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Paleoenvironment and Human Settlement in Japan and Korea

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New paleoenvironmental data and a wider knowledge of variation in the archeological record allow us to draw a fuller picture of the post-Pleistocene cultures of the Japanese islands and the Korean peninsula. Although the historical relationships between these early cultures are not well understood, they can be seen as "mesolithic" cultural units sharing not only the same general environmental zones but also many similar patterns of adaptations. In this article I discuss the environmental conditions in the general area as they are coming to be known, and the trend of human settlement and subsistence.

The Japanese Islands

Environment. In the original analysis of the postglacial climate of Japan, Fuji (*1*) defined seven major periods on the basis of palynology. These climatic stages were seen by Fuji to correspond satisfactorily with results obtained in various parts of the world, except for a cool stage found in Japan from 4000 to 1500 years ago. Yasuda (*2*, *3*) has compressed the seven major periods of Fuji into five periods, L, RI, RII, RIIIa, and RIIIb (Fig. 1). In the first period, L, 12,000 to 11,000 years ago, the climate was cooler than at present. Fuji was able to discern within this period three phases, during which the vegetation changed from a dominance in the pollen spectrum of beech, fir, and larch (*Fagus*, *Abies*, and *Larix*) to shrubs and grasses (*Corylus* and Gramineae) and back to beech, fir, and larch. The period of maximum cold is thought to correlate with a warm period in Europe known as the Allerod, which began some 12,000 years ago. The next stage, RI, 11,000 to 8000 years before present, is transitional from the Late Glacial to the Postglacial Climatic Optimum. The dominant pollen grains are oak (*Quercus*) or pine (*Pinus*) with *Picea* and *Fagus* as generally subordinate associates.

The third major unit is the Postglacial Climatic Optimum, the RII period of the C phase in the original scheme of Fuji, which dates from 8000 to 4000 years ago. This period of maximum warmth appears to be correlated with the Flandrian transgression in Western Europe.

A cool stage (RIIIa, from 4000 to 1500 years ago) followed this. The characteristic forest at this time was comprised of a mixed flora of evergreen trees and *Fagus crenata*. The dominant pollen types are *Cryptomeria* (Japanese cypress), *Castanea* (chestnut), and pine. Finally, the present climatic stage began 1500 years ago.

Coinciding with the height of the Postglacial Climatic Optimum was the Jomon marine transgression, which reached its peak about 7000 years ago and stopped about 5000 years ago (*4*). Higher sea levels brought about flooding of the coastal lands and transgression of the river valleys. The present deltaic plains of Japan probably began some 5000 years ago, subsequent sea-level oscillations being of low magnitude. From the sedimentological analysis of subsurface samples, it seems that the environment of deposition of the Japanese coastal area changed from fresh or brackish water to marine water in the early Holocene (*5*). This means that saltwater conditions prevailed along the shores, backwaters, and coastal flats, except where large rivers maintained a strong enough flow of fresh water.

From the analysis of shell midden deposits and Holocene beach deposits from the Postglacial Climatic Optimum, Matsushima and Oshima (*6*) have shown that warm-water molluscan fauna grew substantially farther north than they do at present. Shellfish that are now found only as far north as northern Honshu were distributed as far north as northern Hokkaido (see Fig. 2), and it is thought that the maximum surface water temperature was 5°C higher than at present. If we look at southern Japan, the ocean temperature difference between the Climatic Optimum and the present is not so conspicuous. In two recent articles, Yasuda (*2*, *3*) has correlated the climatic data with the cultural chronology of the Jomon period, as shown in Fig. 1.

During the Late Paleolithic, Hokkaido, from the north coast to the central portion, was a kind of parkland. From the Oshima Peninsula to Tohoku, northern Kanto, and the central mountain range, the dominant species appear to be spruce, beech, and elm (*Picea, Fagus*, and *Ulmus*). At the same time, the southwestern portion of Japan was covered by a lowland forest in which *Quercus, Fagus, Ulmus, Zelkova*, and *Celtis* were predominant. Hayashi (*7*) has pointed out that two different Paleolithic traditions in manufacturing technique and shape of stone tools are found in northeastern and southwestern Japan at this period, the blade point tradition, in which tools made on long stone blades predominate, and the wedge-shaped core, microblade tradition, in which most of the tools are microlithic and consist of small blades removed from a core which is short and pointed. The interrelationships between these tool assemblages and vegetation zones have yet to be worked out in terms of specific subsistence activities.

Japan is famous for having the oldest

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ceramics in the world. Some Japanese authors consider these early ceramics to be part of the tradition of later ceramics termed Jomon, while others consider the earliest pottery to be in a separate category termed pre-Jomon. I am following Yasuda, who considers all the pottery to be part of the Jomon tradition. The earliest Jomon pottery in Japan belongs to the climatic period termed RI (see Fig. 1), in which the dominant pollen type in northeastern Japan was birch (*Betula*), while broadleaf deciduous trees preferring slightly warmer conditions, such as oak (*Quercus*), dominated the vegetation of southwestern Japan. Thus the forests of southwestern Japan were not comprised of broadleaf evergreens, as they were in later periods of the Jomon; specifically, broadleaf evergreen trees which are later common in southwestern Japan, such as *Cyclobalanopsis* and *Shiia*, are not represented palynologically. Thus Jomon culture began in a cool post-Pleistocene climate.

The Jomon culture of Japan has been divided into five chronological subdivisions (Earliest, Early, Middle, Late, and Latest) and a number of areal groupings on the basis of different styles of decoration and manufacture of pottery. At the time of Early Jomon (period RII) there were three vegetational zones which seem to coincide with local cultural groupings. The first is the northeastern broadleaf forest, dominated by birch (*Betula*); in this area the major type of Early Jomon pottery has decoration composed of lines incised on the surface of the clay. In southwestern Japan, broadleaf evergreen forest coincides with the area of pottery with impressed decoration (Japanese *oshigata mon*). In the central area, where the vessels have distinctive shapes as well as surface decoration, a predominance of oak (*Quercus*), elm (*Ulmus*), and *Zelkova* (related to elm) is noted at this period. The Jomon marine transgression mentioned above, which reached its height in Early Jomon time, reduced the amount of low-lying land and altered coastlines; this may have led to more intensive subsistence patterns to maintain food levels on less territory, and to the dislocation and movement of people. In addition, the development of increased fishing activities may have stimulated movement between Kyushu and Korea, and Kyushu and the Ryukyus, for it is at this time that we can see close similarities between the Early Jomon incised pottery of the Sobata type of Kyushu and the incised pottery of Korea of the same age (roughly 4000 to 3000 B.C.) which is termed Comb Pattern or Geometric. Recent survey work in the Ryukyus (*8*) has yielded pottery which resembles the Early Jomon pottery types of Kyushu, with decoration consisting of incisions (Sobata type) or applied strips of clay (Todoroki type). Until this recent work, the earliest pottery in the Ryukyus was thought to be of Middle or Late Jomon age.

After the Early Jomon the pattern seems to have been set, with little change in cultural groupings or vegetative zones until the Latest Jomon. Seven cultural subgroupings can be seen in Japan until the Latest Jomon, which follows the time period of the Postglacial Climatic Optimum. In this period northeastern Japan—the general area yielding pottery with very elaborate curvilinear decoration and a wide variety of vessel shapes, called the Kamegaoka style—and the central mountain area of Japan were clothed in forests of beech, cypress, and oak (*Fagus*, *Cryptomeria*, and *Quercus*), while in southern Kanto and the area to the west *Quercus* and *Alnus* predominate in the pollen spectrum.

What impact did the people of the Jomon and the Yayoi period which followed it have on the forests of Japan? Local pollen analyses, done at archeological sites and at stations some distance from the sites, provide interesting new data. Pollen analysis of samples from an Early Jomon shell mound at Ugasaki, Natori City, Miyagi Prefecture, shows an abundance of *Pinus* and *Polypodium* (fern). In samples from a nearby mountain bog, however, *Fagus* and *Quercus* were abundant but no pine was present (*2*, p. 119). A similar situation was noted in the Kamo site, Chiba Prefecture, where analysis of pollen from the actual site showed a high frequency of pine, while pine pollen was not found in samples taken some distance from the site.

In Aomori Prefecture pollen samples from the Kamegaoka site showed a high frequency of *Aesculus* pollen in the Latest Jomon. There seems to have been a deliberate selection for *Aesculus* trees around the house, even though the lowland forest of Aomori, on other palynological evidence, was dominated by *Fagus*, *Quercus*, and *Alnus* (*2*, p. 124). The activities of Jomon people created temporary clearings where pine and other secondary vegetation grew, but these areas later returned to the original climax vegetation. The impact of Yayoi cultivators, on the other hand, was more lasting. Analysis of pollen from a number of strata of the Uryudo site, dating to early middle Yayoi and located in Higashi Osaka City, showed that before the construction of the settlement the forest vegetation was *Cyclobalanopsis*, *Shiia*, and *Castanea* (along with other less abundant species). Contemporary with the

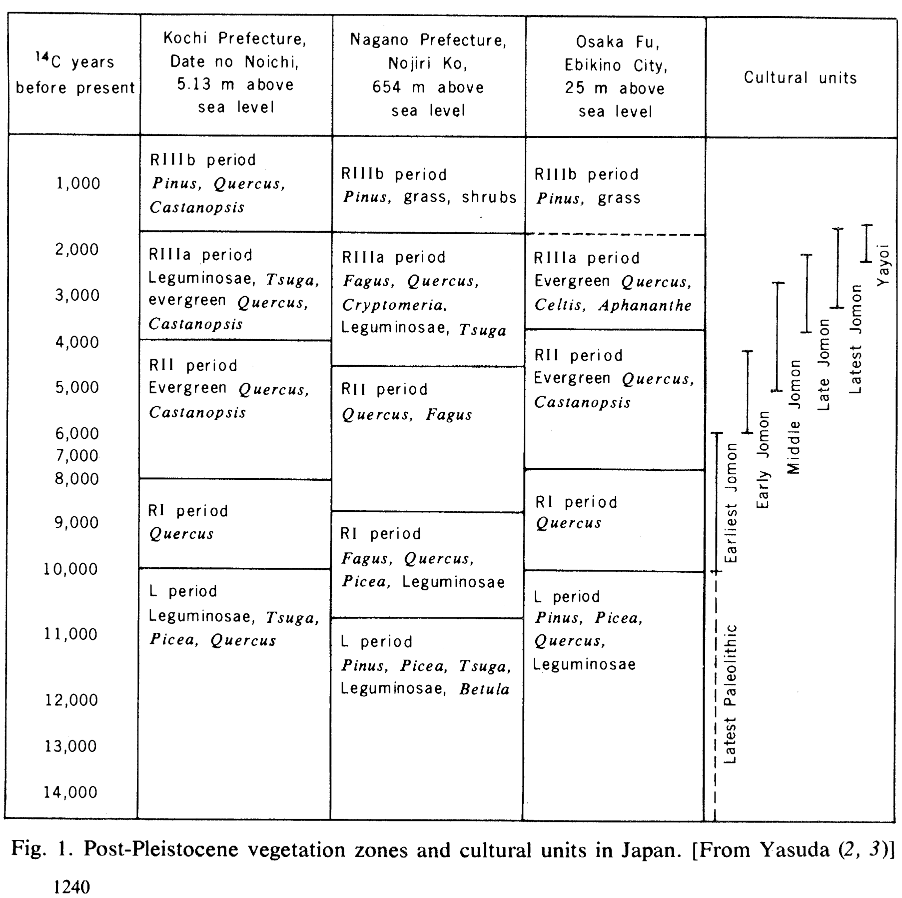

Fig. 1. Post-Pleistocene vegetation zones and cultural units in Japan. [From Yasuda (*2*, *3*)]

Yayoi settlement there was an increase in Gramineae and Polypodiacea, showing the creation of open areas. After the period of settlement, the site environs show forest growth, but it is secondary forest, characterized by *Cyclobalanopsis*, *Cryptomeria*, and *Pinus*. As one further example, the site of Kamihigashi, Okayama Prefecture, shows *Cyclobalanopsis, Quercus, Shiia, Castanea*, and *Abies*. In the layer dated as late Yayoi there is an increase in *Rumex*, Chenopodiaeceae, *Artemisia*, and Gramineae. Thus the effect of Yayoi cultivation on the forest of Japan was much more profound and long-lasting than that of the clearings made by Jōmon peoples.

Settlement. Sugawara (*9*) has provided an interesting descriptive model of the nature of Jomon settlement. He states that in the first part of the Earliest Jomon, sites were in natural caves or rock shelters. The location of the Nishi Karatsu site in Kyushu, about 2 meters underwater, suggests that in the later part of the Earliest Jomon, the sea level in parts of Kyushu, if not in other areas, was at least several meters lower. In addition, Wajima *et al.* (*10*) found that at the Oda site (Tensui machi, Tamana gun, Kumamoto Prefecture), even in the Middle Jomon, the time of the postulated transgression, the water level was not as high as it is at present. This appears to be a local phenomenon created by tectonic shifting around Mount Aso. (The locations of sites in Japan and Korea are presented in Fig. 2.) During the first part of the Earliest Jomon, ceramics were first manufactured, or perhaps introduced (*11*), by groups with the two lithic traditions mentioned above—one characterized by microblades from wedge-shaped cores, and the other by flake points and knives and edge-ground axes.

By the middle of the Earliest Jomon, sites were located not only inland but also along the coast, as indicated by small shell middens. In the first pit houses, found in the later part of the Earliest Jomon, the hearths are not within the houses but outside nearby. Jomon sites of later time periods contain a large number of house remains, often several dozen, yet only a small number of houses were occupied at one time. In the case of the Kanto area the number of houses in each village was two to four for Earliest Jomon, five to six for Early Jomon, six to eight for Middle and Late Jomon, and four to five for Latest Jomon (*9*, p. 59).

The pattern of development in the villages seems to have been for two small groups of houses to occupy a small flat high area in an unequal distribution of the space available, and it was common for each of the two major groups to split again. Archeologists have also found that in one of the two groups house remains tend to overlap, while in the other they are scattered. In addition there are often smaller houses, which may be at the base of the raised flat area of the main site or may be near the other houses. The house foundation in this case is often shaped like a flask, with a bulging subterranean portion. These houses appear to have been for communal use by village members, and at different locations in the Kanto area they have been found filled with fishbones or nuts, or with burials in them. Usually in the middle portion of the site there is a flat area which does not contain any artifacts, but sometimes this area contains a pavement or a group of standing stones. This public or common space, which was apparently used for festivals, does not occur at the coastal shell-mound sites. It has been suggested that the occupants of such sites were probably inland in the autumn, when such ritual facilities would be used.

Another major constituent of the village is a work area. In some sites, such as the Shiomidai site in Kanagawa Prefecture (Fig. 3), areas where stone artifacts were produced have been found around the perimeter. Footpaths between the houses seem to be recognizable in some cases. Burials are located in a number of areas, but are not clearly demarcated in cemeteries or accompanied by grave goods. They usually occur near each house or in the shell midden area, or in the small communal houses mentioned above.

Site location and village interrelationships. The postulation of intersite relationships is based primarily on the sharing of pottery types, particularly local subvariants. Sugawara (*9*, pp. 59–

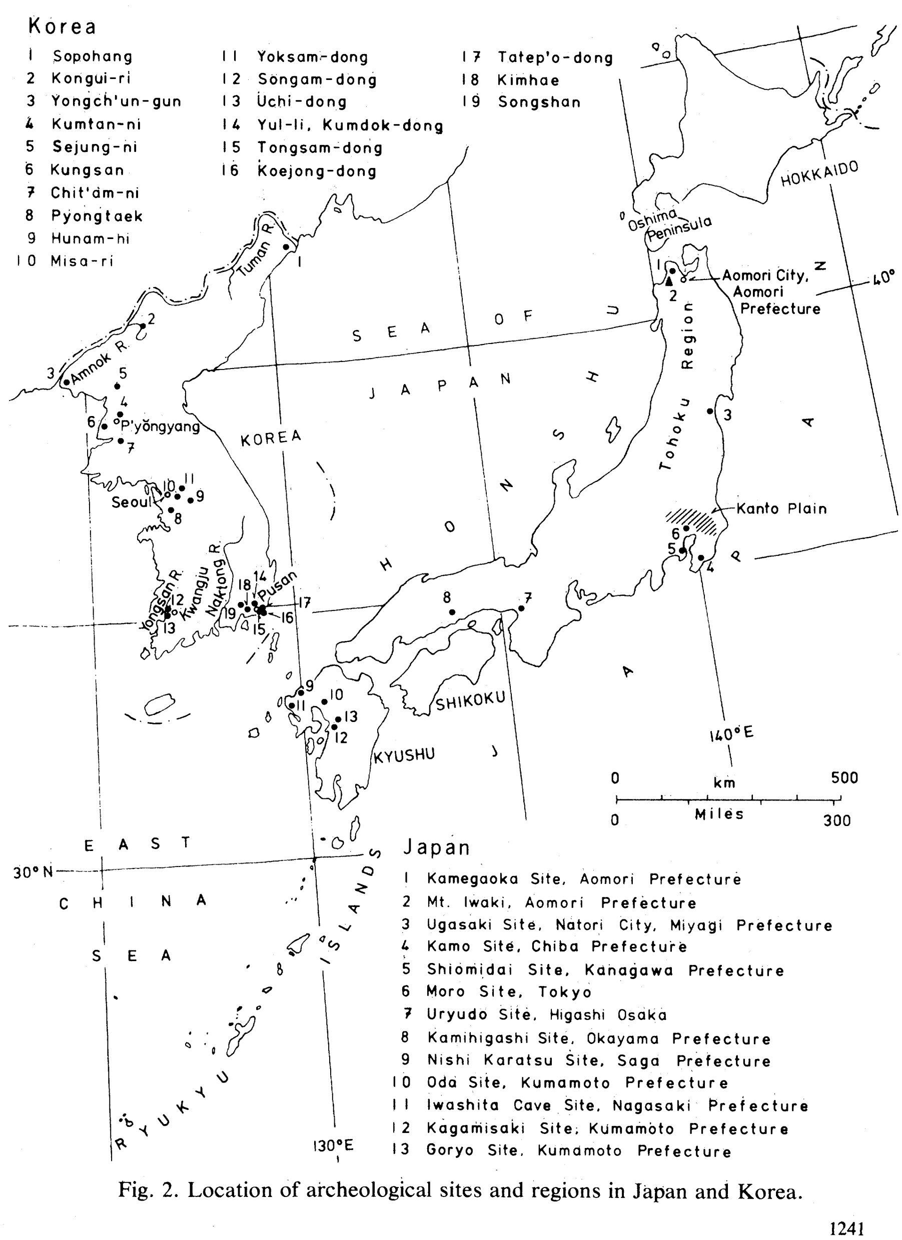

Fig. 2. Location of archeological sites and regions in Japan and Korea.

63) gives several examples of postulated intersite relationships. On the slopes of Mount Iwaki, in Aomori Prefecture, groups of sites are found on the east, west, and south of the mountain. The western group appears to have been isolated from the others. The northern and eastern groups are composed of sites dated as Early, Middle, Late, and Latest Jomon. In each of these groups there is a stone pavement and a group of standing stones. In particular, the western group has a large stone circle, and near it a very large house, 12 by 13 m, dated as Latest Jomon.

Another example, from the coastline of Chiba Prefecture near Chiba City, is also presented by Sugawara. In this case the investigation of a very large number of sites, no doubt partly as the result of salvage excavations, makes it possible to detect shifts in settlement. There are four sites from Earliest Jomon, six from Early Jomon, 31 from Middle Jomon, 40 from Late Jomon, and five from Latest Jomon. Settlement in the Earliest and Early Jomon was along the edge of Tokyo Bay. In the later part of the Middle Jomon saddle or arc-shaped shell deposits are situated at 2-kilometer intervals all along the interior ridges, and the peak of occupation occurred in the Late Jomon. A similar pattern of inland settlement in the Late and Latest Jomon seems to be indicated in the pattern of site distribution near Kumamoto City, Kyushu (Fig. 4) (*12*).

The effects on settlement location of gathering marine resources, such as shellfish and fish, have been studied in some detail. The development of shellfish gathering in Kyushu, for instance, has been divided into four stages (*12*, p. 150). Stage 1, which can be termed initial or incipient shellfish collecting, is dated to the Earliest Jomon. An example of this is the site of Iwashita Cave, in the middle reaches of the Ainoura River 9 km from its mouth, on the top terrace of the river some 200 m above the river level. At this site block sampling for nonartifactual remains was used. Small quantities of shell were found in layers II to IV, which cover the Earliest and Early Jomon. The pottery was predominantly Sobata, Todoroki, and Ataka. Ikawa-Smith (*11*) has suggested that by Late Paleolithic time inhabitants of sites such as Moro in Tokyo were using heated stones for boiling, judging from the remains of fire-cracked rocks. Pottery made the preparation of shellfish more efficient and was important in furthering the adaptation to coastal areas.

Stage 2, when there was an increase in shellfish collecting, seems to be correlated with the Early Jomon, and Todoroki pottery has been found in these sites. A set of fishing tools, associated with Ataka pottery in Kyushu, appears at this time. The typical form of the northwestern Kyushu fishhook is an integral part of this, along with pointed chipped pebbles, which may have been used to open shellfish. "Stone saws," which may have been used as rough fish-processing tools, appeared at the same time, and are said by Yamazaki (*12*, p. 156) to be known from the Korean peninsula. There is also a strong possibility that the fishing-related tools are associated with Early Jomon Sobata pottery as well.

In Stage 3 shellfish collecting seems to have been the main occupation of the inhabitants of Kyushu, and often up to 99 percent of the shellfish are from the same species. The Kagamisaki and Goryo shell mounds of Kumamoto Prefecture correspond to this stage. Shell middens here are much larger and more abundant than earlier ones, and shellfish collecting seems to have been more intensified.

By Stage 4, the subsistence base seems to have changed and shellfish collecting has declined. This may have been due in part to specialization of gathering of land resources or incipient cultivation.

Similarly, Watanabe (*13*) notes that fishing in Japan has gone through a number of stages of development. In Stage 1 it was confined to the inner bays. Net fishing was not used actively, and the kinds of fish caught with nets varied a great deal. There appears to be no evidence for the use of hooks except in the extreme north (Hokkaido or the northern tip of Tohoku). The time period for Stage 1 seems to be from the period of Natsushima pottery (Earliest Jomon) through the Middle Jomon. In Stage 2, as seen in the eastern Kanto area near Tokyo, nets were used and deep-sea fishing was undertaken. Bonito (Japanese *maguro*) were caught at this time. Detachable harpoon heads were developed in the Tohoku area. In Stage 3, which began in the latter part of the Middle Jomon, fishing became a local specialty. This seems to be related in part to the regional production of salt and specialized artifacts for its production through evaporation.

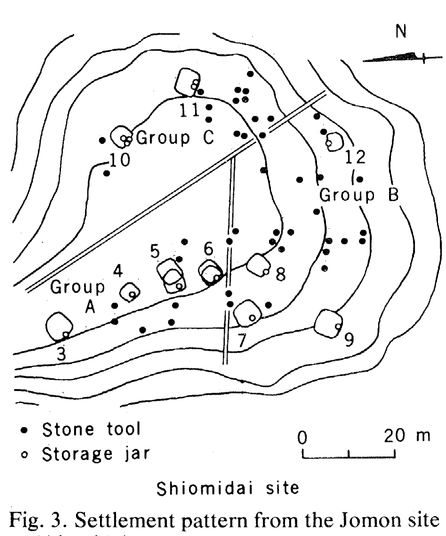

Fig. 3. Settlement pattern from the Jomon site at Shiomidai, Kanagawa, Japan.

The intensification of collecting of land resources in Middle and Late Jomon has been documented by many authors and summarized in various journals (*14*).

The Korean Peninsula

Environment. Similar temperature and vegetation zones extend across the Korean peninsula and Japan (*15*). They include semitropical broadleaf evergreen vegetation in southern Korea, which is similar to that of southwestern Japan; mixed mesophytic forest; deciduous broad-leaved forest predominated by deciduous oaks; mixed northern hardwood forests of maple, basswood, and oak; and montane coniferous forests predominated by spruce and fir (*16*). In the absence of a large body of palynological data, we do not know the patterns of distribution and change of vegetation in prehistory. However, it seems likely that vegetation zones shifted north during the Postglacial Climatic Optimum, creating a wider band of broadleaf evergreen forest in the south than we can find at present. Coinciding with climatic amelioration was a marine transgression, which changed the form of many river valleys, flooding their deeper portions and providing conditions for the buildup of deltas and broad alluvial areas. For instance, Kwon (*17*) states that boring in the Naktong Delta seems to show a pre-Recent erosional valley more than 50 m deep below the present delta. The delta appears to have started with the incursion of the sea in post-Pleistocene time.

The topography of western and southern Korea has recently been described (*18*) as "conical hills and small isolated mountains" in which generalized dissection has left peaks isolated on all sides by depressions. In coastal areas the hills, either high or low, are generally surrounded by wide alluvial plains, which have been reclaimed for rice production.

At present not enough evidence is available to reconstruct the environment of post-Pleistocene Korea. The finding of bones of bovids resembling water buffalo in a number of North Korean sites (*19*) suggests that the climate was warmer at some period in the past, which may coincide with the Postglacial Climatic Optimum. Oh's analysis (*20*) of pollen from a deposit near Pyongtaek can be interpreted to mean that the subsequent climate was moister and cooler. However, these are only suggestions at this point. Faunal remains from sites in the north analyzed by S. K. Kim (*19*) appear to indicate that groups in the eastern and western portions of the northern peninsula differed in their dependence on animals.

Settlement. On the basis of different kinds of ceramics and stone tools, Korean prehistorians have established two major cultural divisions, the Comb Pattern Pottery or Geometric Pottery period (roughly 4000 to 1500 B.C.) and the Plain Pottery period (1500 B.C. in northern Korea, 1000 in southern Korea to about 300 B.C.). The first is characterized by pottery with incised decoration in chevrons or meanders, and a preagricultural subsistence pattern with possible incipient agriculture at the end of the period, while the second is marked by undecorated coarse orangish pottery and the presence of agriculture. Bronze objects have been found in some of the later Plain Pottery sites. The sites of Sopohang, Yongch'un-gun, Kumtan-ni, Sejung-ni, Kungsan, Chit'am-ni, and Misari, are of the Comb Pattern Pottery period, while those of Kongui-ri, Hunam-ni, Songam-dong, Yoksam-dong, Uchi-dong, Kumgok-dong, and Koejong-dong are all of the Plain Pottery period. (Kumgok-dong has components from both cultures.) Kimhae, Songshan, and Tongnae were occupied at the end of the Plain Pottery period and in the succeeding iron-using Kimhae-Ung-ch'on period (300 B.C. to A.D. 100).

Complete excavations of occupation layers or even of wide areas of a single site have not yet been undertaken in Korea. Thus, at present there are few clues to the relationship between activity areas and houses. In addition, some of the sites have deep deposits of many cultural layers, which makes the examination of single occupations more difficult and time- and labor-consuming. In most cases, such as the sites of Sopohang, Kungsan, and Chit'am-ni, excavations have presented a sample of dwellings from different strata in the site; however, there are questions about the simultaneous occupation of houses within each layer, since some house pits were cut through each other and some appear too close to each other to have been lived in at the same time.

Sequences of house forms have been reconstructed for the northeast and northwest. For the former, the site of Sopohang has yielded the greatest amount of information. Dwelling site 9, found in the bottom layer at Sopohang, is of great interest since it is clearly the earliest on stratigraphic grounds and is also the largest—72 m^2. The pit house has a depth of more than 1 m and the floor area is hardened by fire. There are five fireplaces; the two outer ones are lined with stones and the three central ones have an accumulation of river pebbles in the bottom. The first two are thought to have been used for smoky fires, perhaps in starting wood burning, while the three central ones are thought to have been used for cooking on hot coals. There are no postholes. The roof goes right to the ground and also serves as a wall. This period appears to coincide with the Early Jomon of Japan. In the second period, the houses are round or rectangular and the average area is 13.4 m^2. The bottom is spread with clay and fired. Most of the examples have postholes and stone linings for the hearths. The roof structure appears to be conical, and the depth of the house pit is 70 to 80 cm. In the third, fourth, and fifth periods, which would coincide with the Middle Jomon, the houses appear to be about 20 m^2 in area. They are rectangular in floor plan and seem to have developed ridge beams and king beams which extended from horizontal supports. It is thought that in the third period the bottoms of the houses were not fire-hardened, suggesting the use of mats or skins.

In the Hwanghae area of northern Korea, a sequence of house types has been constructed from the remains at Kung-

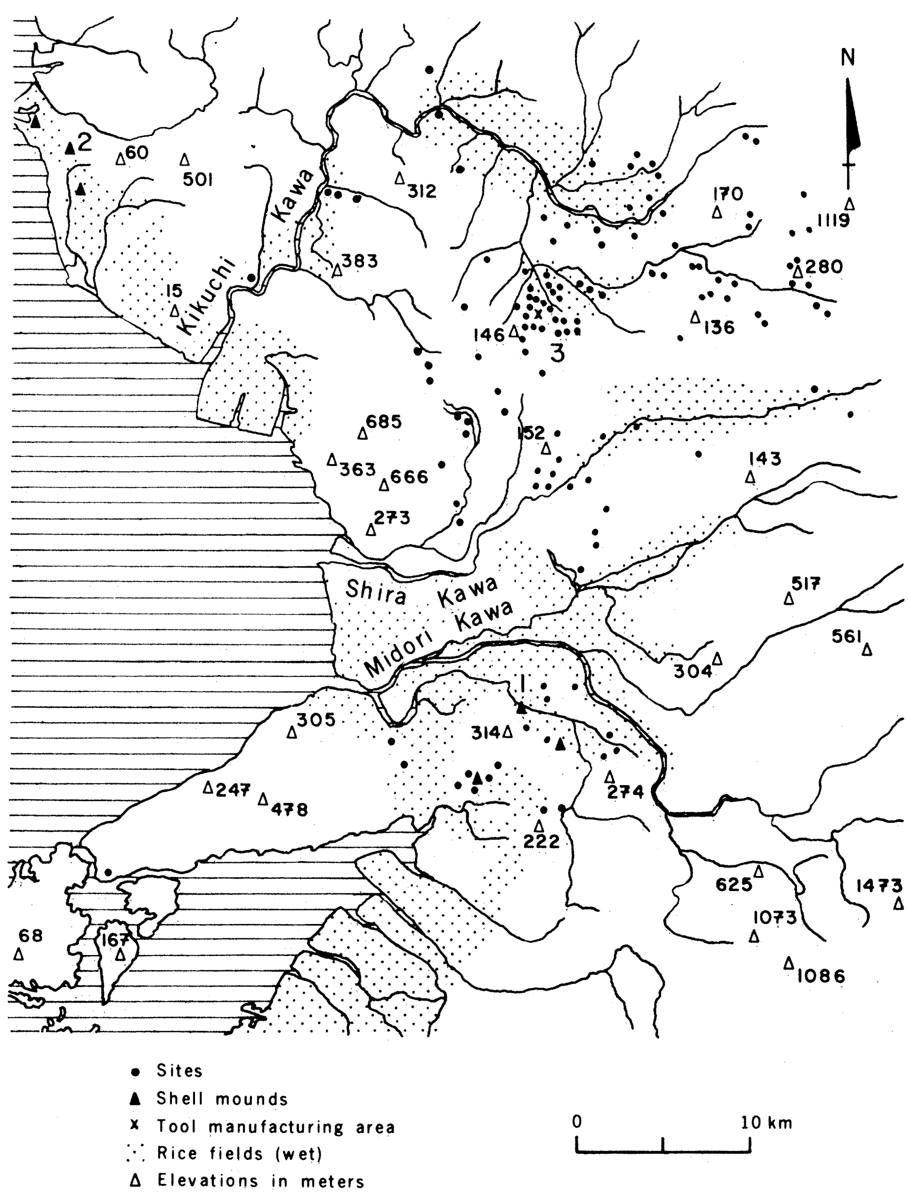

Fig. 4. Distribution of Latest Jomon sites in the Kumamoto area, Kyushu, Japan.

san, Chit'am-ni, and Kumtan-ni. While the floor area did not seem to deviate throughout these time periods from a norm of about 20 m², in later periods the roof beams became more elaborate while the hearths became more simplified. In the later layer of Kumtan-ni, for instance, which might date to the third millennium B.C., the fireplaces have no stone linings or extra accoutrements and there is only one storage pit in each house. This suggests that cooking may have been done outside or in separate houses and that most of the storage may have been outside in separate facilities. Multiple storage pits were common in the earlier house components such as Chit'am-ni houses 1 and 3. At the Kungsan site, a number of deliberately excavated exterior fire pits were found. However their relation to the houses could not be precisely ascertained (*21*).

In the Amnok (Yalu) River basin, sites from Yongch'un-gun have yielded long rectangular houses dug into the ground to a depth of less than 30 cm. They range in floor area from 20 to 30 m². The pattern of these sites, including the Ssang-ta-ja site on the southern Liaotung Peninsula, which is said to belong to the fourth millennium, is different from that of other Korean sites, according to Y.-N. Kim *et al.* (*22*).

The great size of the earliest house found at Sopohang raises several questions. Perhaps the house was a large communal structure rather than a regular dwelling site, in which case Sopohang layer V would resemble some of the Jomon settlements that we have mentioned above. Or it may be that the earliest dwellings in this region of Korea take their form from the prehistoric houses of the Soviet maritime province, although the ones that are best known appear to be later in date (*23*).

From a sample of about ten house sites of the Comb Pattern Pottery period and about 60 house sites of the Bronze Age, C.-K. Kim (*24*) drew the following conclusions about the use of dwelling space. In the Comb Pattern period working space seems to be clearly indicated, often on the eastern side of the house, while the living area is on the west, along with the fire pit. This can be seen in Chit'am-ni. Houses vary in area from 49 m² (Chit'am-ni house 1) to 9 m². Kim suggests that the norm was 18 m² and that the house accommodated two adults, two grown children, and two babies. In the Bronze Age (middle and late first millennium B.C.) the norm seems to be about 20 m², and the house again accommodated two adults, two grown children, and two babies. The range of sizes is particularly interesting. In the sample examined there were 11 floor areas of 20 m², eight of 50 m², and a total of five of 30, 40, or 60 m². However, there was only one example of 45 m² and one of 55 m². Kim's conclusion is that 10 m² is the most significant unit in the houses, and that this represents the space for one adult couple. The wide range of house areas is particularly difficult to interpret, in my opinion, and the normative approach of Kim does little to explain the synchronous intersite or intrasite differences.

In the Amnok Ch'ung Ch'ong area, houses in the Konggye-ri site averaged 70 m². These are long, large, rectangular houses which are similar, perhaps in time period and in form, to the house from the Yoksam-dong site (*25*). At the same time other sites, such as Sejung-ni, dated to the early part of the second millennium B.C. have yielded several small houses with areas of about 12 m², and Ssang-tol-ja, which is thought to be considerably later, has yielded houses with areas of about 15 m².

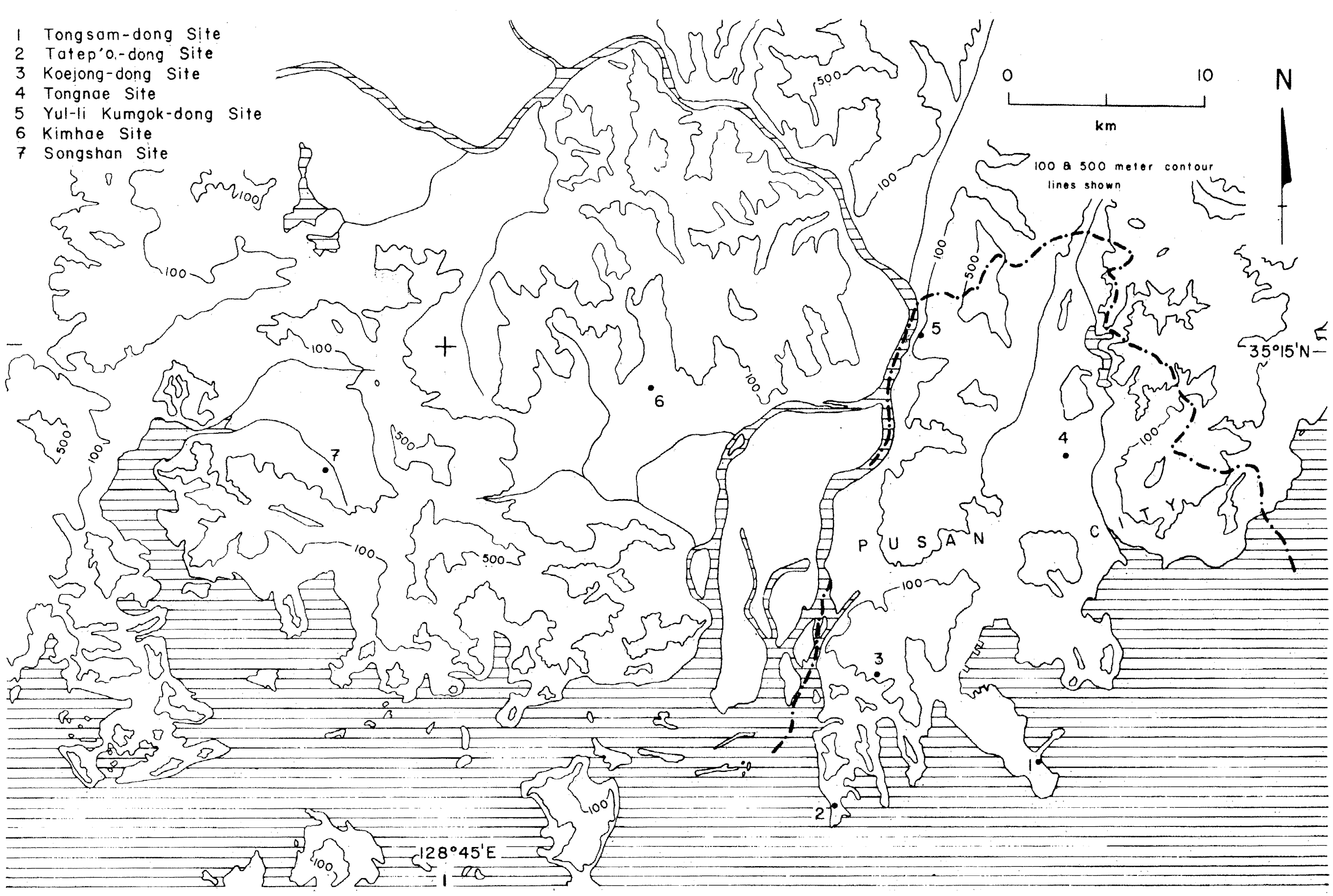

Fig. 5. Location of archeological sites in southeastern Korea.

Site location and village interrelationships. Some idea of changing patterns of site location can be provided from the Han River near Seoul and from the Pusan area. Nelson's study (*26*) of a number of Comb Pattern sites to the east of Seoul, in the vicinity of Misa-ri, on the basis of surface-collected ceramics, seems to indicate that most of the sites were contemporaneous (this seems difficult to establish with her samples and methods) and that they were spaced about 2 km apart. She postulated that the inhabitants were supported by collected resources and some incipient cultivation. While this is still conjecture, it is most useful as a working hypothesis.

In the Pusan area, the early sites such as Tongsam-dong and Tatep'o-dong are found on peninsulas or islands, away from arable bottomlands or gentle hill slopes, suggesting a high degree of maritime adaptation. They may be equivalent in time period to Early or Middle Jomon, and they seem to reflect a similar subsistence mode. Although it is difficult to determine exactly from the maps at hand, the Sopohang site in Unggi gun, in the extreme northeast corner of Korea, is also situated on a peninsula formed by the sea and the Tuman River. Within the peninsula area there is a hill some 200 m in elevation (*27*).

Later sites, which might be equivalent to Late and Latest Jomon in chronology, appear to be on higher ground, often on rather pronounced slopes. In the Pusan area (Fig. 5), Koejong-dong and Kumgok-dong, both of which seem to possess dwelling components, are found on slopes more than 50 m above sea level. The Kimhae and Songshan sites, both in southeast Korea and contemporary with Latest Jomon, are on hills surrounded by marshy areas which were rich in collectable resources and suitable for rice cultivation. Plain Pottery sites dating to the first millennium B.C. are located on hills in the Cholla nam-do area of southwest Korea as well as the Pusan area. In the vicinity of the Yongsan River, sites such as Songam-dong and Uchi-dong (*28*) near Kwangju City occur on isolated low hills. Similar site location occurs in the area of Changheung gun along the southeastern coast of Cholla (*29*). In Cholla, no Comb Pattern Pottery sites have been reported and therefore an early comparison cannot be made. It may be that coastal sites have been obliterated by alluvial deposits and subsidence, and many more may have been lost in land reclamation schemes, which began in the early days of this century.

From the few published examples of Plain Pottery sites in the Seoul area, the same pattern of habitation on hills and slopes seems to exist. The Hunam-ri site, overlooking one of the upper reaches of the Han River, some 123 m above sea level, is an example. From the distribution of surface artifacts the excavators thought that the settlement consisted of a large number of houses in a cluster; however, this still remains to be tested. The excavated houses range in size from 4.5 by 7.6 m (house 4) to 4.7 by 3.8 m (house 5) (*30*). Finally, in the North Korean site of Kongui-ri (*22*) six houses of rectangular form were all found to be connected by a ditch, the function of which has not yet been explained.

One of the greatest gaps in the Korean data concerns the interrelationships between sites. Surveys have generally been concentrated on a very few sites rather than a quadrat or region, and rapid industrial development has probably eliminated many sites around the well-known examples which have been reported for decades. For instance, in the Pusan area urban expansion has probably destroyed sites in the central city area, so that the only ones left are in isolated portions of the city along the sea. In the Plain Pottery period it appears that at least three different types of sites were utilized at the same time: dolmen sites, often found on slopes (almost never on flat alluvial plains), settlement sites on the tops of ridges, and rare shell mounds such as the ones found on Imja Island along the southwestern coast of Korea. These shell middens are located 3 to 5 m above the level of the rice fields, which appear to have been created from alluvial intertidal flats. In prehistory one can imagine that these flats were tidal marshland with abundant birds and marine animals. Detailed local studies of these different types of sites will be of great use in the future.

At the time of these Plain Pottery sites, and also by the Latest Jomon of Kyushu, rice was cultivated, although we know little at this time of the techniques used or of the effects of cultivation on local villages beyond site location. It may well be that early rice cultivators in Korea and Japan avoided the larger rivers or intertidal areas or lowest flats because they were too difficult to manipulate with small localized groups and a limited technology. In this case, the preference may have been for the gentle slopes along small stream valleys. On the other hand, the intermediate site location may reflect not so much the influence of a critical resource as a compromise between cultivated lowland resources and the collected resources of the forested slopes. More detailed midden analyses and regional sample surveys could help to elucidate these problems.

I am not making a case for environmental determinism in showing common trends in Japan and Korea. Clearly, cumulative local developments and differences in many nonmaterial domains of culture have been significant in producing local differences which cannot be monitored through archeological techniques. Nevertheless it is important to see continuities extending across East Asia, since these are often obscured by modern political and cultural boundaries. I hope that I have shown that there are similarities in the structure of the adaptation, as well as in specific content, which are worth a great deal of further scrutiny.

Summary

The climate of Japan changed from cooler than present (12,000 to 11,000 years ago) to warmer than present (8000 to 4000 years ago) to cooler than present (4000 to 1500 years ago). The height of the warm period coincides with the Jomon marine transgression, which flooded coastal lands and invaded river valleys. The Jomon culture of the post-Pleistocene shows changes in subsistence patterns and site location at different time periods. Although it is very long and there is definite cultural continuity, shifts in settlement patterns and the development of fishing and collecting techniques show that it was not static. Village layouts and intersite relationships are examined. While there is not yet enough information for the reconstruction of the environment of the Korean peninsula, investigations seem to show shifts in settlement location from low coastal areas to hills and slopes occurring at relatively the same time periods as in Japan. House plans and average size of dwellings in Korea are briefly discussed.

References and Notes

1. N. Fuji, *Quat. Res. (Tokyo)* **5** (Nos. 3–4), 149 (1966).
2. Y. Yasuda, *ibid.* **13** (No. 3), 106 (1974).
3. ——, *Kokogaku Kenkyu* **21** (No. 4), 20 (1975).
4. H. Iseki, *Quat. Res. (Tokyo)* **11** (No. 3), 117 (1972).
5. H. Mii, *ibid.* **5** (Nos. 3–4), 134 (1966).
6. Y. Matsushima and K. Oshima, *ibid.* **13** (No. 3), 135 (1974).
7. K. Hayashi, *Arct. Anthropol.* **5**, 128 (1968).
8. H. Takamiya, *Kokogaku Janaru* **115**, 15 (1975).
9. M. Sugawara, *Kokogaku Kenkyu* **19** (No. 2), 47 (1975).

10. S. Wajima, M. Aso, Y. Tanaka, *Archaeol. Repr. Ser. No. 6* (1964).
11. F. Ikawa-Smith, *Curr. Anthropol.* **17** (No. 3), 513 (1976).
12. S. Yamazaki, "Various problems in the study of shellmounds in the Kyushu region," in *Kyushu Kokogaku no Shomondai*, Fukuoka Kokogaku Kenkyukai, Eds. (Azuma, Tokyo, 1975), pp. 131–165.
13. M. Watanabe, *Fishing in the Jomon Period* (Kokogaku Sensho No. 7, Yuzankaku, Tokyo, 1974), p. 204.
14. For example, see R. Pearson and K. Pearson, *Antiquity*, in press.
15. J. W. Cha, W. T. Lee, S. A. Lee, *The Climate and Vegetation of Korea* (Seomoon Do, Seoul, 1975), p. 53.
16. C. W. Wang, *The Forests of China* (Maria Cabot Moors Foundation, Harvard University, Cambridge, Mass., 1961).
17. H. J. Kwon, *J. Educ. Korea Univ.* **7**, 78 (1975).
18. A. Guilcher, "Report on preliminary survey of the geomorphological features of the western and southern coasts of the Republic of Korea," mimeographed (1975).
19. S. K. Kim, *Munhwa Yusan 2* (1962); *Kogo Minsok 2* (1966).
20. C. Y. Oh, *Korean J. Bot.* **14** (No. 3), 125 (1971).
21. C. K. Kim, *Asian Perspect.* **18**, 2 (1976).
22. Y. N. Kim, Y. G. Kim, K. D. Hwang, *A Study of Primitive Houses in Korea* (Sahoe Kwahak Chulpansha, Pyongyang, 1975), p. 54.
23. C. S. Chard, *Northeast Asia in Prehistory* (Univ. of Wisconsin Press, Madison, 1974).
24. C. K. Kim, *Hanguk Sa* (Chukochi mit Bunmyo, Seoul, 1973), vol. 1, pp. 63–68.
25. J. H. Kim, *The Archaeology of Korea* (Kawade Shobo, Tokyo, 1972), p. 90.
26. S. Nelson, "Han River Chulmontogi," Occasional Paper No. 9, Program in East Asian Studies, Western Washington University, Bellingham (1975), p. 100.
27. J. G. Kim and K. T. So, *Report on the Prehistoric Site of Sopohang* (Kogo Minsok Runmun Chip 4, Sahoe Kwahak Chulpansha, Pyongyang, 1972).
28. M. Y. Choi, *Yoksahak Yongu* **5**, 25 (1974); *Honam Munhwa Yongu* **7**, 141 (1975).
29. S. N. Song, "Groups of dolmens in the area of Changheung Gun," *Fac. Res. Pap. Kumho High School, Kwangju* **1**, 16 (1975).
30. W. Y. Kim *et al.*, *Anthropol. Pap. Seoul Nat. Univ.* **4**, 1 (1973); *ibid.* **5**, 3 (1974).
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Nepotism and the Evolution of Alarm Calls

Alarm calls of Belding's ground squirrels warn relatives, and thus are expressions of nepotism.

Paul W. Sherman

Alarm calls, vocalizations that alert other animals to impending danger, give the appearance of altruism. Identifying the function of the alarm calls of any species has proved difficult, both because predation is rarely seen in the field (*1*) and because individual identity of and kinship among members of prey species are usually unknown. Moreover, members of many species give several different, predator-specific alarm calls.

During a 3-year field study, I investigated the function of the alarm call that Belding's ground squirrels (*Spermophilus beldingi*, Rodentia: Sciuridae) give when a terrestrial predator approaches. Because the ground squirrel population that I studied contains individually marked animals of known age, among which familial relationships through common female ancestors are also known, discriminating among several hypothesized advantages of giving alarm calls is for the first time possible. A disadvantage of calling is also demonstrated. My investigation indicates that assisting relatives, nepotism, is the most likely function of the ground squirrels' alarm call; this result implicates kin selection (*2*) in the evolution of a behavior that, because it may involve risks to the alarm caller's phenotype, appears to be altruistic.

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Functions of Alarm Calls

Individuals may benefit from giving alarm calls in any of several contexts, because alarm calls may result in one or more of the following six effects.

1) *Diversion of predators' attention to other prey*. This hypothesis would be implicated if, in the absence of cover, alarm calls or screams from captured individuals stimulate aggregation (*3*), group mobbing (*4*, *5*), or pandemonium (*5–7*); or, if the prey are already hidden, alarm calls cause them to behave in a manner that would enhance their crypticity (*6*, *7*). Observations suggesting that "ventriloquial" alarm calls occur that increase the jeopardy of others (*8*) or that callers mislead or manipulate conspecifics so as to increase their own safety (*6*) would also support this hypothesis for the species and call at issue.

2) *Discouragement of predator pursuit*. By calling, potential prey may reduce the likelihood and costs of attacks on themselves, if calls cause predators to terminate pursuits. For example, fleet and elusive prey might discourage predators by indicating to the predators that they have been seen and that the advantage of surprise has thus been removed (*9*). Sudden or erratic changes in prey behavior as well as alarm calls may startle or momentarily confuse predators, and may indicate to them that an attack is unlikely to succeed (*10*). In addition, poisonous prey might signal their distastefulness by giving an alarm call (*4*). Under this hypothesis, callers gain by indicating to a predator that it has been detected or that the probability of a successful or profitable attack is low. This second hypothesis would thus be implicated if predators consistently turn away from or suddenly release callers, regardless of the presence, proximity, or behavior of other suitable prey.

3) *Alerting relatives*. Callers may gain by having placed themselves in some jeopardy if kin are thereby consistently warned (*2*, *11*, *12*). Captured individuals might also give distress (alarm) calls in this context, thereby soliciting assistance from relatives (*4*) or else warning them to flee or to hide. Under this, the third hypothesis, year-round alarm calls must be associated with the continuous presence of relatives [compare Williams (*12*, p. 206)]. If alarm calls are given during only part of the year, they must coincide with proximity of kin. For a given species, this hypothesis would be strongly supported if individuals with relatives living within earshot call more frequently than do conspecifics without them.

4) *Helping the group*. Alarm calling might spread by a process of between-group selection, either if (i) prey populations are composed of small, genetical-