the center of the group become very

limited, and they seldom feed with females and juveniles. On the other hand, all females live closely with each other in the center of the troop. In particular, mother and child often move together. Kawamura (1954, 1956) suggested the importance of mother–child relationships in acquiring this behavior by describing a typical example of the behavior of Imo and her mother Eba. Eba, the mother of the originator of SPW behavior, acquired it early on although she was an adult female. The same can be said for the four females who acquired the behavior when they were older than 4 years.

The order of acquisition of the behavior was the young before the old within the same family: i.e., the child rather than the mother, and the younger brother or sister rather than the older ones. Kawamura (1954, 1956) pointed out that propagation of the behavior had two courses: through playmate relations and through kinship. The propagation in this period was done mostly from child to mother, and from younger sibling to older one. As propagation was done through the relationship of individuals in the first period, this period was labeled the period of individual propagation.

3.1.2.2 The Second Period (The Period of Precultural Propagation)

After 1959, some aspects of propagation were different from those of the first period. SPW behavior was no longer a new behavior to the troop; it had been fixed in the troop during 1958–1959. Monkeys born during this period accepted SPW behavior as a normal feeding behavior and learned it without any resistance.

Sweet potato skins fall to the bottom of the water while SPW-monkeys are eating. This means that babies have the experience of eating their potatoes in water at the beginning of the development of their feeding behavior. The babies are always with their mothers, and they stare at their mother while she is doing SPW behavior. In this manner infants acquire SPW behavior. Therefore, the process of propagation in this period was always from mother to child, which was different from that of the first period. The process of acquiring this behavior by infants and juveniles in this period is described below.

(a) Strengthening affinity to water. Infants are taken to the edge of the water during the period when they are dependent solely on their mother's milk for nourishment. While the mothers are engaging in SPW behavior, the babies strengthen their affinity to water by being dipped in water, or by splashing water by hand.
(b) Eating potato in the water. Infants eat fragments of potatoes that their mothers drop in the water. This begins at about 6 months old.
(c) Acquisition of SPW behavior. Infants acquire SPW behavior when they are 1–2.5 years old.

Thus, the acquisition of SPW behavior begins in infants in the second period. In this period, acquisition or propagation of SPW behavior occurred independently of sex. It can be said that precultural pressure is working toward acquiring this behavior. Therefore, the author calls the second period the period of precultural propagation.

3.1.3 Variations of SPW Behavior

3.1.3.1 From Fresh Water to Salt Water

During 1953–1954, SPW behavior was done on the edge of a brook running into the sea. Monkeys never washed potatoes with salt water, but used the fresh water of the brook. During the surveys of 1957 and 1958, many monkeys began to wash potatoes in salt water. During the survey of December 1961, all the SPW-monkeys washed potatoes in both salt and fresh water. However, when they used fresh water there were particular reasons for doing so: for example, when they were given potatoes in the close vicinity of fresh water, or when subordinate monkeys avoided coming near the seashore for fear of dominant individuals. In other words, SPW monkeys preferred salt water to fresh water. For one thing, the quantity of fresh water was limited. In dry periods, the brook that ran into the sea dried up. Another reason was that if the monkeys became familiar with salt water, it would make the potatoes taste good. The author presumes that these are the two main reasons why the monkeys preferred salt water.

3.1.3.2 Seasoning Behavior

SPW behavior is, as described above, to dip a piece of potato into water by holding it in one hand and brushing off any sand with the other hand. Imo, the originator of SPW behavior, showed this typical behavior, but monkeys do not always brush the pieces of potato. Often they let a piece of potato fall into shallow water and wash the sand off by rolling it with one hand on the bottom. Among the monkeys of the first period, monkeys such as Eba, Sango, and Sasa rolled the potato more frequently than they brushed it. However, during the second period another type of behavior appeared. This consisted of dipping the potato into the water, gnawing it once or twice, and then repeating this behavior. Monkeys collected potatoes and

Table 2. SPW monkeys classified by three types of SPW behavior

Birth year	Age	B-type	BS-type	S-type
Before 1949	Over 13	Eba, Nami		
1951	11	Semushi, Sango, Aome, Harajiro		
1952	10	Imo		
1953	9			
1954	8			
1955	7	Nogi	Sasa	
1956	6	Hama, Zabon	Enoki	Tsuru
1957	5		Ika, Ego, Nofuji	Saba
1958	4		Ebi, Hamo	Tsuge
1959	3	Zai	Namako, Eso, Sakura	Ine
1960	2		Same, Eboshi	Nobori, Hasu, Tsuga

B-type, Brushing; BS-type, brushing-seasoning; S-type, seasoning.

took them to the seashore to carry out this type of behavior. The author considers the function of this behavior to be seasoning the potatoes. Table 2 classifies individual monkeys according to these three types of SPW behavior (B-type, brushing; BS-type, brushing–seasoning; S-type, seasoning). B-type monkeys who retained the old style were those who acquired SPW behavior in the first period, while younger monkeys who acquired SPW behavior in the second period belonged to the BS-type or the S-type. These monkeys were acquainted from their infancy with eating potatoes in water, so they had first learned to eat potatoes with salt seasoning or wet with water, and then acquired brushing behavior to remove sand.

3.2 Wheat Placer Mining (WPM) Behavior

3.2.1 Wheat Placer Mining Behavior

3.2.1.1 Acquisition of Wheat Placer Mining Behavior

The Koshima troop also has another precultural behavior: wheat placer mining behavior (Fig. 4). When grains of wheat were scattered about on the beach, the monkeys ate them by painstakingly picking up one grain after another. However, if a monkey gathers up the grains of wheat together with some sand and then throws them into the water, it succeeds in separating the grains of wheat from the sand more easily. The grains float to the surface of the water, whereas the sand sinks. This is called wheat placer mining behavior, owing to its resemblance to the mechanism of gold mining.

This behavior, which was begun by Imo, was first observed by Kawamura in 1956. Imo was then 4 years old and was well acquainted with SPW behavior. Table

Fig. 4. Wheat placer mining (WPM) behavior

In Kawai's (1965) original paper, this behavior is called "wheat washing" behavior. However, it is actually a bit different from "washing" the wheat, and therefore we use the term "wheat placer mining" to avoid confusion.

3 shows the propagation of WPM behavior from 1956 to 1962. By August 1962, a total of 19 monkeys had acquired this behavior (38.7%).

3.2.1.2 Process of Propagation

In the 1957 survey, the only WPM-monkey was Imo, who was also the originator of this behavior. However, during that year, the researchers used wheat in a test to analyze dominance rank. Because of this, the monkeys grew familiar with wheat, and this seemed to contribute to the rapid spread of WPM behavior. Yoshiba and Azuma noticed Imo's WPM behavior and gave her the conditions which would strengthen this behavior by burying wheat grains in sand and stamping them down. This resulted in an increase in the number of monkeys who learned WPM behavior. The propagation of WPM behavior can be considered to be individualistic up to 1962. It is of interest to examine the course by which WPM behavior was propagated from its initiation by Imo in 1956 until August 1962, and also the conditions in which the acquisition of this behavior took place.

(a) Lineage and playmate relationships. The propagation process for WPM behavior was similar to that for SPW behavior. Especially noticeable was the effect of lineage. Of 15 monkeys (not including 1-year-old infants) of Eba's lineage, to which Imo belonged, 13 used either WPM behavior or snatching behavior (see Sect. 3.2.2). Nori's family also showed a high percentage of WPM behavior. As with SPW behavior, in Nami's lineage, only Jugo used WPM behavior.

(b) Age and sex. According to the data shown in Table 3, WPM behavior was mostly acquired by monkeys aged 2, 3, or 4 years. Monkeys aged 1 year or older than 6 years were not as good as others at acquiring this behavior. In particular, none of the

Table 3. Age and year when monkeys acquired wheat placer mining (WPM) behavior and snatching behavior

	Age						
Year	1.5	2.0–2.5	3.0–3.5	4.0–4.5	5.0–5.5	6.0	Adult
1956				Imo ♀			
1957			(Jugo ♂)				
1958	Ego ♀	Enoki ♀		Jugo ♂			
1959		Nofuji ♀, Ika ♂, Ego(S) ♀, Saba(S) ♂	(Zabon ♀), Enoki(S) ♀	Nogi ♀, Sasa ♀			Eba^{S} ♀
1961–62		Zai ♂ (Eso ♂)	Tsuge ♀, (Ebi ♂)	Saba ♂	Zabon ♀		Aome ♀
1962 (Aug.)		Eboshi ♂, Same^{S} ♂	Sakura ♀, Eso ♂	Ebi ♂		Hama ♀, Tsuru ♂	Sango^{S} ♀

Names in parentheses indicate incomplete acquisition.

^{S} snatching behavior only.

(S) WPM behavior + snatching behavior.

monkeys over 12 years of age (born before 1950) were seen to exhibit WPM behavior. In adolescents and adults, sex differences became important, as they did with SPW behavior, because of the differences in social status. Such sex differences were not important in juveniles.

3.2.2 Snatching Behavior

3.2.2.1 Snatching Behavior

Some monkeys watched the WPM-monkeys and snatched the grains of wheat when they were thrown into the water. The author calls this snatching behavior. In July 1959, an adult female, Eba, and 2-year-old Saba showed this behavior. Enoki and Ego showed WPM behavior, but they often showed snatching behavior also (Table 3). During the period from December 1961 to January 1962, Enoki and Ego did not snatch any wheat from other monkeys, but only showed WPM behavior. In August 1962, Sango and Same began snatching behavior in addition to Eba. Eba and Sango were ranked as No. 1 and No. 2 among the females. When they approached other monkeys aggressively, the other monkeys ran away. Therefore Eba and Sango could eat the wheat in the water without any effort. Same, on the other hand, who was given a high degree of tolerance during cofeeding because he was still only 2 years old, came close to monkeys engaging in WPM behavior and ate wheat with them, or collected the grains which floated toward him, or consumed leftovers after WPM-monkeys had gone.

3.2.2.2 Two Types of Snatching Behavior

As suggested above, there were two types of snatching behavior. One was collecting the leftovers, as shown by Same. This was peculiar to juveniles, and developed into WPM behavior later. The other type was plundering, as seen in the two adults Eba and Sango. They did not perform WPM behavior themselves, but let WPM-monkeys throw the wheat and sand into the water for them. Their behavior was far more effective than WPM behavior itself because they could monopolize the fruit of other animals' labor by plundering.

3.3 Bathing Behavior

3.3.1 Acquisition of Bathing Behavior

The monkeys of Koshima, although they had been living on a small islet surrounded by the sea, were never seen to go into the sea before 1959. Even after they were accustomed to salt water by SPW behavior, all that they did was just to dip their hands and feet in water. None of them bathed in the water.

However, in the summer of 1959, Mrs. Mito attracted monkeys into the water of Otomari Bay by throwing peanuts into the sea. Since then, some monkeys have gone into the sea to get peanuts. The first monkey who went into the sea was, according to Mrs. Mito, 2-year-old Ego. The author calls this behavior bathing behavior (B-behavior, Fig. 5).

In the summer of 1960, several monkeys born after 1954 were observed to bathe.

Fig. 5. Bathing behavior

A thorough survey made in January and in the summer of 1962 produced the following results: (1) of the 49 monkeys available for the investigation, 31 were observed doing B-behavior (63.2%); (2) all the monkeys born after 1955, except for two 1-year-old monkeys and Namazu, bathed in the water; (3) of the monkeys born before 1955, only 6 individuals performed B-behavior (namely 2 solitary males (Gosuke and Jugo) out of 14 males, and 4 out of 9 females). Gosuke probably drowned while he was trying to swim to the other shore across the sea; Jugo swam to the other shore in 1960 and swam back to the islet in the fall of 1964). No other adults ever bathed in the sea, and they also hated even to dip their feet in.

3.3.2 Process of Propagation

3.3.2.1 Acquisition and Propagation

B-behavior quickly propagated to other members of the troop. Within only 3 years after the first appearance of bathing monkeys, almost all juveniles and adolescents began to show this behavior. The level of acquisition in those who were born after 1955, excluding monkeys of less than 2 years old, was 96.1%, but the level of acquisition in adults was very low at 26.0% (6 out of 23 adults).

There are two probable reasons for the speed of propagation. One is that the event which gave rise to this behavior was humans throwing their favorite food into the sea. The other is that, unlike SPW and WPM behavior, bathing is a matter of adaptation to a new habitat and of changing conservatism. This gives us a strong interest in monkeys' conservatism, which is especially marked in adult males. The rate of adaptability to a new habitat seems to be high in juveniles and adolescents, medium in adult females, but very low in adult males.

3.3.2.2 Precultural Propagation

Infants are offered many opportunities to acquire B-behavior because the mothers go into the sea with their infants clinging to their fur. When the mothers go into the

sea, they do not pay any particular attention to whether or not their infants are dipped into the water. Often infants are completely submerged in the water, and sometimes come close to being drowned. In this way, not long after their birth, infants become adapted to bathing in water. As a result, infants accept the sea as a part of their habitat, as they do with the mountains, and feel no reluctance in bathing. Therefore, the acquisition of B-behavior is a precultural acquisition for infants.

3.3.3 Variation of Bathing Behavior

In B-behavior, almost all monkeys used quadrupedal locomotion in the ankle-deep shallows. In deeper places, monkeys used bipedal locomotion. Often they bathed, dipped themselves in water up to their shoulders, or used quadrupedal locomotion with only their head held above the water. With bipedal locomotion, the degree of dipping themselves differed among monkeys: for some the water only came up to their knees, others went in up to their waist, and others went in up to breast height. There were 10 monkeys who swam: eight 2 to 5-year-old monkeys and two solitary adult males. Some juveniles began to take a strong interest in bathing itself. They dived from rocks and enjoyed swimming. It can be said that these juveniles have developed the original bathing behavior into new practices of avoiding the heat and just playing in the hot summer. They also dived under water skillfully, and sometimes took seaweed from the bottom at a depth of 1 or 1.5 m.

3.3.4 Comparison with Other Troops

It is not unusual for Japanese monkeys to go into the river or the sea. Monkeys of several other troops bathe in the river or in a pool. An interesting case is the Jigokudani troop, where some monkeys go into a hot spring in the cold of winter (Suzuki 1965). It is considered to be a general habit of Japanese monkeys to bathe or swim, but, as seen in the Koshima troop, this habit should be recognized as a characteristic of the troop rather than of the individuals. Another point to be noted is the adaptability and tradition of the troop in Japanese monkeys. It is surprising that until 1959, the strong traditions of the Koshima troop meant that they had never gone into the water. However, once that strong tradition began to break down for one reason or another, it could easily be removed.

3.4 "Give-Me-Some" Behavior

3.4.1 Give-Me-Some Behavior

When a human observer put his hand into his pocket to take out some peanuts, the monkeys waited, sitting in front of him, taking up a posture of let-me-have-some-please. This behavior closely resembles that of a human child when he is given sweets or cookies. The author calls this give-me-some behavior (GM behavior). GM behavior could not always be seen when monkeys were given food. When they were not psychologically calm, that is, in a situation where they would easily be disturbed by others or by nearby dominant monkeys, they did not show GM behavior.

3.4.2 Acquisition and Propagation

The initiator, the date of first occurrence, and the process of propagation of GM behavior are unknown. In 1960, Azuma noticed that Kaminari, one of the leader males, showed GM behavior. Many other monkeys must have performed this behavior at a much earlier date. Out of 47 monkeys available for the test, 37 performed GM behavior (two 1-year-old monkeys were not tested). This was 78.8%, which was higher than that for SPW behavior. Among 24 males, 19 (79.1%) showed GM behavior, and among 23 females, 18 (78.2%) did so. No difference due to sex could be observed. The high percentage of acquisition by adults was characteristic of this behavior. There were 10 monkeys who did not perform GM behavior (5 males and 5 females). Included in these were three children of Nami (Nasi, Namako, and Namazu).

3.4.3 Meaning of GM Behavior

Why did GM behavior begin, and how did it propagate? Judging from the intellectual faculties of monkeys, the acquisition of this behavior cannot simply be ascribed to imitation. The remarkable differences between this behavior and SPW and WPM behaviors is that it was performed by all the adult males, including the solitary males. This behavior pattern is believed to be quite general among Japanese monkeys, because GM behavior can be witnessed in other troops, although it remains individualistic and is not a general behavior pattern in these troops.

Compared with other monkeys in Japanese monkey parks, the monkeys at Koshima are distinguished by the fact that they have never bitten or attacked anyone, and have seldom threatened humans since the start of provisioning. In other monkey parks, relationships between monkeys and humans are not always peaceful. At Koshima, there are few sightseers, and it is mainly local monkey lovers or researchers who make contact with monkeys. Thus, the monkeys do not need to snatch their food by threat or attack, and they have learned to wait. In short, what is characteristic of this troop is their gentle, friendly attitude towards humans. Thus, GM behavior is one manifestation of an attitude toward humans born out of friendship and composure on the part of monkeys. The friendly attitude of all the monkeys towards humans can be taken as a kind of "implicit" preculture (Kawamura 1956).

3.5 The Four Behaviors Compared

In each section, the author has suggested that three factors, i.e., age, sex, and kinship, were important in the acquisition and propagation of the four newly acquired behaviors. The author would like to compare the four behaviors with each other. Figure 6 shows the change in the ratio of monkeys who performed each behavior as of 1962 as a function of age. The curves of SPW, WPM, and B-behaviors are similar, while that of GM behavior is of a different form. The ratio of monkeys who showed the first three behaviors began to increase in juveniles, reached a peak in adolescents, and decreased in adults in 1962. However, the highest ratio of GM behavior (100%) was seen in monkeys of 6–11 years old (adolescent and adult),

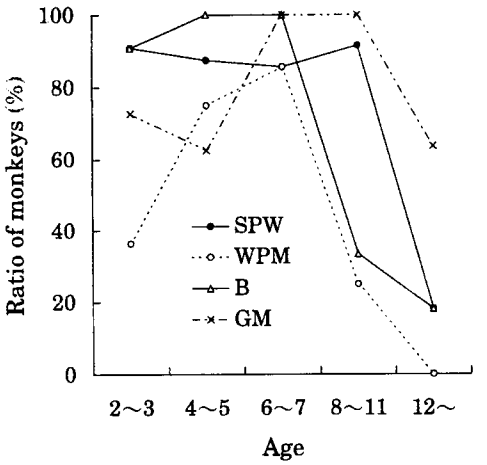


Fig. 6. The change in the ratio of monkeys who performed each behavior as of 1962 as a function of age

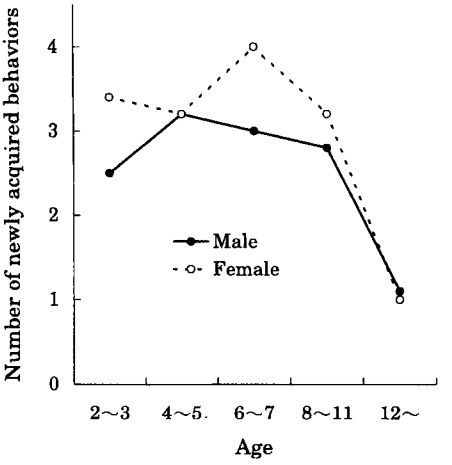


Fig. 7. Average number of newly acquired behaviors by males and females in each age class

and even adults more than 12 years old showed a high percentage. The similarity between SPW behavior and WPM behavior is shown in Fig. 6. The only difference is that the age of acquisition of SPW behavior was lower than that of WPM behavior in the period of individual propagation. This difference is due to the relative difficulty of acquisition. SPW behavior has sometimes been observed in other troops such as Takasakiyama, Ohirayama, Arashiyama, and Gagyusan, although it remains individualistic and has not been propagated to other monkeys in these troops. It seems to be possible to acquire SPW behavior incidentally. In WPM behavior, monkeys have to go through the procedure of collecting wheat by hand and taking it, together with any sand they have picked up, to the water before they can select the wheat they want by putting the mixture into the water. WPM behavior is a more complex activity. Figure 7 shows the differences in behavior acquisition in relation to the sex and age of the animals. In juveniles and adolescents, sex differences had no effect. In adolescents and 8 to 11-year-old adults, the males showed a lower

Table 4. Mean number of newly acquired behaviors (MNNB) by monkeys of each lineage

Mother	Sango	Eba	Imo	Aome	Harajiro	Natsu	Nori	Utsubo	Nami
No. of children	4	8	2	2	3	3	4	2	7
MNNB	4.0	3.6	3.3	3.3	3.0	2.6	2.6	1.6	1.6

percentage of acquisition than the females. This is due, as has been explained, to the differences in status of males and females.

In each section, the author has referred to the differences in acquisition caused by lineage. For example, the children of Sango and Eba acquired these new behaviors very readily, while Nami's children were slow (Table 4). In a society of Japanese monkeys, mother–child relations are known, but it is difficult to determine which animal is the father. Therefore, it is difficult to pursue this genetic aspect with scientific rigor. Nevertheless, it is interesting that a difference in acquisition ability according to lineage has been suggested by the data.

3.6 Environmental Basis of Precultural Phenomena

The precultural behaviors seen above all developed from the monkeys' foraging behavior and their relation to humans. That is, they were all derived from provisioning. Provisioning made great changes in the natural life of the troop. Another important factor is the natural environment. In Koshima, three different environments—precipitous mountains with thick woodland, the sandy beach, and the sea—are beautifully integrated. Before the monkeys were provisioned, the mountains were their only habitat. After provisioning, they came to know contrasting environments such as the sandy beach and the sea. That is, a new, different environment, or niche, was introduced into their natural life. The major precultural behaviors of the Koshima troop are connected with the sands and the sea. It is doubtful whether such inventive behaviors as SPW and WPM would have been developed in their previous niche. Therefore the monkeys have invented adaptive behavior in response to changes in the environmental conditions. Behavioral adaptability or plasticity in response to changes in the environment are important when we think about the evolution of behavior in animals.

4 Return from Revisit: Koshima Monkeys Afterwards

Here we return from Kawai's (1965) paper. What happened to the Koshima monkeys afterwards? A total of more than 450 monkeys were recorded from 1952 until 1999. None of the monkeys who experienced the emergence of these precultural behaviors is alive now, but their descendants are still dipping sweet potatoes into the sea, throwing grains of wheat into the water, and bathing in the sea. These behaviors have been transmitted over the generations.

Table 5. Examples of the variation in SPW behavior within individuals

Name (sex, age)	Type of SPW behavior								
	Se	Ri	Rw	Br	Rh	Pl	Ga	Rr	Others
Uri (♀, 15)	18	12	8			1	1	1	1
Cha (♀, 7)	30	14	1				1		
Chinu (♂, 4)	2	3			2		1		
Chisha (♀, 1)	1	2					8		
Ume (♀, 12)	33	25	2		8	1		1	
Mebaru (♂, 4)	39	13			3		1	1	
Megi (♀, 1)	1						10		
Utsugi (♀, 6)	39	31	3		11		2		
Udo (♀, 3)	7	4	1				3		
Kuri (♀, 16)	35	21	1						
Kemushi (♂, 5)							1		
Keshi (♀, 2)	1								
Kurumi (♀, 13)	40	14	1		4			1	2
Mono (♀, 5)	2	3		3	2		2		
Momiji (♀, 2)	8	5			1		4	1	
Kuma (♂, 9)		1			1		4	1	

Se, Seasoning; Ri, rinsing; Rw, rubbing in water; Br, brushing; Rh, rubbing between hands; Pl, plundering; Ga, gathering; Rr, rubbing on rock.
The data in the body of the table show the number of times each behavior type was observed. Uri, Ume, Utsugi, and Udo are siblings. Kuri, Kurumi, and Kemushi are also siblings. An indented name indicates a mother–child relationship. The individual whose name is indented is a child of the previous individual whose name is not indented.

Kawai and colleagues conducted an intensive follow-up study on these behaviors (Kawai et al. 1992; Watanabe 1994). Five new behavioral patterns have been added to the repertoire of sweet-potato washing, and six to wheat placer mining. An interesting case is "pool-making," which is efficient for wheat placer mining. When grains of wheat are scattered on the beach while it is still wet at low tide, some monkeys dig out some sand and make small pools from the water that oozes up. They then dip a piece of sweet potato or sweep nearby grains of wheat into the pool before they eat them.

By reanalyzing the systematic data taken during this follow-up study, we can infer the process of monkeys' acquiring SPW and WPM behaviors. Table 5 shows examples of the variation in SPW behavior within and between closely related individuals. Different behavioral patterns of SPW were distributed throughout almost all members of the group, and no monkey engaged persistently in any one specialized behavior (for details of the methods of study and descriptions of each behavior type, see Kawai et al. 1992; Watanabe 1994). Although it is difficult to interpret these data exactly in terms of the mechanisms underlying the process of acquisition, we have the impression that these behavior types are established by trial and error by each individual rather than by copying every method from other

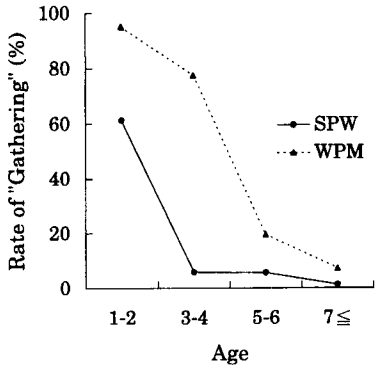


Fig. 8. The ratio of gathering behavior as a SPW- and WPM-related behavior by age class. The data were collected from 69 individuals. A total of 1662 samples of SPW behavior were divided into nine categories (see Table 5 and Kawai et al. 1992). A total of 2805 samples of WPM behavior were divided into eight categories: throwing, sweeping, pool-making, plundering, removing, screening, screening while walking, and gathering (see Kawai et al. 1992)

monkeys. The motor patterns used in these SPW behaviors seem to be general in Japanese monkeys, and can appear spontaneously in each individual. Figure 8 supports Kawai's (1965) hypothesis about the development of SPW and WPM behavior. In infants and juveniles, the gathering of other monkeys' leftovers was the predominant SPW- and WPM-related behavior. This type of behavior decreased in adults, and they engaged in their own methods of processing sweet potatoes or grains of wheat. Infants first learn to eat seasoned or washed pieces of sweet potato, or floating grains of wheat, by gathering others' leftovers. They then begin to engage in SPW or WPM behavior by themselves.

Now, SPW behavior can be seen everywhere on the beach whenever sweet potatoes are given. However, wheat placer mining has become less common. The main reason for this is that the amount of provisioning has been reduced because the population of monkeys on Koshima Island became too large (Watanabe et al. 1992). Potatoes are now given only a few times per year. Sweet potato washing and wheat placer mining began under provisioning, so it is quite natural that these behaviors should have changed as the degree of provisioning has changed.

There is another reason why wheat placer mining behavior has become less common. Imagine the snatching behavior described above. Now that the amount of provisioning is reduced, the competition for wheat is much more severe. Monkeys lose wheat if they throw grains into the water because dominant individuals will snatch them away; it is better to pick them up and eat them directly from the ground. Wheat placer mining can be seen when the monkeys have almost finished eating and there are still a few grains left on the ground mixed with sand. In the case of sweet potato washing, however, the animals can run away carrying the sweet potato in their hands if a dominant monkey approaches. The fact that one or two pieces of sweet potato per monkey are enough is also relevant. For these reasons, wheat placer mining has become less common but sweet potato washing can be seen even under greatly reduced provisioning. In addition, seasoning is now the predominant behavior type in sweet potato washing, and real washing has become very rare. In the 1960s, all sweet potatoes were covered with soil, while now they have already been washed in the market, and there is no need for the monkeys to wash off the soil.

Table 6. Precultural behaviors and the sand-digging test

Result of sand-digging test	No. of newly acquired behaviors				
	0	1	2	3	4
A, B			2	7	13
C, D		6	2	3	
E	3	3	1		1[a]

[a] Uncertain result because of a failure to do an appropriate test.
The results of the tests were classified from A (best) to E (worst).
The numbers of individuals are shown in each category.

Another change for the Koshima monkeys is that they have begun to eat fish (Watanabe 1989). Fish-eating was first reported to happen sporadically among adult males, and initially the habit did not spread to other troop members. In 1982, about 3 years after the first observation, four adult females were observed to eat raw fish. This was the turning point for this habit to spread among the troop. Most members then began to eat raw fish, and this continued until 1986. The reason may be that the population had increased to about 100 at that time, which caused a scarcity of food.

Besides the intensive observation of the behavior of the monkeys, some field experiments were conducted on Koshima. In 1961, Kawai developed a simple test called the "sand-digging test." A human experimenter buried a peanut on the beach in front of a monkey. Then all traces of disturbed sand were carefully smoothed away. When Ego was tested, she immediately dug out the peanut. Later, Kawai and colleagues conducted a systematic study of this sand-digging test on the Koshima monkeys (Tsumori et al. 1965). Eighteen monkeys easily found the peanut. Five other monkeys found it in the second trial. The results for each monkey were classified into five grades from A (best) to E (worst). A correlation was found between the results of the sand-digging test and the number of precultural behaviors they acquired (Table 6). Another experimental study was conducted by Higuchi (1992). He introduced an open operant box to the island, and examined the acquisition and propagation of panel-pressing behavior. Out of 74 monkeys in the troop, 34 acquired the panel-pressing behavior. He concluded that most of the transmission of this behavior occurred through local enhancement, along with individual trial and error.

Imo, the originator of SPW and WPM behavior, died on May 21, 1972, but she is still alive in current literature (e.g., de Waal 1999; Vogel 1999). Ironically, discussions about cultural phenomena in animals have become heated since her death. Galef (1990, 1992) picked up the example of sweet-potato washing to argue about imitation and culture in animals, Visalberghi and Fragaszy (1990) conducted experimental studies on the emergence and diffusion of food-washing behavior in captive capuchin monkeys and crab-eating macaques, and Tomasello et al. (1993) discussed cultural learning in human and nonhuman primates.

Longitudinal observations of free-ranging Japanese monkeys have added two other examples of social transmission of behavior. The first is "stone-handling,"

which was seen in the Arashiyama troop (Huffman 1984, 1996; Huffman and Quiatt 1986). A 3-year-old female began to handle stones in a peculiar manner in 1979, and this stone-handling behavior propagated to other troop members. This behavior initially spread only among individuals of the same age-class as the initiator, but subsequently passed down from older to younger individuals in successive generations. It is now a commonly seen behavior among most individuals of this troop. The second example is the technique of grooming (Tanaka 1995, 1998). Tanaka investigated the techniques of grooming in the Shiga-A troop, and identified four patterns of grooming behavior. An analysis of the distribution of each technique in three maternal lineages showed the possibility of social transmission of the grooming technique from adults to infants.

By looking at animals other than Japanese monkeys, we can find very conspicuous examples of "chimpanzee cultures." Longitudinal investigations of wild chimpanzees at several different sites in Africa have been clarifying the behavioral diversity between different study sites, which cannot be explained by ecological or genetic theories (Goodall 1973; McGrew 1992; Wrangham et al. 1994; Sugiyama 1997; Boesch 1996; Matsuzawa 1998; Whiten et al. 1999).

5 Back to the Question of Culture

Half a century has passed since the start of the research on Koshima monkeys. The study of nonhuman primates has accumulated data from both the field and the laboratory, and by both naturalistic observation and experimental manipulation. Have we succeeded in casting a different light on human culture by keeping our outlook broader? The examples from Koshima Island clearly show that the social transmission of behavior occurs in Japanese monkey society, but it seems to be inappropriate to answer yes or no to the question of whether nonhuman primates have culture. A valuable way forward would be, as Kawamura (1956, 1965) remarked, to trace each step and consider the evolutionary pathway (e.g., van Shaik et al. 1999). In the first place, intensive and longitudinal observations have revealed highly organized permanent social structures in many species of monkeys and apes. Such permanent group living is, as Imanishi (1952) suggested, one condition for the establishment of a culture. In the second place, studies of social learning in animals have revealed more precise mechanisms of social transmission of a behavior. The process of social learning is now divided into several categories, such as social facilitation, stimulus enhancement, emulation, program-level imitation, action-level imitation, etc. (Tomasello 1990; Byrne and Russon 1998). In these terms, the growing body of knowledge has been making it clear that imitation is more difficult for nonhuman primates than was expected in the 1950s: monkeys do not imitate, but are influenced by stimulus enhancement (Visalberghi and Fragaszy 1990); chimpanzees do emulate, and much less frequently they imitate (Whiten et al. 1996). In addition, monkeys do not teach others to do anything, and chimpanzees only do so extremely rarely (Boesch 1991). Therefore, it can be said that imitation and teaching, the two most important elements in human ma-

terial culture, cannot be found in monkeys, and is only seen in chimpanzees to a very limited extent (Myowa-Yamakoshi and Matsuzawa 1999). However, the transmission of material culture in humans is not always accompanied by teaching and imitation either. The fact that human children imitate does not mean that they always imitate (Whiten et al. 1996). It is quite natural to assume that stimulus enhancement and emulation are involved in some cases of the transmission of cultural phenomena in humans as well as imitation and teaching. Although recent experimental studies have been trying to distinguish and separate every social learning process, it is also possible to look at the problem in reverse, that is, we could also try to find a link between stimulus enhancement, emulation, and imitation in terms of cognitive mechanisms.

Drawing a line between culture and nonculture is beyond the scope of this paper. Instead, we would like to conclude by saying that humans and monkeys might share some traits in the social mechanism and cognitive capacity which comprise human culture, and this is more true for apes and humans. The invention and propagation of precultural behaviors shown by Koshima monkeys are valuable examples when thinking of such phenomena. In Koshima, the sixth generation descendants of the monkeys in the initial study periods are still engaging in sweet-potato washing.

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