Jomon Subsistence and Population

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Subsistence-demographic relationships of prehistoric and early historic Japanese populations were investigated to determine possible systematic correlations of population numbers with available food resources. Wild and domestic food sources were identified from archaeological, ethnographical and historical sources and their relative importance estimated using known early historic population levels and recorded archaeological site densities. Carrying capacity of these resources was estimated for the nine regions of Japan.
The Jomon period (8,000–400 B.C.) represents an amazingly long-lived hunting and gathering adaptation. Subsistence during this period focused on wild food resources primarily various kinds of nut products, root crops, wild game and marine and riverine fish and shellfish. Settlement concentrated in mountains, hills and uplands where these resources were abundant. Comparison of site distribution with resource availability indicates that deciduous forest resources were the primary determinant of Jomon population levels.
Site densities were greatest during the middle of the Jomon period (ca. 2,500 B.C.), correlating with both a climatic warming trend and increases in the efficiency of the extractive technology. Population throughout the islands at this time is estimated at 262,500, or a density of 0.89 per km^2. The Kanto plain and Chubu mountain areas were most densely populated; other areas of eastern Japan were well settled, but the evergreen forest area of western Japan was thinly populated. These data demonstrate an impressive correlation between settlement patterns and environmental changes throughout Holocene, and confirm a change from hunting and gathering to rice agriculture during the protohistoric period.

INTRODUCTION

Among the ancient cultures of Japan, perhaps the one which has aroused the greatest interest outside the country is the Jomon. These prehistoric people have been suggested as the ancestors of the Ainu, as part of a non-mongoloid race which first settled the New World, or as the direct source of South American pottery. Yet in spite of this interest by foreign students, Japanese workers have considered Jomon archaeology primarily a typological problem, and beyond its assignment to a hunting and gathering stage little interest has been taken in its economic, ecological or demographic problems.

JOMON PERIOD

The Jomon period is defined on the basis of characteristic pottery styles and is considered to have had a hunting-fishing-collecting subsistence base. Although it is not the earliest pottery-bearing culture of Japan, it is the first prehistoric culture which is known in some detail, and it represents an amazingly stable and long-lasting tradition.

The origin of pottery in Japan is surprisingly early, some radiocarbon evidence would place it earlier than 12,000 years ago. Quite a few sites of this antiquity are reported and they show very similar traits: pottery with a distinctive clay ridge, a stone industry dominated by microblades or tanged points, and a montane site distribution. Some archaeologists [KAMAKI 1965] view this pottery culture as an indigenous development of the paleolithic culture of Japan.

Shortly after 10,000 B.P. there emerged another pottery culture: the beginning of the Jomon tradition. Many of its sites are coastal shellmounds, a type of site not known from previous periods. Varieties of fishing tools such as harpoons, hooks, and net weights in such shellmounds indicate that the people were already well adapted to a marine environment. Sites in the mountainous areas are characterized by an abundance of arrowheads. Pottery in this stage has a uniform pointed-bottom, bullet shape. Various decorative techniques adorn pottery surfaces; the most prominent among these being cord marking (*jomon*). This technique is usually made by rolling a strand of cord on the wet surface of a vessel. It characterizes Jomon pottery and was used throughout the period, although its populatrity varied by time and region.

A strong trend toward more sedentary settlement after 6,000 B.P. is evident in increased site sizes, amounts and varieties of artifacts, and such larger features as pit dwellings. Non-utilitarian artifacts such as earrings, jade beads, shell bracelets and clay figurines also became popular. Pottery vessels invariably have flat bases and show new varieties of shape, size and decorative motifs. Strong localization of pottery types are observed as these techniques developed. A climax of the Jomon culture occurred in the dynamic subcultures of the middle Jomon period in central Japan (Kanto and Chubu regions) around 4,000 B.P.

The end of the Jomon period is marked by an expansion of a new culture, the Yayoi, which emerged in northern Kyushu under obvious continental influence. The people of this new tradition possessed agriculture, bronze and iron artifacts, cloth, glass, and sophisticated navigation techniques, all of which had been lacking in Jomon society. The first wave of the Yayoi expansion quickly covered western Japan and then gradually merged into eastern Japan. Only the northern regions (Tohoku and Hokkaido) remained strongholds of the Jomon tradition. By the end of the Yayoi period, numerous small political groups had been formed and had begun fighting to consolidate political power over wider areas.

AIM AND PROCEDURE

For the past 2,000 years Japan has been basically dependent upon one food source, rice, and one mode of production, paddy agriculture. Due to this consistency in basic subsistence, the cultural history of the country fits a simple model of linear growth, from primitive societies to complex states. However, this simplified model has left the study of Japanese prehistory (the Jomon and earlier periods) poorly understood.

The Jomon period has been considered a "hunting and gathering" stage, but its subsistence base was presumed to consist of anything available in the natural environment without any systematic trophic specialization. Thus the assumption was that the Jomon period represented a static opportunism with a minimum of technological development throughout its history. The work of prehistorians focused upon establishing chronology; interpretive and reconstructive efforts beyond ceramic sequences were considered unproductive. Therefore, examination of Jomon subsistence was halted at the level of listing food remains recovered from archaeological sites.

However, accumulating information, especially from recent large-scale excavations, has thrown considerable doubt upon these assumptions and attitudes. For example the Middle Jomon settlements in central Japan are large, well-planned and densely distributed. Various expalanations have been advanced but most of them have created more controversy and confusion.

The turmoil of Jomon culture history contrasts sharply with that of the later (post-Jomon) period and the reason is apparent: the difference in quality of understanding about subsistence. Therefore, our most urgent task is to reconstruct the subsistence patterns of the Jomon period. If these can be quantified we will have a basis from which to estimate population size and density and to go on to other inferences regarding social organization.

Jomon demography has been previously approached by only two Japanese archaeologists, and neither of these were systematic. Yamanouchi [1964: 136] estimated the Jomon population (specific period not defined) at between 150,000 to 250,000, based upon similarities in land size and subsistence type with prehistoric California. Serizawa [1968: 154] calculated it at 120,000, extrapolating from the premodern Ainu population density in Hokkaido. He mentions the figure as a maximum possible population size for sometime between the Middle and Late Jomon periods.

In this paper I use the number of sites as data for an estimation of population size. The sources of these data are the officially registered sites in each prefectural office, either filed or published.

The Jomon period is described in five temporal units following a conventional method of time division for the period. Each division is treated as an independent period within a sequence. The early agricultural populations of the following Yayoi and Haji periods are added for comparative purposes.

The subsistence of the Jomon period is reconstructed through definition of environmental conditions and exploitative patterns. Population size during each period is estimated and discussed in relation to the efficiency of subsistence.

DEFINITION AND EVALUATION OF DATA

Spatial Units

Statistical approaches to settlement analysis, particularly when used to understand prehistoric demography, require large quantities of reliable data on site distribution, chronology, and size. The present study relies on the official site survey records of the prefectural offices for this information.

Japan is divided into 47 prefectures or administrative subdivisions. Below these major subdivisions are three administrative units of local government—*shi*, *machi* and *mura*—roughly comparable to city, town and village, the difference in names corresponding to the size of the population.

Prefectures are often grouped into regions, which are not administrative units but rather traditional zones reflecting geographical cohesiveness. The most popularly used regional divisions are Hokkaido, Tohoku, Kanto, Hokuriku, Chubu, Tokai, Kinki, Chugoku, Shikoku and Kyushu (Figure 1).

A second conventional division is into Eastern and Western Japan. There is no clear border between these two areas but it is usually placed between the Kinki and Chubu regions, while Hokkaido is usually excluded from the division.

RECORDING SITES

Since 1950 archaeological sites in Japan have been protected under the "Protection of Cultural Properties" law. According to this law, preservation and recording (including academic exacavation) of sites is carried out within a national administrative system.

Traditionally the primary handling of the sites is done by towns (*mura*, *machi*, *shi*), the minimal units of the system. From there records are sent to the prefectural offices for registration. The prefectural offices are obliged to submit a list of registered sites to the supervising central government office. A complete report of registered sites throughout the nation was published as the *The National Site Maps* (47 volumes) in 1965. The primary purpose of this publication, however, was to declare the location of those sites which may not be destroyed without legal procedure, and it does not provide information on the temporal or cultural definition of the listed sites. Thus some prefecture offices have published revised editions of the site maps in order to give specific archaeological information as well as to include an ever increasing number of newly identified sites.

Site information provided usually includes:

1) registration number by prefecture
2) site category
3) location
4) period
5) artifacts and features
6) other information: an elaborated publication gives geographical location, scale, present condition, published references, ownership, etc.

SITE CATEGORIES AND TEMPORAL UNITS

Categorization of the site in official records is not uniform but is done by description such as:

1) shellmounds
2) scattered artifacts (often unexcavated)
3) village settlements (often excavated and revealing some dwellings)
4) cave or rock shelters
5) camp sites
6) mounded tombs (of the Tumuli period)
7) relics of some historical period (Buddhist temples, castle fortifications, kilns, stone mounds, monuments, etc.)
8) others (sometimes with no description).

The temporal units for the sites are given by conventional time divisions (periods) or by artifact types (pottery chronology) (Table 1).

The Jomon period is often subdivided into five stages or phases usually translated as Earliest, Early, Middle, Late and Latest. Here, these are termed simply Jomon 1 to 5. When Jomon subdivisions could not be ascertained, the site is counted in another category, unidentified Jomon. In referencing site records, these Jomon subperiods and the Yayoi and Haji periods were used to characterize individual site components. Thus in the computation below sites containing more than one component are counted more than once (Table 2 and 3).

Data Reliability

Because of the systematic method of recording archaeological sites in Japan, the quality of data is in general quite reliable. However, three major confounding factors exist and must be considered. The first of these may be called the "urbanization ef-

Table 1. Cultural periods and pottery traditions of prehistoric and historic Japan

AGE	PERIOD	POTTERY
1610–1687 A.D.	Edo	
1599–1609	Azuchi-Momoyama	
1334–1598	Muromachi	
1192–1333	Kamakura	
794–1191	Heian	
710–793	Nara	
500–700	Asuka	Haji
300–500	Tumuli	
200 B.C.–300 A.D.	Yayoi	Yayoi
	Jomon 5 (Latest)	
	Jomon 4 (Late)	
	Jomon 3 (Middle)	Jomon
	Jomon 2 (Early)	
	Jomon 1 (Earliest)	
	Sub-Jomon (Sosoki)	

Table 2. Distribution of known Jomon and Yayoi sites by prefecture*

Code	Prefecture	Area (km²)	J–1	J–2	J–3	J–4	J–5	UIJ **	Jomon Total	Yayoi Total	Haji Total
(Tohoku)											
2	Aomori	9,614	60	195	293	489	263	71	934	38	285
3	Iwate	15,376	57	193	518	442	445	338	1452	88	395
4	Miyagi	7,289	83	165	298	211	278	324	953	208	—
5	Akita	11,609	7	100	214	159	289	138	733	39	—
6	Yamagata	9,325	25	104	380	163	212	206	919	45	576
7	Fukushima	13,871	17	44	242	360	158	641	1324	179	456
(Kanto)											
8	Ibaragi	6,087	95	121	439	292	61	311	1058	305	752
9	Tochigi	6,413	165	287	308	274	72	376	991	148	584
10	Gunma	6,336	50	118	250	134	29	617	1038	248	557
11	Saitama	3,799	291	421	1065	429	49	—	1986	293	1785
12	Chiba	5,100	90	94	269	396	29	221	903	69	318
13	Tokyo	2,143	349	571	1210	426	69	360	1994	295	845
14	Kanagawa	2,383	173	170	436	197	12	418	1131	410	654
(Hokuriku)											
15	Niigata	12,577	41	119	761	522	154	216	1507	154	660
16	Toyama	4,252	3	24	128	57	35	128	364	29	76
17	Ishikawa	4,196	5	22	83	67	22	498	680	103	585
18	Fukui	4,188	3	10	54	8	3	5	69	84	10
(Chubu)											
19	Yamanashi	4,463	29	145	296	107	18	—	359	31	—
20	Nagano	13,954	237	796	2408	633	120	1732	3773	1245	1206
21	Gifu	11,296	111	114	291	178	112	376	807	227	—
(Tokai)											
22	Shizuoka	9,292	201	116	394	176	69	515	1218	537	426
23	Aichi	5,105	77	93	156	141	206	208	694	450	—
(Kinki)											
24	Mie	5,772	20	33	65	80	19	312	442	536	329
25	Shiga	4,061	4	6	6	16	6	37	60	110	166
26	Kyoto	4,612	1	9	8	13	6	11	39	129	65
27	Osaka	1,855	2	3	4	5	5	20	44	204	16
28	Hyogo	8,359	2	5	6	8	10	128	142	434	129
29	Nara	3,692	4	7	9	35	25	15	60	204	—
30	Wakayama	4,772	2	9	20	26	17	85	163	317	125
(Chugoku)											
31	Tottori	3,491	3	3	1	7	4	20	31	86	7
32	Shimane	6,626	5	15	19	23	38	28	69	91	105
33	Okayama	7,083	26	15	19	31	23	16	86	237	74
34	Hiroshima	8,449	9	6	7	28	15	16	56	290	44
35	Yamaguchi	6,090	10	15	5	9	4	26	61	346	311
(Shikoku)											
36	Tokushima	4,144	1	1	1	7	2	—	10	53	—
37	Kagawa	1,875	2	4	4	15	2	—	23	45	—
38	Ehime	5,661	20	10	2	84	15	—	106	259	—
39	Kochi	7,106	7	3	3	5	2	—	17	181	—
(Kyushu)											
40	Fukuoka	4,934	36	13	16	27	50	120	228	257	—
41	Saga	2,416	14	15	11	15	16	65	106	172	—
42	Nagasaki	4,098	17	22	24	27	40	6	227	252	—
43	Kumamoto	7,391	68	43	44	120	99	285	576	472	164
44	Oita	6,326	30	8	7	32	20	—	89	42	—
45	Miyazaki	7,734	23	13	24	43	9	—	77	94	—
46	Kagoshima	9,151	55	119	95	155	27	87	397	588	98
Totals			2530	4399	10893	6672	3159	8976	27996	10624	11803

*Hokkaido and Okinawa excluded from data **UIJ: Unidentified Jomon

Table 3. Distribution of known Jomon and Yayoi sites by region

Region	J–1	J–2	J–3	J–4	J–5	Jomon Total	Yayoi Total	Area (1000 km²)
Tohoku	249	801	1945	1824	1645	6315	597	67
Kanto	1213	1782	3977	2148	321	9101	1768	32
Hokuriku	52	175	1026	654	214	2620	370	25
Chubu	377	1055	2995	918	250	4939	1503	30
Tokai	278	209	550	317	275	1912	987	14
Kinki	35	72	118	183	88	950	1934	33
Chugoku	53	54	51	113	60	303	1950	32
Shikoku	30	18	10	111	21	156	538	19
Kyushu	243	233	221	419	261	1700	1877	42
Totals	2530	4399	10893	6687	3135	27996	11524	294

fect." Because of the recent legal attempts to protect archaeological resources, scientific investigation is required whenever site destruction is inevitable. Therefore, when a land development project is planned, an archaeological survey or excavation is undertaken beforehand. This results in an enormous increase in the number of known sites. This tendency is especially pronounced in urban areas. For example, in the Kanto region, a correlation is clearly present between site density and proximity to Tokyo (Table 4). A secondary effect, not apparent in the table, is that information about the recently discovered sites is more detailed and more accurate because survey

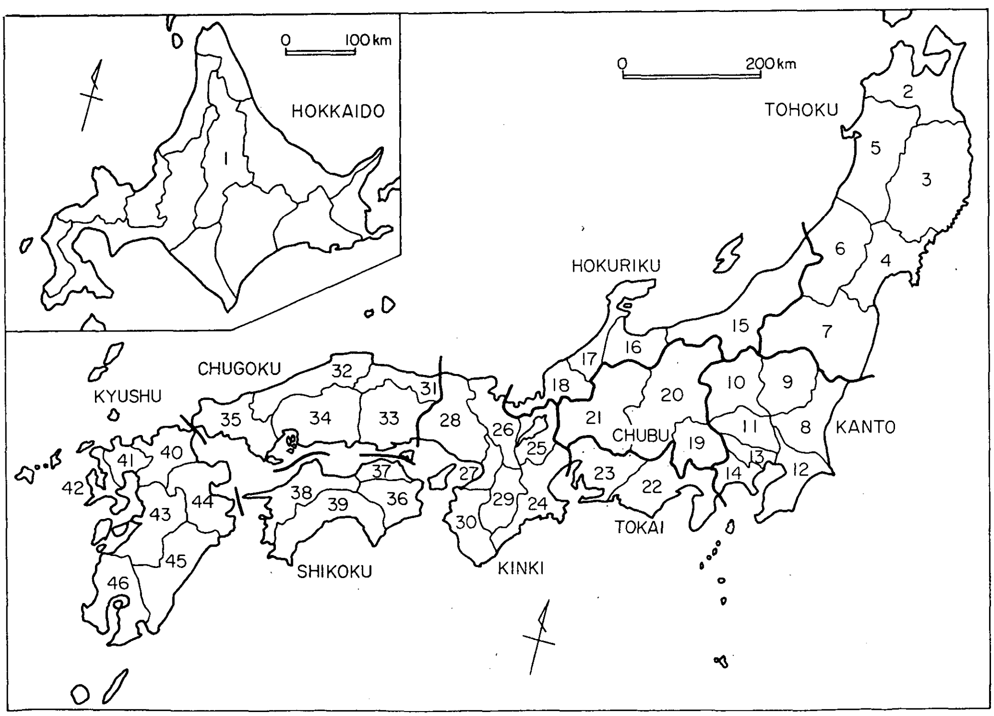


Figure 1. Administrative divisions and regions of Japan

Table 4. Registered sites in Kanto

Prefecture	No. of sites in 1965	Site density per km²	No. of sites in new edition	Date	Site density per km²	Increase index (1965=100)	Pop. density (1973)
Ibaragi	2,594	.36	3,622	'74	.60	140	371
Tochigi	1,306	.20	2,920	'75	.45	224	257
Gunma	2,259	.36	3,821	'74	.60	169	270
Saitama	1,413	.37	6,079	'75	1.60	430	1140
Chiba	2,789	.55	..............not yet published..................				735
Tokyo	747	.35	3,618	'74	1.68	484	5283
Kanagawa	1,337	.56	3,156	'71	1.32	236	2491

teams are now composed of specialists. This tendency is strong in urban areas, but it exists throughout the rest of Japan as well.

The second confounding factor is "interest effect," which results from the traditional interests of local archaeologists. As early as 1956, Nagano Prefecture, one of the centers of Jomon study, had compiled an extensive local site list containing specific information on pottery types, geographical location and publication references. After 20 years this still provides better information than is available for any other prefecture. Not surprisingly, Nagano Prefecture contains the largest number of known Jomon and Yayoi sites. This factor affects not only knowledge of site locations but also knowledge of temporal placement, especially for Jomon divisions. If we take the number of time-unspecified Jomon sites (VIJ) and divide it by total Jomon sites (JT), the resulting value is generally higher in western Japan. This is due to the fact that a Jomon chronology has been worked out in eastern Japan.

The final confounding factor results from the date of publication of the material. The number of known sites increases annually, and newer site records have consistently increased in quality. Information is most reliable when taken from site maps in newer editions. Some prefectures publish only site lists, which are fair in quality. Such lists, however, frequently exclude information on Jomon divisions. In such cases prefectural files were consulted. These files vary in quality but are usually poor because the data avaialable are old. When the above references were not available, other publications were consulted. These usually list major sites only, and consequently drastically reduces statistical credibility. The data are evaluated in terms of these confounding factors in Table 5.

Temporal Units: Pottery Chronology

Prior to the introduction of radiocarbon dating, no known Jomon cultural remains which could be used for absolute dating existed. Consequently, dating of sites relied upon relative methods, among which was pottery chronology. Because the study of Jomon culture history has been heavily based upon this system, and because it remains a reliable tool, pottery chronology will be discussed in some detail.

JOMON PERIOD: JOMON POTTERY

The Jomon period is often described in five subperiods based upon an ideographic

Table 5. Data reliability

Code	Prefecture	Density 100 (JT+YT)/km^2	Temp. ID ratio UIJ/JT	Source of data	Date of pub.	Total Evaluation
01	Hokkaido	002	—	SL & PF	(71)	1
02	Aomori	132	6.3	PF	(75)	2
03	Iwate	182	12.4	SM	(74)	3
04	Miyagi	150	11.9	SL	(73)	2
05	Akita	66	18.8	PF	(73)	1
06	Yamagata	107	21.5	SL	(69)	2
07	Fukushima	101	52.0	SL	(64)	1
08	Ibaragi	228	29.6	SL	(74)	3
09	Tochigi	188	31.0	SM	(75)	3
10	Gumma	132	65.5	SM & PF	(74)	2
11	Saitama	585	20.0	SM	(75)	3
12	Chiba	228	53.7	PF	(65)	2
13	Tokyo	673	21.4	SM	(74)	3
14	Kanagawa	223	41.4	SM	(71)	2
15	Niigata	132	32.5	SM	(75)	3
16	Toyama	154	50.3	SL	(72)	2
17	Ishikawa	197	75.5	SM	(74)	2
18	Fukui	038	—	—	(69)	1
19	Yamanashi	155	—	—	(68)	1
20	Nagano	380	43.1	SL	(66)	3
21	Gifu	91	48.5	SL	(72)	2
22	Shizuoka	178	47.2	PF	(75)	2
23	Aichi	218	31.4	SM	(72)	3
24	Mie	169	74.1	PF		2
25	Shiga	39	67.2	PF	(65)	2
26	Kyoto	36	43.0	SM	(72)	2
27	Osaka	163	51.1	SL	(71)	2
28	Hyogo	69	83.7	SM	(71)	2
29	Nara	33	38.0	—	(65)	2
30	Wakayama	53	53.0	SM	(74)	2
31	Tottori	36	60.6	SM	(63)	1
32	Shimane	26	—	—	(74)	2
33	Okayama	45	18.0	SM	(74)	2
34	Hiroshima	42	33.3	SL	(61)	2
35	Yamaguchi	77	20.0	SM & PF	(72)	2
36	Tokushima	15	—	PF		1
37	Kagawa	39	—	PF		1
38	Ehime	158	—	—	(73)	2
39	Kochi	17	—	—	(66)	1
40	Fukuoka	87	58.2	PF		2
41	Saga	119	60.3	SL	(64)	2
42	Nagasaki	128	—	SL	(66)	2
43	Kumamoto	102	48.7	SL	(62)	2
44	Oita	24	—	—	(71)	1
45	Miyazaki	22	—	—	(68)	1
46	Kagoshima	121	22.1	SM	(74)	3

JT=Jomon Total YT=Yayoi Total UIJ=Unidentified Jomon
SM=Site map SL=Site list PF=Prefectural file
—=Others

pottery chronology. This scheme was first put into its present shape by S. Yamanouchi in 1937 to end the chaos in interpretation of different pottery types from either the same or from different regions. Through observation of stratigraphic evidence, as well as changes of decorative styles and vessel shapes in northern Japan, Yamanouchi proposed to divide the Jomon period into five main stages.

His working hypotheses were:

1) There were (as of 1937) about 30 pottery types in Tohoku and more than 20 in Kanto, and the number of types was increasing.
2) These types indicate temporal differences.
3) There had been a unilinear development of pottery techniques throughout Japan proper; therefore, each region should have types corresponding to those of other regions.
4) Each major division (stage) may include up to ten subdivision (types).

He then defined the main divisions as follows:

1) Soki (Earliest Jomon): a group of types with pointed bottom vessels.
2) Zenki (Early Jomon): a group of types (conventionally called Moroiso types) with decoration on plain surface and with flat bottom vessels.
3) Chuki (Middle Jomon): pottery with thick coarse walls (thick wall types) and with applique decorations, abundantly distributed in central Japan.
4) Koki (Late Jomon): pottery with thin and refined walls (thin wall types) and with fine incised decoration and various shapes, distributed in the coastal areas in central to northern Japan.
5) Banki (Latest Jomon): the so-called Kamegaoka types, more refined development of the styles of the previous stage and heavily distributed in the northern Japan.

These subdivisions, therefore, were empirical rather than theoretical, using conventional pottery types of the periods. However, its simple and convenient format was convincing enough for it to gain acceptance by a majority of Japanese archaeologists, and the continuing development of pottery typology was rapidly subsumed within it. Over the last four decades a massive and complicated, though still incomplete, chronology has been worked out.

Excavations of paleolithic sites, which became popular after the early 1950's in Japan, revealed more possible types in the earliest division. Thus Yamanouchi in 1962 proposed one more division before the Earliest, and named it Sosoki (grass-root period) based upon one of his original criteria, i.e., a main division should include 10 types [YAMANOUCHI 1969]. However, some archaeologists, for instance, Y. Kamaki [ESAKA, et al. 1972], oppose this new division because the so-called Sosoki types are based on non-Jomon characteristics (lack of cord making, rounded bottoms) and thus have no clear traditional continuity with Jomon culture. (Similar differences occur in lithic technology.) Therefore, Kamaki prefers to treat them as a non-Jomon cultural tradition. Another opponent, C. Serizawa [1967], would include these types in the late paleolithic era because of the prominent mesolithic technology of the lithic industry (micro-blades, tanged points) and radiocarbon datings of over 10,000 B.P.

Increasing numbers of sites which yield these particular pottery types are forcing archaeologists to further examine this temporal category. In this paper Kamaki's definition is adopted by calling it the "Sub-Jomon" period. It will not be considered in the present treatment.

YAYOI PERIOD: YAYOI POTTERY

Yayoi pottery succeeds the Jomon chronological sequence. Like Jomon ware, Yayoi pottery has been broken down into numerous types based on decorative techniques and is divided into three stages, although its total duration is considerably shorter than that of any of the Jomon divisions. The earliest Yayoi pottery appeared in northern Kyushu apparently as a result of continental stimuli and spread toward the eastern regions where strong Jomon traditions still remained. It was accompanied by metal (iron or bronze) artifacts and rice farming. The vessels usually have plain surfaces or simple decoration and are divisible into three functional sets, cooking vases, storage jars and ceremonial vessels.

Absolute dates for this period are provided by some imported Chinese artifacts, such as a Chinese coin *Huo-chuan* (貨泉), minted in A.D. 14, a gold signet given to a local king by the Chinese Emperor in A.D. 57, and many Han dynasty bronze mirrors.

TUMULI AND EARLY HISTORIC PERIODS: HAJI POTTERY

The dividing line between the Yayoi and Tomb periods is usually associated with the emergence of states in Japan about 300 A.D. Archaeologically, the new period is characterized by the construction of huge tombs designated for early Emperors and their families.

The pottery of this period is called Haji. It follows the Yayoi tradition but with greater stylization and uniformity throughout Japan. Pottery of this style was strictly utilitarian and bears little decoration. It was used until 1200 to 1300 A.D. when it was replaced by stoneware. This change took place earlier in western Japan; in the east Haji were lingered somewhat longer (and this has resulted in an elaborated local pottery chronology). Archaeological and historical evidence agree in identifying this period as being one characterized by a stable and expanding agricultural society.

Radiocarbon Dating

DEFINITION OF TEMPORAL UNITS

The main divisions of the Jomon chronology provide a convenient framework within which to examine the changing conditions of a culture with an extremely long duration. However, it is necessary to examine whether the divisions of this relative chronological scheme can indeed stand as temporal units supported by absolute dating.

A sufficient number of radiocarbon dates (137) have been reported for the Jomon and succeeding Yayoi periods (Table 6).

Table 6. Radiocarbon dating of the Jomon and Yayoi periods

Sub-Jomon

	Lab Sample #	Date X̄	(B.P.) S.D.	Region	Prefecture	Site
1	I–943	10,085	320	Shikoku	Ehime	Kamikuroiwa Cave VII
2	I–944	12,165	600	//	//	Kamikuroiwa Cave IX
3	Gak–949	12,400	350	Kyushu	Nagasaki	Fukui Cave II
4	Gak–950	12,700	500	//	//	Fukui Cave III

Jomon 1

	Lab Sample #	Date X̄	(B.P.) S.D.	Region	Prefecture	Site
1	M–767	9,450	400	Kanto	Kanagawa	Natsujima S–M
2	M–770	9,240	500	//	//	// S–M
3	N–168	8,150	180	//	Chiba	Nishinojo S–M
4	N–170	8,240	190	//	//	//
5	N–174–1	9,190	190	//	Ibaragi	Tokisaki S–M
6	N–174–2	8,740	350	//	//	//
7	N–368	6,740	130	//	//	Dochi
8	N–372	7,290	145	//	//	//
9	N–373	6,910	145	//	//	//
10	N–514	7,080	150	//	Kanagawa	Kayama S–M
11	M–237	8,400	350	Chugoku	Okayama	Kijima S–M

Jomon 2

	Lab Sample #	Date X̄	(B.P.) S.D.	Region	Prefecture	Site
1	N–242	4,870	130	Tohoku	Aomori	Morita
2	N–175	5,192	130	Kanto	Ibaragi	Okitsu
3	N–175	4,880	130	//	//	//
4	N–176	4,520	130	//	//	Mukoyama S–M
5	N–365	4,920	195	//	//	//
6	N–366–1	5,090	130	//	//	//
7	N–366–2	5,090	140	//	//	//
8	N–369	5,260	130	//	//	//
9	N–191–1	5,640	150	//	//	Ta S–M
10	N–191–2	5,630	140	//	//	//
11	N–280	4,960	125	//	//	//
12	N–200–1	5,340	140	//	//	//
13	N–177–1	4,920	130	//	//	Kaigakubo
14	N–177–2	4,900	130	//	//	//
15	N–454a	5,100	135	//	//	//
16	N–454b	4,780	125	//	//	//
17	N–458	4,900	140	//	//	//
18	M–240	5,100	400	//	Chiba	Kamo
19	N–385	5,290	140	//	//	//
20	N–178	5,340	150	//	//	Uebo
21	N–241	5,520	140	//	//	//
22	N–241	5,520	140	//	//	Kozaki
23	N–1156	5,790	140	//	//	Kode
24	N–1157	5,900	115	//	//	//
25	N–286	5,460	130	//	//	Nishinojo
26	N–288	4,840	140	//	//	Hatayaaraku
27	Gak–379a	4,730	90	//	Kanagawa	Orimoto
28	Gak–379b	4,760	90	//	//	//
29	TK–1	4,790	80	//	//	Minamibori
30	N–287	6,030	135	//	//	Shimogumi
31	Gak-536	4,800	200	Hokuriku	Toyama	Otake
32	N–268	5,190	130	Kyushu	Kumamoto	Sobata

Jomon 3

	Lab Sample #	Date X̄	(B.P.) S.D.	Region	Prefecture	Site
1	N–144	3,340	120	Tohoku	Iwate	Hanaizumi
2	N–453	4,210	125	Kanto	Ibaragi	Mitareda
3	C–548a	4,546	220	//	Chiba	Ubayama
4	C–548b	4,850	270	//	//	//
5	C–548c	3,938	500	//	//	//
6	C–603	4,513	300	//	//	//
7	N–167	4,540	140	//	//	Saburosaku
8	N–183	4,280	130	//	//	Ikazuchi
9	N–182–1	4,400	110	//	//	Atamadai
10	N–182–2	4,480	110	//	//	//
11	Gak–1068	4,790	80	//	//	//
12	N–1431	4,170	105	//	//	Kainohana
13	N–374	3,940	125	//	//	//
14	SI–125	5,090	65	//	Tokyo	ICU
15	UCLA–279	4,570	150	//	//	//
16	N–321	4,160	130	//	//	Kitami
17	N–322	4,240	125	//	//	//
18	SI–93	4,580	60	Chubu	Nagano	Omiyama
19	N–103	4,340	130	Tokai	Aichi	Onedaira
20	N–104	4,810	190	//	//	//
21	N–317	3,960	175	Kyushu	Kumamoto	Todoroki
22	N–318	3,960	130	//	//	//

Jomon 4

	Lab Sample #	Date X̄	(B.P.) S.D.	Region	Prefecture	Site
1	N–375	3,960	125	Tohoku	Miyagi	Minamizakai
2	N–114	3,680	130	//	Akita	Oyu
3	N–94	3,000	120	Kanto	Saitama	Ishigami
4	M–1862	3,190	160	//	//	//
5	N–128	3,250	140	//	//	Seibuen
6	N–59	3,780	150	//	Chiba	Horinouchi
7	N–376	3,070	120	//	//	Takayagawa
8	N–179–1	3,130	140	//	//	Nado
9	N–170–2	3,050	130	//	//	//
10	N–180	2,970	120	//	//	Kohara
15	N–181	3,120	120	//	//	Okura
12	G–767	3,630	90	//	//	Kasori
13	N–1429	3,940	105	//	//	Kainohana
14	N–1430	3,840	190	//	//	//
15	N–367–1	3,130	120	//	//	Shin
16	N–367–2	3,230	120	//	//	//
17	Gak–768	3,150	100	//	Tokyo	Nijima
18		2,900	120	//	Kanagawa	Sannomiya
19	M–174	2,870	250	Tokai	Aichi	Yoshigo
20	Gak–170	3,060	110	Kinki	Osaka	Kusaka
21		3,534	70	Kyushu	Fukuoka	Aratari
22	Kuri–0049	3,849	78	//	Saga	Arita
23	N–269	3,300	125	//	Kumamoto	Sobata
24	N–320	3,260	120	//	//	Todoroki

Jomon 5

	Lab Sample #	Date X̄	(B.P.) S.D.	Region	Prefecture	Site
1	N–110	2,820	130	Tohoku	Aomori	Hichimanzaki
2	N–53	2,700	170	Kanto	Tochigi	Nishippara
3	N–166	2,990	130	//	Saitama	Shinpukaji
4	N–171–1	3,020	130	//	//	//
5	N–171–2	2,940	130	//	//	//
6	M–1861	3,110	190	//	//	Ishigami
7	N–166–1	2,260	130	//	Chiba	Arami
8	N–166–2	2,290	120	//	//	//
9	N–166–3	2,780	110	//	//	//
10	N–165	2,800	600	Tokai	Aichi	Yoshigo
11	Kuri–0053	2,370	100	Kyushu	Saga	Ukikunden
12	Kuri–0054	2,240	50	//	//	//
13	Gak–722a	3,620	100	//	Kumamoto	Sakaizaki
14	Gak–722b	3,560	100	//	//	//
15	Gak–723a	3,630	100	//	//	//
16	Gak–723b	3,520	100	//	//	//

Yayoi

	Lab Sample #	Date X̄	(B.P.) S.D.	Region	Prefecture	Site
1	N–68	1,890	120	Kanto	Saitama	Goryo
2	N–124	1,940	120	//	Chiba	Abiko
3	N–1115	1,930	100	//	//	Suwanohara
4	N–1116	1,820	100	//	//	//
5	N–1117	1,830	100	//	//	//
6	N–57	1,220	130	//	Tokyo	Ochiai
7	N–280	1,410	110	//	//	Honancho
8	N–125	1,860	120	//	//	Kameyama
9	N–123	1,830	130	//	//	Kurihara
10	Gak–390	1,380	90	Hokuriku	Ishikawa	Hakui
11	Gak–389	1,500	100	//	//	//
12	Gak–310	1,690	80	//	//	Sakanomiya
13	Gak–317	1,460	100	//	Fukui	Fukui
14	Gak–316	1,570	100	//	//	//
15	Gak–315	1,850	90	//	//	//
16	Gak–796	1,720	90	Tokai	Shizuoka	Toro
17	N–71	1,940	120	//	//	//
18	N–73	1,940	100	//	//	//
19	N–70	1,950	130	//	//	//
20	Gak–793	1,960	80	//	//	//
21	N–74a	2,010	120	//	//	//
22	Gak–794	2,060	90	//	//	//
23	Gak–798	2,240	90	//	//	//
24	Gak–795	2,300	120	//	//	//
25	Gak–797	2,590	100	//	//	//
26	TK–97	2,100	70	//	//	//
27	N–108	1,950	130	//	Aichi	Nishimukai
28	TK–100	1,770	140	//	//	Takahashi

Sources: Kidder and Koyama [1967] Watanabe [1967]
Suzuki [1974]

Table 7. Means and standard deviations of radiocarbon datings for the main divisions of the Jomon and Yayoi periods

Group	Division	C_{14} samples	Mean	S.D.
1	Sub-Jomon	4	11,837.5	888.2
2	Jomon 1	11	8,130.0	989.1
3	Jomon 2	32	5,157.9	369.8
4	Jomon 3	22	4,350.3	389.8
5	Jomon 4	24	3,328.9	354.9
6	Jomon 5	16	2,915.6	483.4
7	Yayoi	28	1,846.8	292.7
All		137	4,041.8	

To test whether chronological differences exist between the divisions, we used the expected values as variables and grouped them into the traditional divisions.

A summary of data from each division in Table 6 is as follows (Table 7):
The result of one-way analysis of variance is represented in the following summary (Table 8):
The assumptions here are that 1) sampling is random and 2) variances are equal. The null hypothesis is that the expected values of C14 dating of the seven divisions are identical:

$$H_0: \mu_1=\mu_2=\mu_3=\mu_4=\mu_5=\mu_6=\mu_7$$

and the alternative hypothesis is that differences exist.

$$H_1: \text{not } H_0$$

We can reject H_0 which means there is a strong evidence that differences truly exist between these subdivisions. However, our real interest is not in the gross differences of these groups but in this sequencial differences. To achieve this, the performance of all possible two treatment t-tests might help but that entails a possible increase in the risk of Type 1 errors. Therefore in this case Scheffe's method of multiple contrast will be applied [MARASCUILO 1971].

For our data, necessary pairs for comparison are limited to six because the populations are temporal series. They are summarized in Table 9. The results indicate strong radiocarbon support for the traditional divisions of the Jomon and Yayoi periods. The only exception is Jomon 4 and Jomon 5 which are not sufficiently

Table 8. Analysis of variance for Table 7

Sources of Variation	df	Sum of squares	Mean square	f values
between	6	684,035,930.4	6,114,005,988.4	520.3
within	138	30,675,835.3	219,113.1	
total	144	714,711,765.7		

Table 9. Scheffe's method of multiple contrast for the main divisions of the Jomon and Yayoi periods

Comparison	$\bar{X}_i$-$\bar{X}_j$	SSE	Range	Decision
Sub-Jomon vs. Jomon 1	3,707	932.64	7,872–6,006	significant
Jomon 1 vs. Jomon 2	2,972	592.34	3,570–2,386	//
Jomon 2 vs. Jomon 3	808	471.72	1,274– 328	//
Jomon 3 vs. Jomon 4	1,021	503.86	1,468– 460	//
Jomon 4 vs. Jomon 5	413	549.84	971– 129	not significant
Jomon 5 vs. Yayoi	1,069	509.53	1,578– 567	significant

distinct chronologically for statistical detection. Thus, we may conclude that the use of these time units is relevant.

DURATION OF TEMPORAL UNIT

In the preceding section the analysis concerned only expected values and disregarded standard deviations; therefore the credibility of the data in terms of probability is not high if we want to talk about average dates and duration of these temporal units. To determine properties in the data, the following procedure was carried out:

1) Calculate the range of a sample by $\bar{X}\pm2\sigma$ to increase the credibility of the data to .9546. It will be expressed as a bar of $(\bar{X}+2\sigma)$ to $(\bar{X}-2\sigma)$ length.
2) Weight first σ range by two. The thickness of the bar is doubled in that portion.
3) Arrange the samples on a graph with a minimal unit of 100 years (fractions rounded-off).
4) Rearrange the graph by each population into a histogram.
5) Carry out statistical analysis

The results are given in the following Table 10. They are basically identical to those in the case of central tendencies, although this method reveals slightly higher means and smaller standard deviations.

For the duration of each temporal unit, it is possible to take the difference between the maximum and minimum values, but the ranges shown by the Z scores ($Z=\pm2.00$) may be more statistically integrated figures. It should be noted, however,

Table 10. Z scores and other data for radiocarbon datings of the Jomon and Yayoi periods

Period	Mean	SD	Mode	Max.	Min.	Range Z score =2.00	Duration (Z=2.90)
Sub-Jomon	12,200	850	12,800	13,700	10,100	13,900–10,500	3,200
Jomon 1	8,500	750	8,400	10,000	6,800	9,000– 7,100	2,800
Jomon 2	5,200	400	4,900	6,300	4,300	6,000– 4,400	1,600
Jomon 3	4,400	400	4,400	5,400	3,000	5,200– 3,600	1,600
Jomon 4	3,400	300	3,400	4,200	2,800	4,000– 2,800	1,200
Jomon 5	2,900	450	2,900	3,900	2,000	3,800– 2,000	1,800
Yayoi	1,900	250	1,900	2,800	960	2,400– 1,500	900

Table 11. Indices of standard deviation of radiocarbon datings for the Jomon and Yayoi temporal units

Period	Average of SD	Index of deviation (Y=100)
Sub-Jomon	475	450
Jomon 1	234	220
Jomon 2	142	134
Jomon 3	142*	134
Jomon 4	126	118
Jomon 5	119**	112
Yayoi	106	100

Deviated samples were excluded. * C–548C, C–603 ** N–165

that there is a tendency for earlier dates to have larger SD's. The average SD for each temporal unit should clarify this tendency; for example, by taking the ratio of the average SD values using the latest unit, the Yayoi, as a base, we can detect the varying differences in SD quality for each unit (Table 11).

The index shows that the older the stages are, the looser the time ranges. If we adjust the duration of each unit by this index the ranges become:

Sub-Jomon	1,000
Jomon 1	1,300
Jomon 2	1,000
Jomon 3	1,000
Jomon 4	1,100
Jomon 5	1,000
Yayoi	900

This adjustment indicates that these temporal units have fairly even time ranges.

ENVIRONMENT

Natural Landscape

Japan consists of four main islands, Hokkaido, Honshu, Shikoku and Kyushu and more than a thousand smaller islands. Its total area is slightly more than 370,000 km^2. Part of a volcanic island chain along the Pacific coast of Asia, it lies between 31° and 45°N. To the north, Hokkaido is separated by a narrow strait about 50 km wide from Sakhalin; Korea is about 300 km northwest of Kyushu.

The predominant landscape of Japan is mountainous; a series of high mountain ridges form a spine running lengthwise down the islands and separate the watersheds of the Pacific from those of the Sea of Japan. Lateral mountain spurs cut the coastal area into a series of small disconnected units. Except for limited areas of coastal lowlands and narrow valleys, hills and mountains back the shoreline. In the interior, occasional small basins provide the only level land. High ridges, some of them exceeding 3,000 m above sea level, are concentrated in central Japan. This area is called the Japan Alps. Volcanic belts cover the northern (Sea of Japan) coast, the central mountains, and southern Kyushu, where there are many active volcanoes.

LANDFORMS

Kawai [1959], assuming that topography is the strongest natural factor in determining regional demographic characteristics in Japan, produced a land classification map as a base for her analysis of modern census data. Definitions for her land classification are as follows:

1) montane
   a) mountains: high non-volcanic mountains with local relief more than 300 m, slope greater than 15°.
   b) volcanoes: volcanoes formed during the Quarternary period, covered with lava and debris.
   c) hills: mountains with local relief less than 300 m with basically even ridge lines and well developed fluvial erosion systems, usually composed of Tertiary rocks.
2) level land
   a) piedmonts: the lower parts of mountains with slopes less than 15°.
   b) volcanic piedmonts: the lower parts of volcanoes with slopes less than 15° and covered with ejecta.
   c) uplands: low tablelands and terraces, mainly of Pleistocene formation. Includes fluvial fans and deltas, coastal plains, river and marine terraces, lavaflows, mudflows and Karstic tablelands.
   d) lowlands: mainly of post-Glacial formation including alluvial fans, flood plains, deltas, backmarshs, sand dunes and sand bars.

For the total area of Japan statistics of landforms are as follows (Table 12).

CLIMATE AND VEGETATION

Due to Japan's long north to south latitudinal extension and complex topographic configurations, its climate exhibits numerous local variations. However, two basic factors control its climate. One is the continental factor, observed primarily in the temperature (winter and summer temperature severe for the latitude, relatively large annual ranges of temperature, steep latitudinal temperature gradients in the cold months, as well as a prevalent summer maximum of precipitation). The other is the marine factor of humidity (high relative and absolute humidity, abundant rainfall, moderately wet winters).

General climatic conditions are reflected in the distribution of vegetation zones. There are three principal forest zones in Japan. Subarctic mixed broad-leaved decidu-

Table 12. Areas of different landforms in Japan

	Total	Mountains	Hills	Subtotal montane	Piedmonts	Uplands	Lowlands	Subtotal Level lands
Area*	372	225	42	267	13	44	48	105
%	100	61	11	72	3	12	13	28

(Kokudo Chiriin [1972])

* 10^3 km^2.

Note: Volcanoes and volcanic piedmonts are included in mountains and piedmonts, respectively.

ous and coniferous forest occurs in most of Hokkaido. Cool temperate broad-leaved deciduous forest and warm temperate broad-leaved evergreen forest divide the rest of the country about equally. Within these zones there are a few islands of subalpine coniferous forest at higher elevations (Figure 2).

The important forest zones in Japan (except Hokkaido) are as follows:

1) Subalpine evergreen coniferous forest is found in relict stands in high mountain ranges in the northern half of Japan. Larger zones are concentrated in the central mountain area. The prominent species are varieties of spruce (*Picea*), hemlock (*Tsuga*), fir (*Abies*) and tamarack (*Larix*). Birch (*Betula*) often occurs as secondary forest growth in the north. A slightly warmer element composed of Japanese cypress (*Thuja*), cedar (*Chamaecyparis*) and pine (*Pinus*) occurs at lower altitudes. The upper limit of the zone is about 2,500 m and the lower is at 1,600 m in central Honshu. In the southwestern area, Kinki and Shikoku, it occurs only on mountains higher than 1,800 m.
2) Cool temperate broad-leaved deciduous forest. Typical vegetation in this zone is bush forest mixed with deciduous oak and with dwarf bamboo undergrowth. Beech (*Fagus*), oak (*Quercus*), elm (*Ulmus*), linden (*Tilia*) and maple (*Acer*) trees are the dominant species. In the area of high precipitation, cryptomeria (*Cryptomeria*) and umbrella pine (*Sciadopytis*) forests are formed. In northern Honshu, the lower limit is at 500 to 600 m; in central Honshu it is slightly higher. In the southwest it is limited to the higher mountain ranges.
3) Warm temperate broad-leaved evergreen forest. A typical forest is a community of varieties of oak and chinquapin (*Castanopsis*). Because of the characteristic hard shiny surface of the leaves of these trees, it is sometimes called laurelled forests. This forest originally covered western Japan and

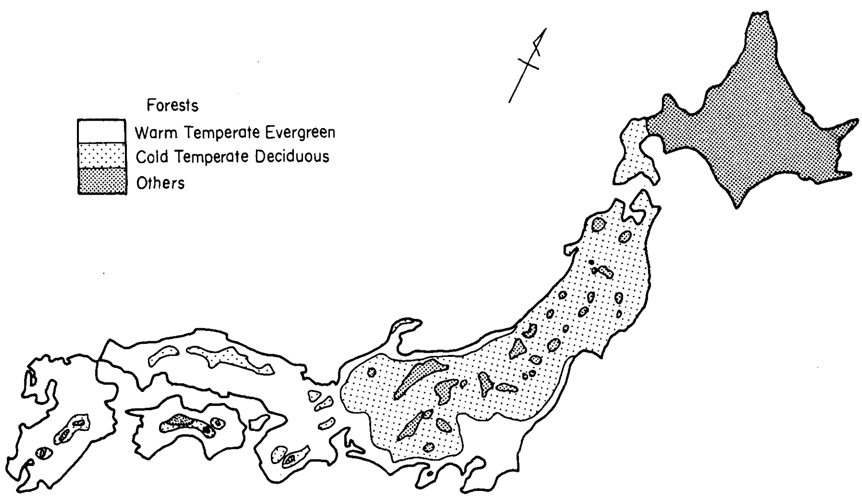


Figure 2. Major Vegetation Zones of Japan (modified from Numata [1974])

the northeastern coastal area. Large areas have been destroyed by agricultural activities and today are replaced by secondary red pine (*Pinus densiflora*) or deciduous oak trees. Artificial forests of cedar and Japanese cryptomeria now occur in the mountain areas.

4) Warm temperate broad-leaved deciduous forest. This zone is usually included in the cool temperate broad-leaved deciduous forest, but due to the effect of elevation it contains characteristic components such as chestnut (*Castanea crenata*), not prominent elsewhere.

T. Kira [1949] explained the distribution of forest zones by using temperature indices. Assuming +5°C is the minimum temperature for any plant to grow, he added all the positive values of mean monthly temperatures after subtracting +5°C, and called the sum a Warmth Index. Negative values, then, are the Cold Index. Isotherm maps of these indices correlate well with the vegetation map. The areas included in the warm temperate zone by the Warmth Index but in the cool temperate zone by the Cold Index cannot support evergreen oaks because the weather is too cold during the winter. Chestnut is predominant in the landscape, thus it is sometimes called the chestnut belt (Figure 3).

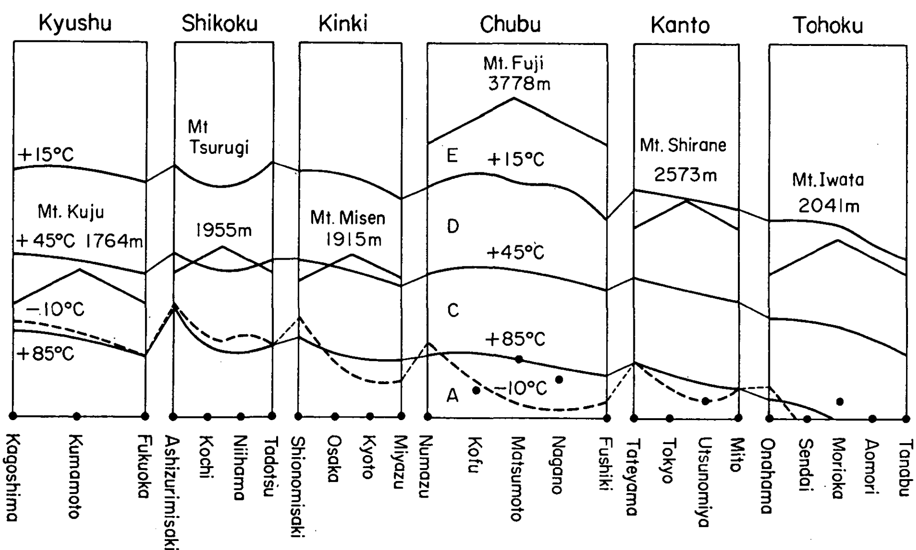


Figure 3. Relationships between the vertical distribution of forest zones and the warmth and cold indices (after Kira). A, Warm-temperate evergreen forest zone; B, warm-temperate deciduous forest zone; C, cool-temperate deciduous forest zone; D, subalpine coniferous zone; E, alpine zone. The diagram shows the +15, +45 and +85°C warmth indices, and the −10°C cold index. Principal meteorological observation sites are indicated by black dots. (after Numata [1974])

Environmental Changes

Landforms

Unstable geological conditions in the Japanese islands, especially active volcanoes may have caused drastic changes in some local conditions, but generally speaking topographic changes for the past 10,000 years have had a negligible effect on human settlements, except in coastal lowlands. The Kanto plain, one of the few large lowland plains in Japan, is known to have changed its landscape considerably during the Jomon period, mainly due to marine transgression. The distribution of archaeological sites shows that until the Jomon 1 period the coastline was at roughly its present position. The presence of later Jomon shellmiddens containing marine shells more than 50 km inland from the present coastline was noticed early by archaeologists [Togi 1930]. The coastline estimated from the location of such sites at the peak of ingression in Jomon 2 was at the present 10 m contour line. This would make Tokyo Bay during this period almost twice as large as it is today, and give it a rugged coastline with numerous inlets into the lower Pleistocene terraces. The sea thereafter regressed throughout the Jomon period until during the Yayoi period it reached a level slightly below that of today. Thus the change in physical landscape resulting from marine transgression in the Kanto plain was quite abrupt and extensive, especially during the Jomon period. Kaizuka [1964] calculated the rate of this transgression in Tokyo Bay (Table 13). At its peak the shifting occurred as fast as 15 m per year. The length of the bay shore in Jomon 2 was more than four times as long as is today's shoreline.

The cause of this transgression was at first considered isostatic, and peculiar to the Kanto plain. More recently, however, evidence of marine transgression has been found elsewhere in Japan [Esaka 1965; Fuji 1965]. Today, the changes are attributed more to the eustatic effects of the post-Glacial warming trend in the global climatic regime. Fuji [1965] explicity demonstrated a good correlation between a temperature curve based on fossil pollen and the sea level shift in the Izumi plain, Toyama Prefecture. Iseki [1972], using C14 dates obtained from alluvial deposits attributes the formation of most of the deltaic plains in the coastal area to the period after 5,000 B.P., conditions closely resembling those extant today having been reached during the Yayoi period. Consequently, among the topographic factors which could

Table 13. Holocene sea transgression in Tokyo Bay

Period	Location	Sea level at present heights(m)	Duration	Move (km)	Speed (km/ 100 yrs)
Jomon 1	Present coast	0			
			3,000	+50	1.6
Jomon 2	Kurihashi, Saitama	10			
			1,000	−15	1.5
Jomon 3	Kusakabe, Saitama	8			
			1,500	−20	1.3
Jomon 4,5	Adachi, Tokyo	5			
			1,500	−10	0.6
Tumuli	Sumida, Tokyo	3			
			1,500	−5	0.4
Edo	Koto, Tokyo	1			

(data modified from Kaizuka [1964])

affect Jomon subsistence adaptation, evironmental changes in the costal plains should be carefully considered.

CLIMATE AND VEGETATION

Increasingly sophisticated reconstruction of climate and vegetation has been made possible by the recent efforts of paleobotanists. Records of more than 100 Japanese peatbogs and archaeological sites have been published [YASUDA 1974], and much of this material has been synthesized by Tsukada [1974] into a model of the environmental history of the last 10,000 years. Using his earlier work in Central Mountain lake sediments and peatbogs [TSUKADA 1967], he divides Holocene pollen profiles into five zones.

1) L: The Late Glacial period. The end of this interval is given as 10,500 B.P. [TSUKADA 1967]. The present cool temperate area was covered by subarctic coniferous forests of spruce, fir and pine, while the warm temperate zone was occupied by coniferous forests of pine, fir, and hemlock and deciduous woods of oak, elm, zelcova (*Zelcova*), hornbeam (*Carpinus*), hackberry (*Celtis*) and birch. Mean annual temperature was approximately 5°C lower than today. The upper limit of the deciduous forest had climbed to 600 to 700 m in the Central Mountain area by the end of this interval [TSUKADA 1974: 87].
2) RI: A short transitional interval from Late Glacial to Hypsithermal, lasting 10,500 to 9,500 B. P. An abrupt decrease in spruce pollen (from 40% to 10% in the Central Mountains and almost disappearing in western Japan) marks the beginning of this period. Birch became dominant in the north, oak forests expanded in central Japan and increasing deciduous oak forests with sage brush (*Artemisia*) and chnopodiaceac were known in the west. The temperature approached that of the present.
3) RII: Hypsithermal. The transition from RI to RII is marked by an increase in oak pollen at about 9,500 B.P. The warming tendency continued until it reaches to an apex about 6,000 B.P. with an annual mean temperature 2°C higher than that of today. The vegetational zones were equivalent to those of today; evergreen oaks (*Cyclobalonopsis* and *Castanopsis*) with the proportion of oak (*Quercus*) decreasing rapidly from the preceding period in the west. Oak forest (*Quercus-Fagus*) was dominant in central and northern Honshu. The upper limit of deciduous forest in the Central Mountains climbed as high as 2,000 m.
4) RIIIa: RIIIa is separated from RII by the beginning of a steady increase of coniferous pollen and a decrease in oak pollen at high elevations. The zone ranges from 4,500 to 1,500 B.P. The climate was getting colder and probably wetter. In the north, beech displaced oak (*Quercus*) from its dominant position and boreal elements such as birch, hemlock, and fir appeared. In the mountains of central Honshu, the coniferous forest expanded and the upper limit of the deciduous forest retreated some 600 m to 1,400 m in alti-

tude. There was also a considerable expansion of coniferous forests dominated by pine in western Japan. Tsukada suggests that the general increase of cryptomeria and umbrella pine in the latter part of this interval indicates higher precipitation, because natural forests of cryptomeria are found in areas of greater than 1,800 mm and umbrella pine in areas of greater than 1,500 mm annual precipitation.

5) RIIIb: The onset of this zone at 1,500 B.P. was marked by a sudden increase in pine and grass (Gramineae, *Artemisia* and Compositae) pollen which is attributed to forest clearing and the secondary succession of red pine due to intensified agricultural activity. This phenomenon appears earlier

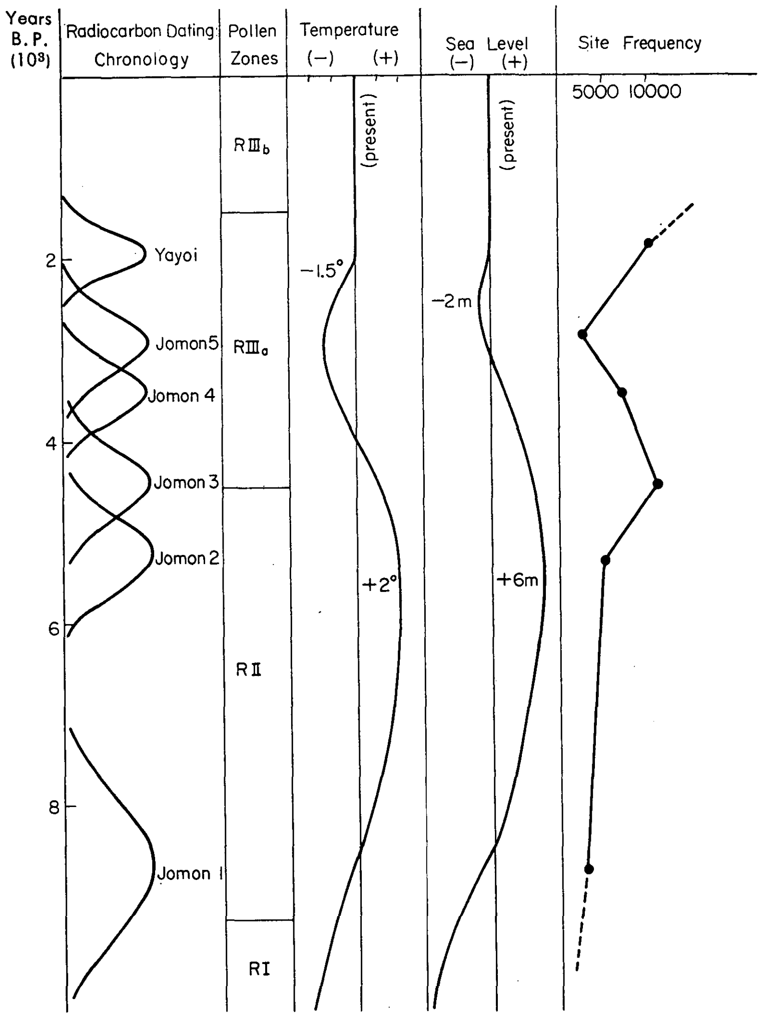


Figure 4. Holocene environmental changes in Japan (data modified from Teshigawara [1975])

in western Japan. There is no indication of any eminent climatic change, but it is considered slightly warmer and drier than the preceding period.

POLLEN CHRONOLOGY

Jomon 1 and 2 fall within the warming trend of the RII interval. The number of sites accordingly increased in eastern Japan while declining from Jomon 1 to 2 in the west. Jomon 3 corresponds to the early part of RIIa when the climate turned colder; site numbers reach a climax in the Central Mountains and on the Kanto Plain at this time but decline precipitously in the following Jomon 4 and 5 periods, during the latter part of RIIIa. In the west, sites increased in number during the cooling trend. The Yayoi period coincides with the deforestation of the RIIIb zone, and the changes in pollen rain and in culture procede eastward together through the warm temperate deciduous forests.

FOOD RESOURCES

During the Jomon period a large variety of resources was utilized as food, and at least 354 species of shellfish, 71 fishes, 35 birds, 70 mammals and 39 plants have been recovered from Jomon shellmounds [SAKAZUME 1961; WATANABE 1974]. These foods, however, since they vary in quantity and distribution, were not equally important. Therefore for the purpose of this study it is necessary to identify the most important staple foods of the Jomon subsistence base. Staple food resources would be those available in abundance and over extended periods of the year, the latter criterion usually implying suitability for storage and use during lean periods [BAUMHOFF 1963: 161].

As mentioned in the previous chapter, the natural landscape of Japan is complicated by local variations and also by significant changes due to past climatic fluctuations. Therefore what is necessary here is not only identification of the staple food resources of the Jomon population but also definition of the geographical and chronological variations in the utilization of these resources.

Identification of the important food resources will be approached using actual remains from archaeological sites as well as ethnographic data from latter periods.

Plants

NUTS

Archaeological recovery of plant remains is unusual, not only largely because they are perishable, but also because traditional excavation techniques have been inadequate for the recovery of such small and inconspicuous materials. Recent improvements in field procedures and a rising interest in subsistence topics, however, have begun to provide us with better information. M. Watabane [1974] compiled a list of 208 Jomon sites which yielded 39 species of food plants. This is a phenomenal increase over Sakazume's [1961] list of 27 species from 29 sites. Those species respectably represented in archaeological records are all hardshelled nuts such as walnuts

Table 14. Nutritive values of nuts and starch

	Cal.	Water	Protein	Fats	Fiber	Carbohydrate	Ash
walnuts[1] (*Juglans regia*)	626	4.1	23.1	60.3	1.8	8.4	2.3
chestnuts[1] (*Castanea crenata*)	180	55.0	3.1	.5	1.0	39.6	.8
acorn[2] (*Quercus chrysolepis*)	360	9.0	4.1	8.7	12.7	63.5	2.0
buckeye[3] (*Aesculus californica*)	136	64.7	2.9	.5	1.8	28.9	1.4
arrowroot (*Pueraria lobata*)	336	16.5	.2	.1	—	83.1	.1

[1] Kagaku Gijutsucho Shigen Chosakai [1963]
[2] Baumhoff [1963] median species of all samples
[3] Wolf [1945]

(136 sites), acorns of various species (68 sites), chestnuts (59 sites), and buckeyes (29 sites). Granting the greater facility of nuts for resisting deterioration and for being recognized by the excavator, they are still excellent resources known ethnographically and archaeologically to have been used in many other places in the world. Nuts, generally, have high nutritive values (Table 14).

Grouping the sites by regions and periods, it is possible to detect the characteristics of nut product utilization during the Jomon period.

Table 15 elucidates two points:

1) Those sites yielding walnuts and chestnuts are concentrated and continuously distributed in the northern half of Honshu, while in the west the acorn-bearing sites have these characteristics. In the west, chestnut and walnut records are limited to Jomon 1 when the climate was significantly colder. This apparently results from a change in the distribution of such trees.
2) Despite the existence of oaks, utilization of acorn resources started late in the Tohoku region. Buckeyes seem to have been exploited early in central Japan but later elsewhere. This could reflect the more involved processing technology required.

WALNUTS

Among the archaeological records of walnuts, Siebold walnuts (*Juglans Sieboldiana*) are the most important. Most of the identified samples (19 out of 21) are of these species and many unidentified samples are also considered to belong to it. The only other identified form is the heartnut (*J. ailantifolia* var. *cordiformis*) (2 sites), merely a botanical variety of Siebold walnuts. Walnut trees grow rapidly and older trees in favorable sites sometimes attain massive size. In natural forests they often occur sporadically as isolated stands along streams. They endure low temperatures and are, in fact, basically cool temperature deciduous forest trees. The distribution of modern walnut orchards still retains the same pattern, being more abundant in the cold regions.

Table 15. Site records of nut utilization

(Tohoku)

Nuts/Period	Jomon 1	2	3	4	5
walnuts	1	11	14	15	20
chestnuts	0	2	3	2	8
acorn	0	0	0	6	3
buckeye	0	0	0	0	12

(Kanto)

Nuts/Period	Jomon 1	2	3	4	5
walnuts	1	8	11	16	
chestnuts	0	1	3	5	
acorn	0	1	2	6	
buckeye	0	2	1	4	

(Hokuriku)

Nuts/Period	Jomon 1	2	3	4	5
walnuts	0	5	3	1	3
chestnuts	0	3	4	2	3
acorn	0	2	1	0	3
buckeye	0	2	1	0	2

(Chubu & Tokai)

Nuts/Period	Jomon 1	2	3	4	5	Yayoi
walnuts	7	3	12	0	3	
chestnuts	1	6	9	3	2	
acorn	2	1	7	3	1	5
buckeye	0	0	0	0	0	

(Kinki)

Nuts/Period	Jomon 1	2	3	4	5	Yayoi
walnuts	1	0	0	3	2	
chestnuts	0	0	0	0	1	
acorn	1	0	3	8	7	5
buckeye	0	0	0	3	2	

(Chugoku & Shikoku)

Nuts/Period	Jomon 1	2	3	4	5	Yayoi
walnuts	1	0	0	0	0	
chestnuts	0	0	0	0	0	
acorn	2	1	4	0	4	2
buckeye	0	0	0	0	1	

(Kyushu)

Nuts/Period	Jomon 1	2	3	4	5	Yayoi
walnuts	1	0	0	0	0	
chestnuts	0	0	0	0	0	
acorn	0	2	2	6	0	1
buckeye	0	0	0	0	1	

The size of the nut is small, the average being about the size of a hickory nut (approx. 3 cm), although it varies with soil conditions and climate. Bearing starts early, at 5 to 6 years. The average modern commercial orchard crop is 60 to 100 kg per tree. Since the nutritive value of walnuts is high, their potential as a food resource is high, even if nut production decreases in the natural forest habitat.

Walnut gathering is simple, consisting either of collecting nuts from the ground or of knocking them from the branches. Consequently, no collecting tools have been found in archaeological sites. Harvesting is done in the fall. For transportation, a large and light container would have been convenient. Although actual remains are scarce it is certain that there was a well-developed basketry technology during the Jomon period, some of the pottery vessels being exquisite copies of baskets.

Storage was mainly done in deep pits. Numerous examples of such pits characterize Jomon sites from a very early period [KOYAMA 1971]. In some cases these have been filled with nuts [WATANABE 1975: 23].

Walnuts are ready to eat immediately after removal of the shells. Some archaeologists attribute the pitted stones and slabs which occur in Jomon deposits to nut cracking [FUJIMORI 1970: 6]. The numerous charred fragments of walnut shells recovered from the earthfill of pit dwellings [MORII 1975: 192] are reminiscent of ethnographic records of shell removal by soaking in water after roasting [JINGUSHICHO 1971: 149].

CHESTNUTS

The Japanese chestnut (*Castenea crenata*) is one of the principal tree species of the warm temperate deciduous forest zone. Its range is similar to that of walnuts but it is more abundant in central Honshu. The species is generally not conspicuous in the pollen record. It grows rapidly to a massive size under favorable conditions but is vulnerable to cold weather and insect pests, and the nut crop is prone to failure under the combined effects of these two enemies.

Chestnuts are traditionally a favored food in Japan, and this is reflected in the variety of local hybrids resistant to divergent climatic conditions and diseases. Today it is the third largest orchard product in Japan and is grown over a wider area than its original range. An important aspect of the trees is their early bearing ability. Under good growing conditions they fruit at three years of age. It is said that the chestnut is self-sterile, thus better harvests are expected in the forest. Under commercial cultivation crops average 9 kg per tree or 65 kg per 10 km^2. The size of nuts varies, some commerical varieties reaching 30 g, but wild nuts average only about 4 g [McKAY 1969]. Wild chestnuts are still important today; Kyoto Prefecture, for instance, marketed 2.1 tons in 1966 [KYOTO PREFECTURAL OFFICE 1968]. Due to a near absence of fats, the caloric value of individual chestnuts is not high. The species' propensity for occasional abundant harvests, especially with human intervention, made chestnuts the main cause of the expanding populations of Jomon 3 in Kanto and Chubu—possibily as a case of incipient agriculture [SAKAZUME 1967].

Chestnut gathering and processing technology is almost identical with that of walnuts.

ACORNS

Ten species of oaks have been identified from acorn remains (Table 16). Distributions of these trees can be roughly divided into two broad areas, the cool temperate deciduous forest zone and the warm temperate evergreen forest zone. Oaks are dominant species in both zones. Inside the forest zones dominance of species varies vastly according to local conditions.

Tree size varies from shrub to massive, and two or more species often grow together in the same forest. Some species, obviously preferred and planted, are frequently found around human habitations. Quantitative information about acorns in Japan is not precise. One large *Q. mongolica* tree produced about 126 lit. of acorns (Niigata Prefecture). Acorns of the *Q. acuta* species could produce 90 to 180 lit. at one place (Nara Prefecture) [WATANABE 1975].

Despite the lack of precise documentation about acorn yields, we may safely assume a fairly stable supply of acorns from the fact that oaks are the principal com-

Table 16. Acorn species identified from Japanese archaeological sites

1.	*Konara* (*Quercus serrata*)	Deciduous	Central Japan
2.	*Mizunara* (*Q. mongolica* var *grosseserata*)	//	//
3.	*Kunugi* (*Q. acutissima*)	//	//
4.	*Kashiwa* (*Q. dentata*)	//	//
5.	*Akagashi* (*Cyclobalanopsis acuta*)	Evergreen	West Japan
6.	*Arakashi* (*C. glauca*)	//	//
7.	*Ichiigashi* (*C. gilva*)	//	//
8.	*Tsuburajii* (*Castanopsis cuspidata*)	//	Southwestern Japan
9.	*Sudajii* (*C. cuspidata* var *Sieboldii*)	//	//
10.	*Matebashii* (*Pasania edulis*)	//	South Kyushu
	Unidentified but Important Species		
11.	*Shirakashi* (*Q. myrsinaefolia*)	Evergreen	West Japan
12.	*Tsukubanegashi* (*C. paucidentata*)	//	//
13.	*Urajirogashi* (*C. stenophylla*)	//	//
14.	*Ubamegashi* (*Q. phillyraeoides*)	Deciduous	//

ponent of the extremely dense Japanese forests. There is a general correlation between site numbers and oak pollen abundance during the Jomon period.

Acorn technology involves the same simple steps as do other nuts, except for the addition of a final preparatory step: removal of the bitter tannic acid. Acorns of evergreen oaks contain a weaker tannic acid and some are made edible by simply roasting. In most cases, however, this is insufficient and leaching is required. Leaching is done either by soaking the acorns in a river or by placing them under dripping water. The duration of this process varies from a few days to more than two months, probably depending on the immediacy of the need and the strength of the acid. Tannic acid content of some deciduous oaks (especially *Q. mongolica*) is so strong an additional step—heating before leaching—is required.

Artifacts of the acorn industry comprise a set of tools closely resembling the *mano* and *metate* (muller and milling stone) of the New World. Milling slabs, a prototype of *metate*, are known from several sites as early as Jomon 1, but round or oval types became common in the latter part of Jomon 2 and well-made examples prevail in Jomon 3 sites in the east, becoming eventually more elaborate but less abundant. In the west *metates* were scarce until Jomon 4 when the slabtype became common.

During Jomon 3 large settlements are always located near springs possibly because of a need for leaching sites for this staple food [ESAKA 1944].

BUCKEYES

Buckeye (*Aesculus turbinata*) is a deciduous tree distributed mainly in the cool temperate forest zone. It is found primarily shady valleys with very moist soil, where it often forms forests of pure stands or combines with *Cercidiphyllum japonicum* [NUMATA ed. 1974: 96]. Buckeye pollen is usually scarce in Japanese sites, but at the Kamegaoka site in Tohoku (Jomon 4) an abnormally high ratio of *Aesculus* was found. This may indicate that such an environment was deliberately chosen for the settlement.

Precise records concerning buckeye production in Japan are not available, but it seems to be large in favorable localities. Ethnographic records of modern villages show 18 to 180 lit. of buckeyes could be easily collected when necessary, and in California related species *A. californica*, produces yields of 3,600 kg per 4,000 m² [Wolf 1945: 60]. Some village strictly regulated the onset of collecting and the allocation of sites.

The size of the nut is large, which makes harvesting easier and more efficient than with acorns. However, buckeyes contain a poisonous alkaloid principle which is difficult to remove by simple leaching. Ethnographically, this was solved by adding ash at the time of heating and/or leaching [Matsuyama 1977]. It was undoubtedly this factor which was responsible for the delay in adoption of buckeyes as a common food source until late in the Jomon period. The nutritive value of buckeyes is not high because of a low fat, high water content, but they have been preferred historically to acorns due to better flavor and efficiency in collecting the nuts.

The early 19th century ethnography of Gifu mountain villages in the northern Chubu region provides us with interesting records on acorns and buckeyes. The area totals 1,712 km², almost all of it mountainous [Kokudo Chiriin 1972]. The villages practiced swidden agriculture, but also heavily utilized acorns and buckeyes as food. Acorn collection records are available for 46 households; the total gathered crop equaled 2,274 lit. or an average of 50 lit. per household. Corresponding records of buckeyes gathered by 41 households totaled 3,299 lit. (average 80 lit. per household). If we assume a liter of these nuts weighs 2 lb the caloric value of these crops totals 7,367,760 cal for acorn and 2,183,161 cal for buckeye, or a grand total of 9,550,921 cal. Assuming an adult daily requirement of 2,000 cal the reported crop is sufficient to support 13 men for full year. The caloric output of 1 km² of land is a minimum of 5,600 cal which means these nuts are good staple foods.

Root Crops and Cereals

Root crops and millets, if they were utilized, could serve as excellent staple foods. Heavy utilization of root crops during the Jomon period has been taken for granted by archaeologists because of an abundance of digging tools (so-called chipped stone axes) and milling stones in the subculture of Jomon 3, in central Japan. However, discussions often take the form of whether there was "agriculture" in the Jomon period rather than examining the kinds of plants utilized.

The work of natural scientists, and their recent cooperation with archeologists in studying the origin and dispersal of plant species, have lent some order to these confusing arguments. One important contribution has been ethnobotanical research on edible plants in Southeast Asia by Nakao [1967]. Nakao identifies a core root crop agriculture complex composed of four important cultigens—taro, yam, banana, and sugar cane—in tropical Southeast Asia. In the peripheral area to the north, there is a variant of this complex adapted to the cooler climate which is called the "lucidophyllus forest belt". This ecological zone includes the area from northern India to southern China and western Japan. Within this zone only two major root cultigens are grown:

Table 17. Evolution of the agricultural complex in Japan

		Scientific name	English name	Japanese name
1.	Gathering stage			
	Roots	*Pueraria lobata*	arrowroot	*kuzu*
		Pteridium aquilinum var. *latiucylum*	fern	*warabi*
		Arisaema japonicum	a kind of taro	*mamushigusa*
	Bulbs	*Cardiocrinum cordatum*	lily bulb	*ubayuri*
		Erythronium japonicum	adder's-tongue lily	*katakuri*
	Nuts		nuts & acorns	
2.	Selecting stage (incipient cultivation)			
	Roots	*Dioscorea japonica*	yam	*yamanoimo*
		Lycoris radiata		*higanbana*
	Nuts	*Castanea crenata*	chestnuts	*kuri*
3.	Root crop cultivation			
	Roots	*Dioscorea Batatas*	yam	*nagaimo*
		Colocasia antiquorum	taro	*satoimo*
		Amorphophallus konjac	devil's-tongue	*konnyaku*
4.	Millet cultivation			
	Millets	*Eleusine Coracana*		*shikokubie*
		Echinochloa frumentacea		*hie*
		Panicum miliaceum		*kibi*
		Setaria italica		*awa*
	Rice	*Oryza sativa*		*ine*

(after Nakao [1967])

a yam (*Dioscorea Batatas*) and a taro (*Colocasia antiquorum*). (Cereals for swidden agriculture were added later through contact with the savanna agricultural complex of adjoining northern India.) Nakao suggested four stages in the evolution of this complex in Japan and listed the possible cultigens and exploited plants of each (Table 17).

Nakao's theory gave impetus to the Jomon agriculture dispute and narrowed the choice of plants involved according to the stages recognized in Jomon culture. A conservative view, accepted by most archaeologists, would restrict Jomon attainment to Nakao's Stage 2, at least until near the end of the Jomon period. All the species involved exist as wild plants today. Those who accept Jomon agriculture argue for millet cultivation but suggest its adoption in different time periods. Fujimori [1950], for instance, associates its introduction with the huge settlements of Jomon 3 in central Japan, Sasaki [1971] assigns it to late Jomon 4 as support for a rapid increase of Jomon sites in western Japan, while Kagawa [ESAKA ed. 1972] would associate the introduction with a possible lanshanoid tool complex during the Jomon 5 period of northern Kyushu.

In this chapter, discussion will be limited to the important wild and (possibly) indigenous plants.

Arrowroot (*Pueraria lobata*)

Utilization of arrowroot is known ethnographically from Japan to Melanesia. It is originally a temperate zone plant which does not fruit in tropical areas. Consequently, it is considered to have been carried southward from the temperate zone.

Huge colonies of the plant are often found at abandoned sites. The starch of this plant is still used in Japan as a delicacy. Production today is concentrated on the Japan Sea side of the Chugoku region because of the favorable, hot and humid, climate. Arrowroot fiber is sometimes used for weaving.

Fern Root (*Pteridium aquilinum*)

Fern is a thriving wild plant which grows on sunny hillsides throughout Japan. Use of fern root is known in the area from Japan to China. Young sprouts are served throughout a wider area. Nineteenth century ethnographic reports from Gifu Prefecture record that Nomugi Village's 39 households yearly produced 360 lit. of fern root starch, comparable in importance to their production of such cultigens as millet (367 lit.), buckwheat (490 lit.) and peas (130 lit.) [KOKUBU 1970: 73].

Bulbs (*Cardiocrinum cordatum*, *C. c.*var. *Glehni*, *Erythronium japonicum*)

Lily bulbs occur in scattered populations as forest undergrowth, sometimes forming thriving colonies in danker areas. Bulbs achieve larger size in the cool temperate zone. *C. c.*var. *Glehni* is restricted to Hokkaido and is an important staple food of the Ainu. *Erythronium* starch is still popularly used in modern Japan.

Taro (*Colocasia antiquorum*)

This particular type of taro is poisonous in the natural state, but with heating it becomes edible. It is found in the warm temperate zone but is presently scarce. Utilization is known ethnographically in Japan only on the Pacific ocean islands off Honshu, but similar species are said to be still in popular use in the Himalayan area.

Yam (*Dioscorea japonica*)

This is the only wild and endemic species of yam in Japan. It prefers warm, wet conditions and is thus more common in western Japan. It is not plentiful under wild conditions. This type of yam is still a popular side dish among modern Japanese.

For use as food, these plants, except at the gathering stage, undergo a common process similar to that of nuts. Digging tools are requiried for gathering. Labor intensity varies from deep digging (yams) to simple turning (lily bulbs). Because of strong vegetative reproduction (yams and taros) or thriving colonization in favorable soil conditions (arrowroot and lily bulbs) it is possible to vastly improve yields with minimal human care. Preparation for food involves beating (or milling) and leaching sometimes heating and adding ash. Storage of starch would be very efficient. The Ainu preserve lily bulb starch either as pure powder or as dry cakes [SONODA 1972]. Neither form requires much space and both preserve well. Nutritive value of the starch is high, about 1,500 cal per pound. It is not balanced, however, lacking fats and protein.

Cereals

The number of archaeological remains of cereals (including impressions on pottery surfaces) increase markedly after the Yayoi period. Sato [1971] listed 472 occurrences, most of them rice. The occurrences include 11 Jomon sites, but except for one dubious Jomon 3 report in Kanto, all are Jomon 5 sites in the west (Kyushu and Chugoku regions). Fuji [1971] suggests that cultivation of rice could have started in late Jomon 2 and he is certain of it in Jomon 5 in the Hokuriku region based upon a group of large-grained Gramineae pollen in his palynological samples. Tsukada [1974] rejects this idea because of the near impossibility of differentiating the pollen of cultivated *Oryza* from other grasses by size alone.

Technologically, sites of cereal cultivators on the Asian mainland usually yield distinct forms of "reaper knives". The Kyushu Jomon 5 sites yield coarse forms of this implement, but Yayoi assemblages usually include well-made knives. Granting that there were several small waves of cultural flow during the Jomon period, the general supposition of Japanese archaeologists that the Yayoi culture was formed by a strong continental stimulus seems still to hold in the sense that the food production pattern changed the context of Japanese society to the extent of forming states in the peripheral area of greater China.

Game

Game Resources

There are four species of large land mammals in Japan, deer, boar, bear and antelope. Among these the most important for Jomon people were deer and boar. Of the shellmound sites which have yielded animal bones, 98% have one or both of these animals. This combination is consistent in mountain sites such as caves rock shelters where bear and buckhorn appear more often than in the coastal sites [Kaneko 1967]. Deer and boar are also the preferred game in historic and ethnographic records.

Japanese Deer (*Cervus nippon*)

There are three subspecies of this type of deer in mainland Japan: Khuysu deer (*C. nippon nippon*) located in Kyushu and Shikoku, Honshu deer (*C. nippon centralis*) on Honshu, and Ezo deer (*C. nippon yesoensis*) on Hokkaido. Average stage of these subspecies weigh 44 kg, 70 kg and over 80 kg respectively [Imaizumi 1960: 186–189]. Their favorite habitat is deciduous forest and adjoining grasslands. Distribution today is limited and spotty in the mountainous areas, but old literature and ethnography indicate that deer were once abundant throughout Japan. In the colder areas of the Japan Sea coast they migrate seasonally between mountains and coasts to avoid deep snows.

Deer population, in spite of restriction in range, are still relatively high. Yamaguchi Prefecture records the hunting of around 1,000 deer annually from 1963 to 1966. Kyushu, Chugoku and Chubu regions record relatively high yields as well [Chiba 1969].

Boar (*Sus scrofa*)

Boars weigh 75 to 190 kg and have been ethnographically a favored meat. Distribution of the animals is concentrated in the west. They do not extend to Hokkaido.

Despite the common recovery of boar bones in the Tohoku region, the local population is almost negligible today. Naora [1962] attributes this to Jomon overkilling, but it may be due rather to environmental limitations—*sasa* type grassland vegetation (resulting from the cold and snowy climate)—being unfavorable boar habitat. Throughout the Jomon period, Tohoku sites always yield less boar than deer. In Jomon 5, as the climate cooled, the number of sites yielding boar decreased further in spite of an increase in deer. This contrasts with other regions where the ratio between the two remained constant. Boar today are still quite abundant from central to western Japan, and many prefectures in these regions record annually huntings of more than 1,000 animals.

Bear

There are two species of bear in Japan. The brown bear (*Ursus arctos*) is restricted to Hokkaido, while the white collar bear (*Selenarctos thibetanus*) ranges through the other islands. White collar bears weigh 100 to 250 kg; brown bears are twice as large. Bears prefer colder climates and their modern distribution is limited to the high mountain ranges of the Chubu-Tohoku region. About 100 bears are hunted annually in Iwate, Fukushima and Gifu Prefectures. Few Jomon sites (12 shellmounds and 5 caves) have yielded bear bones but these coincide well with the present distribution of the animals. Some mountain sites provide evidence of intensive bear hunting activity. At Karasawa Cave (Jomon 5) in Nagano Prefecture, for example, 15 individuals were identified—more than of any other kind of game [KANEKO 1967].

Antelope (*Capricornis crispus*)

Antelope live in high mountain ranges at altitudes of more than 1,000 m. The population is small and today hunting is prohibited by law. Only six Jomon sites

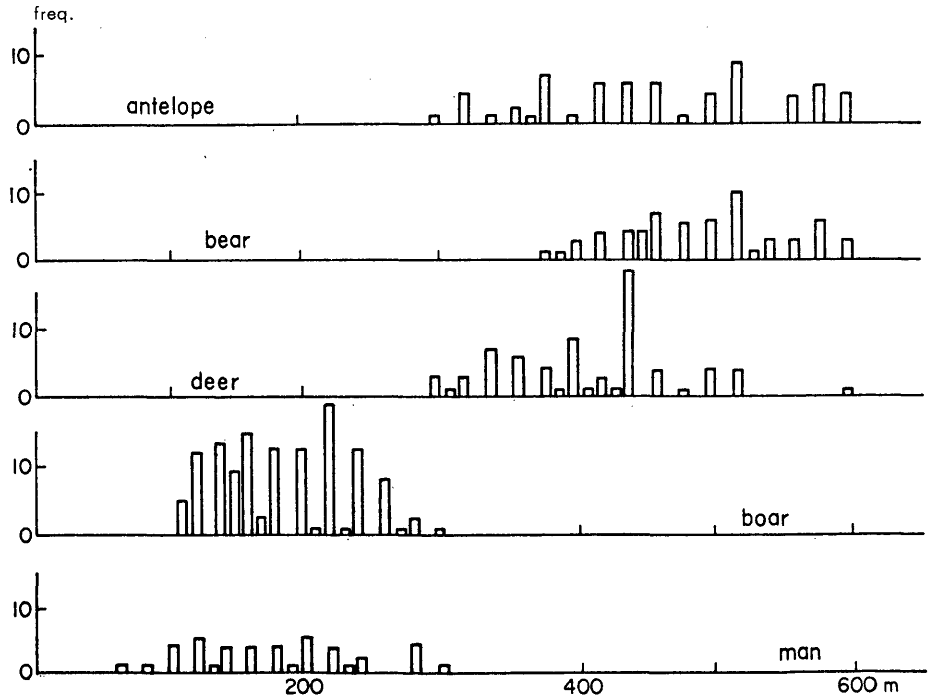


Figure 5. Land use by large mammals in Kunisaki Peninsula, Kyushu (after Chiba [1959])

have yielded antelope remains, so the species may be considered of negligible importance as a food resource.

Recent research on the distribution of large land mammals in northern Kyushu provides interesting information on the habitat and behavioral patterns of these large game species [CHIBA 1959]. At Kunisaki Peninsula in Oita Prefecture, grid units of 500×500 m were scored for intensity of slope (relief energy). Utilization by humans and by each game species was then plotted for the same areas (Figure 5). The results show that man and boar share practically the same habitat, concentrating in relatively flat areas, while the other three species prefer steeper mountains. The favored food of boar (root crops, nuts and young buds) occurs in the flatter areas and provides a potential for competition with humans which could become serious at the agricultural stage. The prehistoric trend of exploiting boar first and then deer secondly, often observed at Jomon sites in the Kanto area, presumably results from this situation [KANEKO 1973].

TECHNOLOGY

Shooting and snaring are the universal methods for hunting these large game species. Deer are often obtained by drives. Bears are often killed during hybernation. Archaeological remains related to hunting are bow, arrow(head), spear and dog.

Bows and Arrows

Excavated examples of bows are limited, but they show that a long bow, more than 1 m in length made of solid wood, was commonly used. The bow and arrow may have been a technological innovation of the Jomon period, because no clear evidence of arrowheads, in the sense of stylized form and regular size, has been found in the preceeding sub-Jomon and late paleolithic sites in Japan. Chipped stone arrowheads are the most common artifacts in the Jomon period, although the quantity, material and form varies. They are sometimes found imbedded in the bones of boars (Shizimizuka shellmound, Aichi Prefecture, Jomon 4), or of men (Ikawazu shellmound, Aichi Prefecture, Jomon 4–5). The latter case becomes common among Yayoi sites. A Yayoi bronze bell illustrates a man with a long bow aiming at a deer.

Spears

Fine examples of long points are found in preceramic sites but fewer and coarser specimens are known during Jomon times. They are found only in eastern and northern Japan, and disappear by Jomon 3, except in the Tohoku and Hokkaido regions. The distribution seems to best correlate with that of bear.

Dog (*Canis familiaris*)

The dog, an effective hunting aid, was raised at least by late Jomon 1 in Japan. More than 120 Jomon sites have yielded dog bones, and these differ from other animals in being found as burials. At Kikuna shellmounds, Kanagawa Prefecture, (Jomon 2) about 20 individuals were identified [OKAMOTO 1974: 108]. The number of sites yielding dog correlates well through time with the occurrance of boar and then with deer. A relief on a Yayoi bronze bell shows dogs surrounding a boar which a man with a long bow is trying to shoot. Use of dog for hunting boar is the most common method in Japan.

Esaka [1973: 31] suggests that hunting regulations (prohibition of killing females and infants) may have been in practice during Jomon times. At Kikuna shellmounds and nearby Shimogumi shellmound, Kanagawa Prefecture, all the deer skulls had antler pedicles, and only one-third of the boars were female. Also no young or infant bones were found among them.

Fishery

Fish has been the main protein resource for the Japanese population throughout its history. One reason is the physical environment of the country—no part is more than 75 miles from the sea. Small cave sites deep in the mountains often yield marine shells and fish bones. This natural reliance was increased during the historic period by the introduction of Buddhism, which disdained the killing of mammals. Already in the early historic period the fishing industry had developed to the extent of forming specialized fishing groups, and the Japanese language has developed many specific terms for species of fish, shellfish, and sea weeds, as well as their products. This tradition obviously goes back to the beginning of the Jomon period which is characterized by the formation of shellmounds on the shoreline—some of which are middens 60,000 m^2 in area. No shellmound of the pre-Jomon period has ever been found and those of Yayoi and later periods are considerably more limited in size and in the variety of species they contain.

BAY FISHERY

More than 60% of Jomon shellmounds are located in the Kanto region, which, during the mid-Holocene sea ingression, became a shallow bay. Large shellmounds were made along the old inner-shoreline of these bays. Bays and the Inland Sea were the favorite locations for Jomon fishery; at Atsumi and Ise Bay areas in the Tokai region, on the middle Inland Sea area of the Chugoku region and on Ariake Bay in west Kyushu where a majority of Jomon shellmounds of each region are located.
Shellfish

The main trophic activity in such areas was shellfish collecting—an activity which requires no special technology. The main species of shellfish are at Table 18.

The habitats of these shellfish are either tidal flats or shallows; all are easy to

Table 18. Main species of shellfish found in the Jomon shellmounds

	Japanese name	Site records	% of all shellmounds
oriental clam (*Meretrix lusoria*)	*hamaguri*	494	86%
oyster (*Ostrea* sp.)	*kaki*	398	69
rollshell (*Rapana venosa*)	*akanishi*	369	64
Japanese little neck (*Ruditapes philippinarum*)	*asari*	340	60
small rollshell (*Batillaria multiformis*)	*uminina*	249	43
small rollshell (*Umbonium moniliferum*)	*ibokisago*	131	23

Table 19. Main species of fish found in the Jomon shellmounds

	Japanese name	Site records	% of all shellmounds
sea bass (*Lateolabrax japonicus*)	*suzuki*	98	76%
black porgy (*Acanthropagrus schlegelii*)	*kurodai*	71	55
grey mullet (*Mugil cephalus*)	*bora*	62	51
blow fish (*Spheroides* spp.)	*fugu*	43	27

collect and can be obtained in quantity. Shells of the last two species often occur in thick homogeneous layers or large blocks in the sites. As the sea regressed in later Jomon times the main components of the shellmounds shifted to freshwater shells, *Corbicula* spp.

Fish

Fish bones obtained from this type of shellmound are at Table 19.

These fish are considered to have been caught in the inner areas of bays, because they prefer estuarine habitats where fresh and salt water mix. Watanabe [1973] suggests that most of the re-utilized shards which become common beginning in Jomon 3 in Kanto are weights for drag nets used to catch these fish.

When the shell component changes to freshwater species, carp (*Cyprinus carpio*) and eel (*Anguilla japonica*) become prominent [KANEKO 1965: 393].

These shellfish and fish, as individual species, may not have comprised a staple calorie source, but taken together they could provide a stable day-to-day basic protein source.

OCEAN COAST FISHERY

The Pacific Ocean side of the Tohoku region, another center of Jomon shellmound distribution, has a jagged coast line composed of numerous small inlets—a type of coastal landscape common in Japan. Many such locations, although poorly used during the Jomon period, became important fishing areas later in the historic period.

Shellfish

Shellfish on rocky shores are often small rollshells, which are not plentiful as clams in tidelands. Large shellmounds are consequently limited to areas of beach formation [KANEKO 1965: 392]. The main components of shellmounds in the Tohoku region are the same as in Kanto, except that the relative positions of oyster and oriental clam are reversed (Table 20). However, compared to Kanto, rocky shore shellfish such as small rollshells are more common and plentiful.

The most important shellfish in this area is abalone. Important abalone species in Japan are *madaka* (*Nordotis giganta*), *megai* (*N. sieboldii*), and *kuro* (*N. discus*). *N. giganta* ranges from Kanto to Kyushu on the Pacific coast and along the Japan Sea coast in Honshu. It lives on deep bottoms at depths of 10 to 50 m and may grow to a diameter of 24 cm. The range of *N. sieboldii* is almost identical with that of *N. giganta*, but it occurs on shallower bottoms. *N. discus* covers a wider area than the other two species, reaching Hokkaido and Korea. It also lives at shallower depths.

Table 20. The important shellfish found in the Jomon shellmounds in the Tohoku Region

	Japanese name	Site records	% of all shellmounds
oyster	*kaki*	50	50%
oriental clam	*hamaguri*	57	48
Japanese little neck	*asari*	48	40
small rollshell (*Thais bronni*)	*reishi*	32	
small rollshell (*T. clavegera*)	*ibonishi*	23	
small rollshell (*Lunella coronata coreensis*)	*sugai*		

The latter two species are slightly smaller in size than *N. giganta*. Abalone meat is usually eaten after drying. Numerous recipes for it in this form have been developed. Relative scarcity and the greater difficulty in obtaining it have made abalone valuable.

A high value for abalone in prehistoric times as well can be assumed from the fact that the shell was often utilized as material for accessories. In the Jomon period, abalone shells and shell artifacts are sometimes found in inland sites. Abalone products were important as ritual as well as secular items in Japanese life [Koyama 1970]. Rather than implements, gathering technology involves physical training for long diving, in later times a specialization of women. Chinese records of the third century A.D. mention Japanese abalone divers.

Fish

Dominant fish bones obtained from shellmounds in this area are sea bream (*Pagrus major*; *madai* in Japanese), tuna (*Thunnus orientalis*; *hagatsuo*), bonita (*Katsuwonus pelamis*; *katsuo*), and shark (*Subclass Plagiostomi*; *same*). Sea bream is a medium sized fish still popular among the Japanese. Tuna and bonita form migrant schools in the Pacific. The former gather along the Japanese coast during winter, while the latter come from early summer through fall. Tuna sometimes reach lengths of 3 m and weigh 350 kg. Bonita are smaller, averaging 50 cm and weighing 10 to 15 kg. The warm *Kuroshio* and cold *Oyashio* currents meet offshore in this area and provide a good fishing field even today. Various kinds of sharks may be available at any season.

The shellmounds, many of which were formed during Jomon 4 and 5, commonly yield fishhooks and harpoons made of deer antler. At the Terawaki shellmound in Fukushima Prefecture, the number of individual fish was reconstructed separately for

Table 21. Major fish species from Terawaki shellmound, Fukushima Prefecture

	Jomon 4	Jomon 5
sea bream	73	119
tuna	4	19
bonita	6	3
shark	20	49
Total	103	190

(after Watanabe [1973])

the Jomon 4 and Jomon 5 components. The differences (Table 21) are significant according to a chi square test (df=3, χ^2=13.9, r_m=.21). This comparison reveals an interesting aspect of the fishery: tuna bonita, though they are minor components of the faunas, contribute heavily to the obtained chi square value. This may indicate a stable fishery role for sharks and sea bream, but there a large chance factor involved in obtaining migrant fish.

According to historical literature as well as modern ethnography, shark, tuna and bonita are preserved by drying. Sea bream is usually eaten fresh, either raw or broiled.

Offshore fishing may be of equal or greater value than bay fishing, but yields are less reliable. Topographic conditions restrict the size of settlement as well as intercommunication between sites and with other regions. Thus lack of facilities for transport of fish makes it less important regionally.

INLAND FISHERY

Despite scanty data on freshwater or anadromous fish remains, it is reasonable to assume the importance of an inland fishery during the Jomon period from the fact that remains of freshwater shellfish are common, if not extremely abundant. Historic and ethnographic data support the assumption. *Engishiki*, compiled in 907 A.D., documents that freshwater and anadromous fishes such as salmon, *ayu* (sweet fish), carp, crucian carp and *amenouo* (a land-locked salmon) were taxed resources for certain provinces [KUROITA ed. 1965]. Among these forms salmon and *ayu* are the most important, but there is a distinct difference in distribution between the two species. Salmon provinces are concentrated on the Japan Sea coast from Hokuriku to northern Chugoku, while those of *ayu* are in the western region, along the Pacific coast. In 1974, freshwater fishery production in Japan totalled 112,329 tons. Although this figure is distorted by modern technology the basic components of the fishery, and perhaps their relative importance as well, have been consistent since the Jomon period.

The technology of freshwater fishing has included angling, spearing, weirs, nets, and (in the historic period) cormorant fishing for *ayu*, but actual remains are scanty. That fishhooks were used as early as Jomon 1 is demonstrated by a specimen from the Tochikura rock shelter in Nagano Prefecture [WATANABE 1973]. Possible net weights made of shards or pebbles are found beginning in Jomon 3. These implements increase in Jomon 4, but do not sufficiently elucidate the quality of the technology by period and region.

Salmon

Dog salmon (*Oncorhyncus keta*) occur in large spawning runs in the rivers during fall and winter. Major runs are restricted to Hokkaido, but they occur in smaller numbers as far south as the Tone River in Kanto, on the Pacific coast, and to near Kyushu, on the Japan Sea coast. Present important fishing fields in Honshu are the Shinano River in Niigata and Nagano Prefectures, and the Naka and Tone Rivers in Kanto. Dog salmon was important to the Ainu in Hokkaido, who practiced a series of rituals at various phases of the fishing period and also a variety of fishing methods.

Cherry salmon (*O. masou*) is a slightly smaller fish and covers a wider local area than dog salmon, occuring as far south as northern Kyushu. Spawning runs take place from late spring to summer.

Ayu (*Plecoglossus altivelis*)

Ayu is a small anadromous fish (20 cm, 100 g) commonly found in Japanese rivers during summer. It is a highly favored diet any item among modern Japanese. Today *ayu* are stocked in many rivers. This may be responsible for the large yields in recent years.

Freshwater resources as day-to-day protein resources may be equivalent to bay fishing in potential. Except for salmon, they are not readily preserved, due to their small size; this is evident in traditional recipes, which reflect a preference for eating fresh *ayu*.

Regional Food Resource Potentials

One of the main factors controlling distribution of wild food resources is climate. This is especially true of plants. Among the important staple foods of the Jomon period, walnuts, some species of oaks, and bulbs grow well in a cold climate, while arrowroots, yams and other species of oaks are limited to or yield better in areas with a warm climate. Chestnuts grow well only at the borderline of the two zones. Game also follows this pattern, boar favoring warm climate areas and bears concentrating in colder areas. Of the major anadromous fishes, salmon run in the colder rivers of the north; *ayu* are more common in the southern part of the country. Deer are unaffected by the zonation, while marine resources slightly differ in character. Ocean currents and coastal landscape are determinant factors for the latter resources, thus whenever local conditions are favorable good yields can be expected anywhere. Such conditions, however, are usually better along the Pacific.

Topography is another strong controlling factor. Most of the large coastal plain was formed during the Jomon period, and during this ontogenesis marshy and unstable flood plain conditions excluded the staple food plants. Much of this area was inundated during the marine ingression. Chestnuts, ferns and some oaks favor mountainous terrain, while buckyes favor shady valleys and lilies often form large colonies on wet lowlands, but distribution of plant food will be assumed constant to any landform, except in the higher mountains, where subalpine coniferous forests with low food resource potential occur. Topography seems more important to animals (including man) than to plants. Boar and man prefer flatlands, while deer, bear and antelope have adapted to more rugged terrain.

If distribution and quantity of food resources can be determined, it will provide a solid base for estimates of prehistoric populations of the area.

Nine regions are evaluated using the following procedure:

1) Food items are all wild resources including nine plants, three animals and three types of fishing (yielding a 3:1:1 ratio for plants, game and fish re-

spectively) in order to reconstruct roughly equivalent dependence on these in the Jomon people's diet.

2) Resources were scored ordinally as poor (1), moderate (2) or abundant (3). Any attempt at greater precision would be misleading in view of the contrasting large size units involved in the study.
3) Evaluation is based upon distribution of each species in the original habitat under roughly the same climate as today. No technological preferences are made.

The calculated potential food resource value for each region is provided in Table 22. To examine the validity of given values, a simple statistical test—Spearman's rank order correlation [SIEGEL 1956: 204]—will be carried out. Firstly, regions are ranked according to food value and then the same procedure is repeated on the total number of sites of the Jomon 1 through 5, Yayoi and eighth century Haji populations. Data for the last category is Sawada's estimated population derived from tax records [SAWADA 1927: 178–190].

The result of the calculations is demonstrated in Table 24. The Jomon 1 and Haji figures are below the significant level (p>.01). The size of the correlation coefficient rises sharply in Jomon 2 and continues to be high through Jomon 4. It then declines from Jomon 5 through the eighth century. The Jomon 2 rise coincides with the fact that technology of food exploitation was developed by the end of this period. The rank of potential value for regions correlates well with the rank of site frequency during Jomon 2 through 5. A change starts in the Yayoi period and continues into the historic period, documenting an increasing dependence on rice rather than wild

Table 22. Regional food resource potentials

Resource \ Regions	Tohoku	Hokuriku	Kanto	Chubu	Tokai	Kinki	Chugoku	Shikoku	Kyushu
walnut	2	2	3	3	1	1	1	1	1
chestnut	2	3	3	3	1	1	1	1	1
acorn (nonprocessed)	1	2	2	2	3	3	3	3	3
acorn (processed)	3	3	3	3	3	3	3	3	3
buckeye	3	3	3	3	2	2	1	1	1
fern	3	3	3	3	3	3	3	3	3
arrowroot	2	2	3	3	3	3	3	3	3
bulb	3	2	2	2	1	1	1	1	1
yam	1	2	3	3	3	3	3	3	3
deer	3	2	3	3	3	3	3	3	3
boar	2	2	3	3	3	3	3	3	3
bear	3	3	2	3	1	1	1	1	1
inshore species	3	2	3	1	3	3	3	3	3
offshore species	3	2	3	1	3	1	2	2	3
riverine species	3	3	3	3	2	2	2	2	2
total	37	36	42	39	35	33	33	33	34

Table 23. Rank orders of food resources and sites by region and period

Rank orders by cateogry	Food resources	Jomon 1	2	3	4	5	Yayoi	Haji
Tohoku	3	4	3	3	3	1	9	9
Hokuriku	3	9	5	4	4	5	8	5
Kanto	1	1	1	1	1	3	2	3
Chubu	2	2	2	2	2	2	4	8
Tokai	5	5	6	5	7	6	6	7
Kinki	7	7	7	6	6	7	3	1
Chugoku	9	6	8	7	8	8	1	2
Shikoku	8	8	9	9	9	9	7	6
Kyushu	6	3	4	8	5	4	5	4

Table 24. Rank order correlation coefficient

Period	Food Potential
Jomon 1	.63
2	.98
3	.98
4	.98
5	.97
Yayoi	.61
8th Cent. A.D.	−.44

foods. Conversely, the results of the test may strengthen the association of the Jomon economy with the exploitation of wild food resources.

LAND USE

In the preceding chapter, regions were evaluated by distribution of wild food resources. However, distribution of resources in each region varies, mainly in this case, according to landscape topography. Therefore, topographic variables become strong controlling factors for settlement patterns in each region. Chang introduced the idea of the *settlement* as an archaeological abstraction for the primary social group which is called a community among living societies. He defines an *archaeological settlement* as "the physical locale or cluster of locales where members of a community lived, ensured their subsistence, and pursued their social functions in a declineable time period. ··· it must be occupied and made use of by a single group of people" [CHANG 1968: 3]. If we can specify the settlement pattern of a group, it will help to define the exploitative pattern of the period. One of the best methods in actual operation is to establish transects of the area where the quality of archaeological survey is good and the landscape is representative. Due to the character of the data employed here, such areas are usable only when site-maps are available and the specific temporal identity of the sites is known. In spite of these restrictions, three transects are created here: Niigata Prefecture (Hokuriku), Tokyo (Kanto) and Yamaguchi (Chugoku). Niigata represents the Japan Sea coast, Tokyo represents the Pacific oceanbay region. Both are situated in the intermediate forest mixed deciduous-evergreen forest zone, although the Niigata transect includes more of the deciduous forest zone. Yamaguchi Prefecture shows an evergreen forest mostly of the Inland Sea environment.

The "standardized local mesh method" [SORIFU TOKEIKYOKU 1974] was utilized to establish a grid system within each transect. Topographical maps (1:50,000 scale) were divided into ten rectangular tracts, measuring about 4 km².

For each tract of a transect, presence or absence of (1) five landforms [KAWAI 1959] and (2) sites of each period were recorded. The first category represents the topography of Chang's "physical locale" (a tract) and the second indicates the use of such locales by "a group of people" of a particular temporal unit. A computer program was made to cross tabulate these in a variety of ways.

Transect 1 (Niigata)

This transect (Figure 6) measures roughly 22.6 km by 129.4 km and covers an area from the Japan Sea coast to the mountains. The general landscape of the transect is a flat plain—a corner of the Niigata plain—in the north and the narrow valley of the Shinano River which descends from the Central Mountains in the southern side of the transect. Small units of an upland Pleistocene formation exist along the mid-stream of the river.

Archaeological survey in Niigata Prefecture has been extensive. A total of 5,143 sites are recorded and about 30% of them are of Jomon age. Characteristics of Jomon site distribution in this area are that early periods are represented only in limited numbers (probably due to harsh climatic conditions), followed by a major expansion in Jomon 3, and then a gradual decrease toward the end of the period. The Yayoi intrusion was generally weak. Haji pottery of the early historic period consists mostly of late types of the seventh and eighth centuries which continued in use until around the 12th century. A total of 456 tracts (77%) are occupied by sites.

Table 25. Landform and site distribution in transect 1 (Niigata)

(Landform types and number of tracts)

Freq./Landforms	M	H	U	L	MU	HU	LM	LH	LU	LMU	LHU	Total
No. of tracts	182	17	18	189	27	5	99	24	22	8	5	596
%	30.5	2.9	3.0	31.7	4.5	0.8	16.6	4.0	3.7	1.3	0.8	100
(Number of tracts occupied by period)												
Jomon 1	0	0	1	0	3	1	0	0	1	1	1	8
Jomon 2	1	0	1	3	6	7	10	1	1	0	1	24
Jomon 3	12	1	14	28	19	3	45	11	16	5	4	158
Jomon 4	4	2	10	18	13	3	34	8	11	3	2	108
Jomon 5	1	1	2	10	2	2	12	1	6	1	1	39
Yayoi	1	1	1	9	2	0	8	2	2	0	0	26
Haji	2	2	0	60	0	0	17	8	1	0	3	93

M=Mountain H=Hill U=Upland L=Lowland

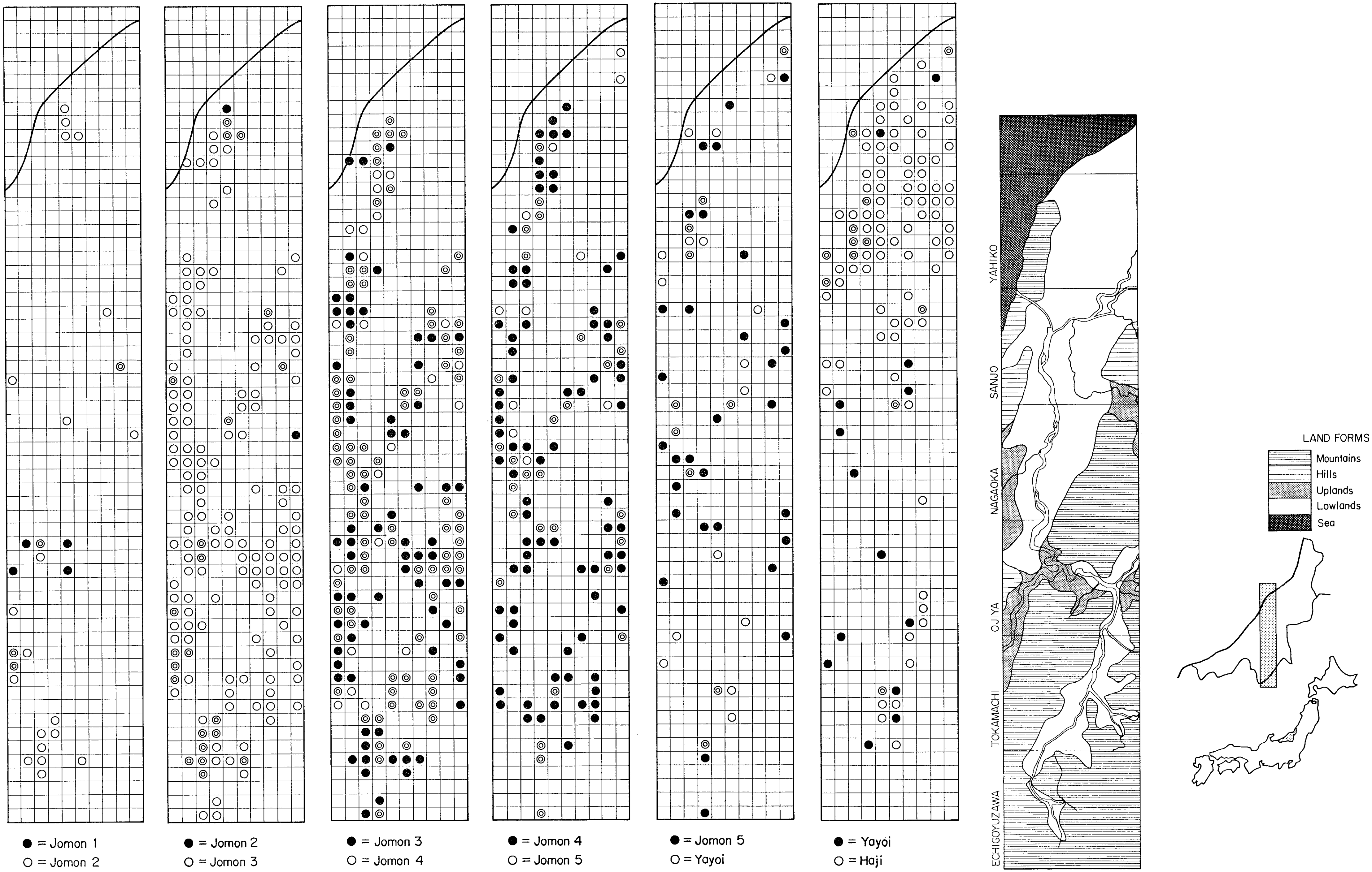


Figure 6. Transect 1 (Niigata)

This transect is composed of 596 tracts. A result of tabulation by landform and sites is shown in Table 25. Combining of four landform elements (piedmont is not present) resulted in 10 categories in this transect. The dominant landscape is lowlands (31.7%), followed by mountain (30.5%) and lowland-mountain combination (16.6%).

Landform Preference by Period

During Jomon 1 the area was thinly populated, only eight (1.3%) of the tracts being occupied. No specific landform preference appears in the statistics, but close examination reveals that every locale utilized in this period includes uplands located in the central part of the Shinano River.

In Jomon 2 the number of sites is triple that of Jomon 1, but site distribution is still thin. The most frequently used type of locale is the lowland-mountain combination, although many of the Jomon 1 tracts are still in use. Exploitation of the mountain resources may be a new specialization for the people of this period.

Jomon 3 is characterized by great increase in the numbers of tracts utilized. More than 25% of all the transect utilized. Tracts of all landform types are in use, although the habitat preference is virtually unchanged. Site distribution in Jomon 4 is almost identical with that of Jomon 3. Only the number of settlements decreases, and this tendency continues into the following period. The thinning appears faster in the mountain areas. One new aspect of Jomon 5 land use is that lowlands below 50 m elevation begin to be used more extensively.

Yayoi settlement in this area is quite sparse, and the fact that only 4% of the tracts are utilized shows a difference in landscape preference. Pure lowland surpasses traditional lowland-mountain locales and 88% of the tracts utilized in this period include lowland elements.

Haji land use is characterized by intensive concentration in the lowland, especially on the coastal plain. Locales on the coastline which had been seldom utilized during the Jomon period are occupied frequently. Use of the upland on the central reaches of the river, which had been favored throughout the Jomon period, is conspicuously absent.

Land Use Continuity

Observation of the figures in the table and the distribution pattern of occupied tracts show that there is a consistant pattern of land use during the Jomon period. Differences in land usage, for example occupation of mountain locales, seems to be due to population pressure. When the exploitative pattern is constant, the space for usable land is limited and such places had to be used repeatedly. For example, caves and rock shelters in rugged mountain areas often yield layers of cultural materials of different time periods, but always consisting of hunting-oriented artifacts. Such available locations are so rare that hunters had to use the same places repeatedly. In the same sense, if a tract is used continuously over several periods, its value is assumed to be high. Table 25 shows the number of tracts reused in succeeding periods.

Table 26. Tract re-use in transect 1 (Niigata)

	Jomon 1	Jomon 2	Jomon 3	Jomon 4	Jomon 5	Yayoi	Haji
1. tracts utilized	8	24	158	108	39	26	93
2. tracts re-utilized		4	22	86	29	10	12
3. % of re-urilized tracts		50	92	54	27	26	46
4. % of new tracts		83	86	20	25	61	87

The percentage of re-utilized tracts shows the intensity of cultural tradition, while the percentage of new tracts indicates the intensity of change or expansion. The figures show that Jomon settlement developed markedly while retaining the traditional distribution as well until Jomon 3. Declining value in the same settlement pattern is shown clearly by the low percentage of new tracts. The trend towords a new tradition starts with the Yayoi period. The continuity between it and the Haji occupation is moderately strong.

AGRICULTURE VS. HUNTING AND GATHERING: A TEST

Haji pottery sites represent the early agricultural period. The food resources of this period were overwhelmingly wet-rice agriculture and fishing, as is apparent from the numerous documents of this period. The Jomon period, on the other hand, is supposed to represent a hunting and gathering adaptation. If the latter supposition is correct, the settlement patterns of these two cultures should differ. The Niigata transect may be a good place to test this hypothesis because it is divided into two distinct areas: a large marshy plain with little in the way of wild food resources but amply suited to wet-rice cultivation, and a mountain area where little flat land is available but where a variety of nut crops and game was obtainable. Climatic conditions also differ between the two areas, being generally warm on the coast and cold in the mountains. For purposes of the test a third, intermediate area is added.

Land use in the two periods can be simply compared using a chi square test. The null hypothesis (H_0) is that there is no difference in settlement distribution between the "agricultural" stage and the "food collecting" stage. The alternative hypothesis (H_1) is that there is a difference. A chi square test shows the difference between the two cultures is significant and important (Table 27).

Transect 2 (Tokyo)

Transect 2 measures 9.2 by 71.2 km and runs through the middle of Tokyo, from

Table 27. Land use during the Jomon 3 and Haji periods at transect 1 (Niigata)

	Coast	Intermediate	Mountain	Total
Jomon 3	13	84	61	158
Haji	70	14	9	93
Total	83	98	70	251

$\chi^2=117.24$ $r_m=.56$

Table 28. Landform and site distribution in transect 2 (Tokyo)

(Landform types and number of tracts)

Freq./Landforms	M	H	U	L	MU	HU	HM	LM	LH	LU	LMU	LHU	LHM	Total
Number of tracts	155	3	179	73	3	9	2	6	36	151	20	8	5	650
%	23.3	0.5	27.5	11.2	0.5	1.4	0.3	0.9	5.5	23.2	3.1	1.2	0.8	100
(Number of tracts occupied by period)														
Jomon 1	4	0	20	2	0	1	0	1	9	31	4	2	0	74
Jomon 2	7	0	11	4	0	0	0	0	10	36	7	2	2	79
Jomon 3	19	1	35	3	0	0	0	2	18	69	16	7	3	177
Jomon 4	10	1	20	4	0	0	0	0	7	54	9	5	1	110
Jomon 5	1	0	3	1	0	0	0	0	0	12	5	0	0	22
Yayoi	0	0	5	1	0	0	0	1	5	44	4	1	0	61
Haji	1	0	26	5	0	0	0	0	13	54	7	5	3	114

the shoreline of the old bay through the wide flat Tokyo upland to the Kanto mountain range (Figure 7). The border between upland and mountains is formed by the Tama River system and the Tama Hills. Tokyo is the best-surveyed area in Japan, with a total of 3,590 sites recorded (about 1.7 sites per km^2). Because of this greater sample size, the size of the tracts was made 1 km^2.

In this area, sites have already appeared in abundance by Jomon 1—presumably as a result of moderate weather and favorable habitat. The peak of Jomon culture was again Jomon 3, marked by scores of large sites with a high artifact diversity. A decline begins in Jomon 4, and this becomes precipitous between Jomon 4 and 5. Yayoi and Haji settlement, particularly the latter, is well-developed. Data treatment is identical to Transect 1 (Table 28).

The landform type of the tracts reflects the local scenery, where rivers collecting water from springs incise upland and hills. The favored environment for site location throughout history was the lowland-upland combination. Villages were situated on the edge of a plateau near a spring. Most of the purely upland tracts also fall into this category. Hilly land is almost insignificant in this transect. Therefore, only the mountainous element is to be examined.

If we take the occupied tracts which include mountain elements and compare them with those of other landforms by period the results are as follow at Table 29.

Table 29. Use of mountain and other tracts in transect 2 (Tokyo)

Period/Frequency	Mountain Tracts	%	Others	%
Jomon 1	9	12.2	65	87.8
Jomon 2	16	20.2	63	79.8
Jomon 3	40	22.5	137	77.5
Jomon 4	20	22.2	90	77.8
Jomon 5	6	27.2	16	72.8
Yayoi	5	0.8	55	99.2
Haji	11	0.9	103	99.1

Table 30. Landform and site distribution in Transect 3 (Yamaguchi)

(Landform types and number of tracts)

Freq./Landforms	M	H	MU	HM	L	LM	LH	LHU	LHM	Total
Number of tracts	129	140	3	43	57	69	54	4	12	511
%	25.2	27.4	0.6	8.4	11.2	13.5	10.6	0.8	2.3	100
(Number of tracts occupied by period)										
Jomon	0	2	0	1	7	4	2	0	0	16
Yayoi	3	12	0	4	28	24	25	1	5	102
Haji	9	19	0	3	31	37	27	3	3	132

Thus there is a marked difference between the Jomon and Yayoi-Haji periods ($\chi^2 = 8.07$, df=1, $p<.01$). A sharp population decline from Jomon 4 to 5 is characteristic of this area. During Jomon 4, 17% of the tracts in this area had been utilized, but during Jomon 5 it is barely 3%. The cause may be explained as the influence of a colder and wetter climate. If we compare the distribution of occupied locales between Jomon 3 and Jomon 5, the upland area in the middle portion of the transect was most affected, while locales on the coast and in the mountains remained fairly constant.

Transect 3 (Yamaguchi)

Transect 3 (18 by 130 km) runs longitudinally across the Inland Sea side of Yamaguchi Prefecture (Figure 7). The common landscape is mountains and hills covered with thick evergreen forest backing directly onto the coast. Flat land is limited in extent and located only on the coast. Jomon site records are unsatisfactory since the subperiods are not distinguished, and the total number of Jomon sites is small. Yayoi and Haji sites are abundant and well documented. Data were processed as Table 30.

The Jomon occupation is confined virtually to the lowland tracts (81%). Mountain elements which were important in the transects of central Japan are conspicuously absent in this area. This fact may indicate a difference in subsistence base between the two areas. Okazaki [KAMIYAMA ed. 1961] suggests that the evergreen forest here is usually so dense that the only adequate hunting areas are at ecotones where breaks in the forest occur.

The number of sites increases vastly after the Yayoi period (the ratio of occupied tracts approaches that of Jomon 3 in central Japan), but tracts containing lowland elements are, as might be expected, especially favored—81% of them contain Yayoi sites, 76.5% contain Haji sites. Of the Yayoi tracts, 65% continue to be used by the Haji population and there is practically no difference in choice of locales between the two (rank order correlation $r_s = .82$, $p<.05$).

DISTRIBUTION OF SITES

It has been pointed out in the preceding chapters that Jomon subsistence depend-

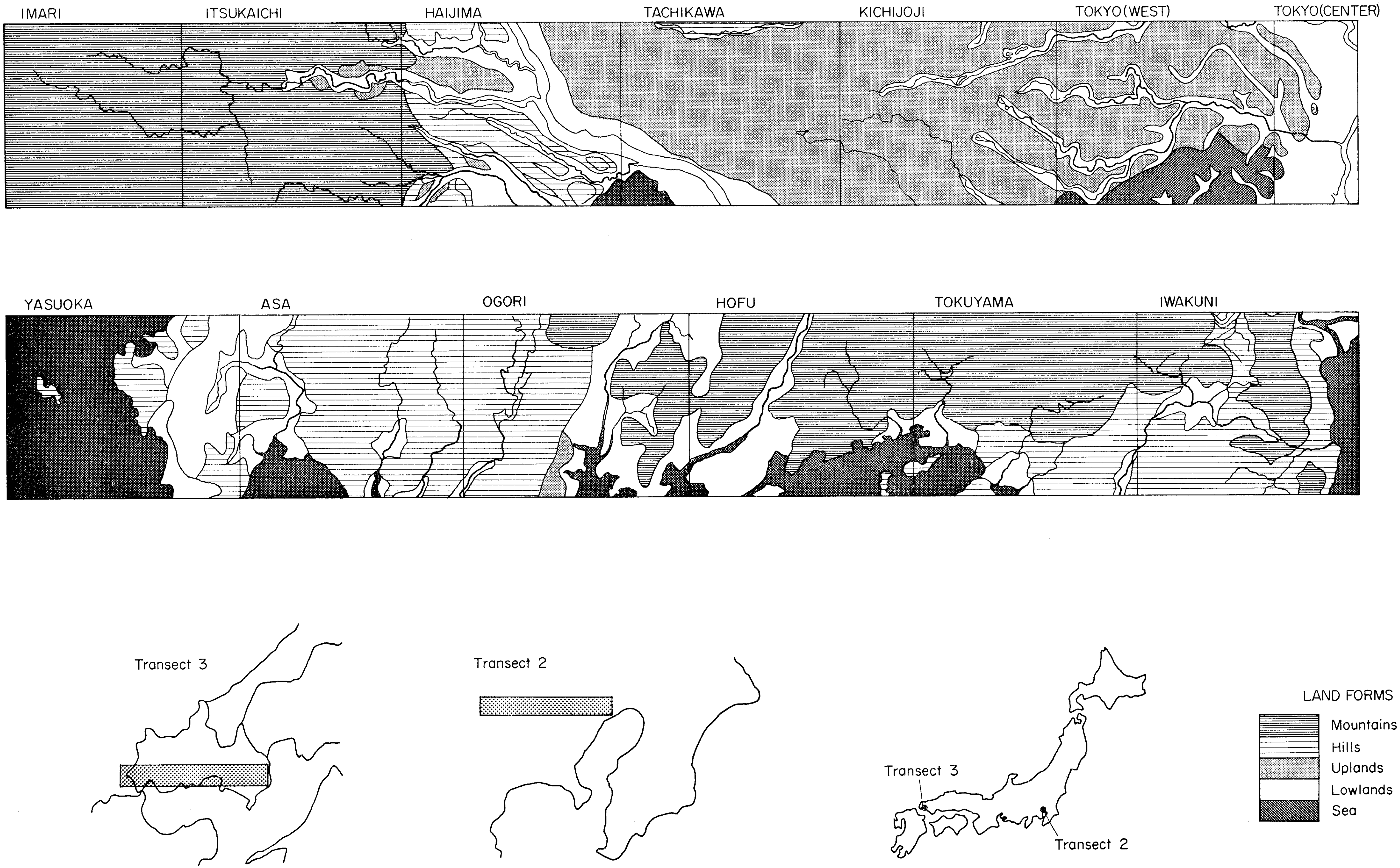


Figure 7. Transect 2 (Tokyo) and Transect 3 (Yamaguchi)

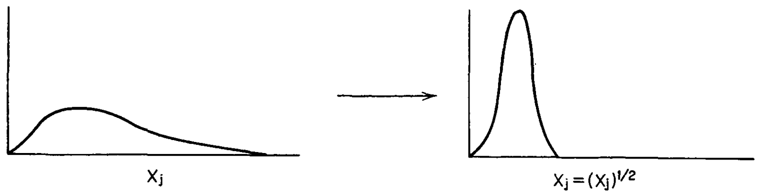


Figure 8. Effect on data distribution by transformation to squareroot function

ed upon wild food resources, and that the distribution of sites is therefore determined largely by the distribution of food resources and their relative yields. In general, sites concentrate in the deciduous forest zone but are sparsely scattered in the evergreen forest zone. Within regions, sources and quantities of foods are of variable distribution so that topography or landform plays a significant role in site selection. In the deciduous forest zone, mountainous landscape was prefered; while in the evergreen forest, sites were confined to the coastal lowland. These characteristics of Jomon settlement, particularly in the deciduous forest zone, contrast markedly with those of the early agricultural period when land use was basically limited to lowland rice production. Palynologists have demonstrated a climatic change during the Jomon period and its temperature curve correlates well with the general increase and decrease of sites in the Jomon subperiods. It is now possible to examine the way in which these factors affect the distribution of sites.

Methods

Statistical maps of the Jomon 1 through 5 and Yayoi period bave been constructed by superimposing a grid system of 1,000 km^2 (approx. 32 by 32 km) mesh on the map of Japan (excluding Hokkaido), defining a total of 307 tracts. (The resulting 307,000 km^2 area is only slightly inflated above the actual area of 293,978 km^2.) The number of sites in each tract was then tabulated according to period. Site numbers in each grid were transformed into square foot functions in order to tighten up the distribution of original values and to minimize quality differences in original data resulting from variable survey intensity (Figure 8). Finally, using the center of each grid unit as a datum point, two contour lines (at the square root functioned values of 3 and 7) were generated, thus the tracts are classified into three categories: a) thinly populated tracts (0 to 8 sites), b) well populated tracts (9 to 48 sites), and c) densely populated tracts (49 or more sites).

Results (Figure 9)

JOMON 1

In the Tohoku region, spotty, weak concentrations are observed on the Pacific coast side of the island, and sites are conspicuously absent or very thinly distributed on the Japan Sea side. In this region birch, mixed with small quantities of oak and other species, dominated the low altitude forests, while the mountain areas were

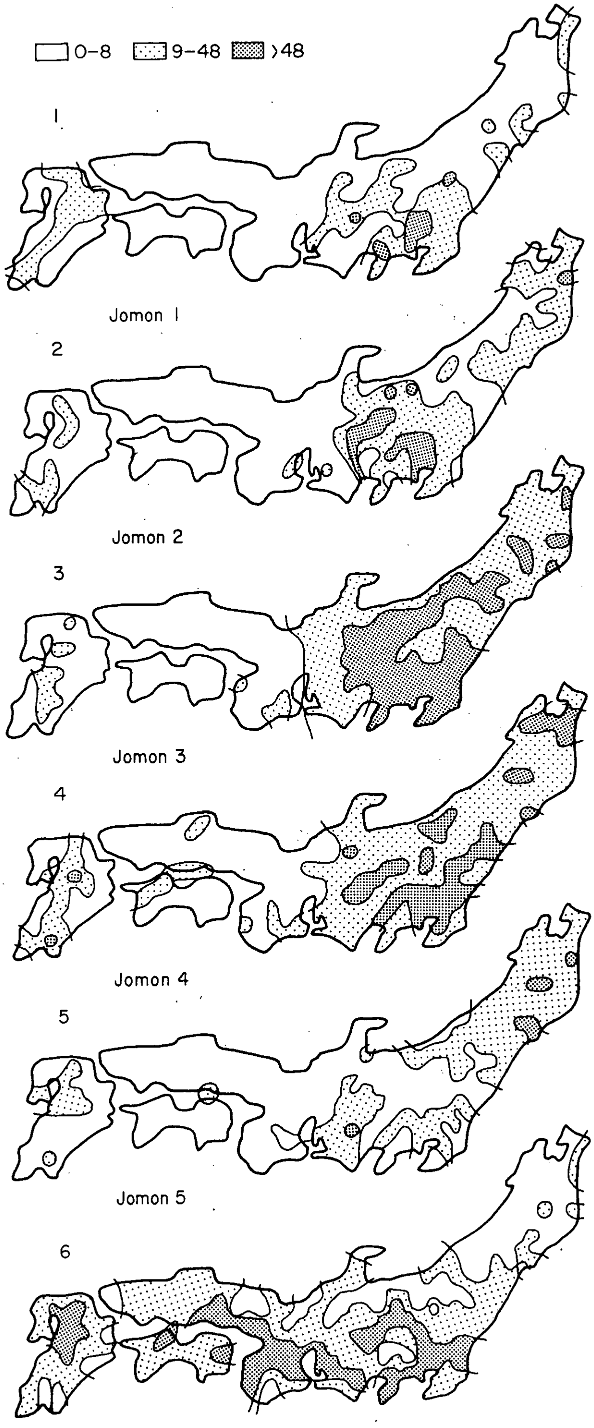


Figure 9. Distribution of sites (Jomon 1 to Yayoi)

covered thickly by coniferous trees. The percentage of birch pollen was significantly higher on the Japan Sea side of Tohoku before 10,000 B.P. [YASUDA 1974: 110]. The environment was poor in resources and not hospitable to human habitation, except in the coastal areas.

The Kanto, Chubu and Tokai regions at this time were already covered extensively by sites. Dense clusters of sites appear around Tokyo Bay and along the rocky Shizuoka coast; a few densely populated tracts occur in the mountain area as well. The oak ratio in pollen samples generally exceeds 50%, indicating excellent environmental conditions for human habitation.

Western Japan (Kinki, Chugoku and Shikoku) is virtually unoccupied at this time except along the Inland Sea area where in Jomon 1 there is a change from a freshwater lake to a sea. A couple of tracts of medium occupation intensity are located on both sides of the original lagoon.

Kyushu was well populated during Jomon 1, the sites being concentrated in the mountain region rather than on the coast. Deciduous forest occupied Kyushu during this cold period, so the value of wild food resources would have been higher than at later times, even if the earlier exploitative technology was less sophisticated.

According to Kamaki [1965], pottery type differences indicate that Jomon 1 Japan was divided into two cultural zones. Western Japan (including Kyushu) was the domain of the "rouletted pottery" culture (characterized by vessels with pointed bases)—a hunting-oriented society whose sites yield large quantities of arrowheads. Pottery vessels in eastern Japan are "shell scraped or incised" with the same pointed bases. These two types merge in Kanto and Chubu where the site distribution is the densest. In Kanto, "string impressed" poterty is distributed prior to the intrusion of these pottery types. This kind of merging of pottery types in central Japan is characteristic of the region throughout the Jomon period.

JOMON 2 AND JOMON 3

The early Holocene warming trend reached its peak around 8,000 to 7,000 B.P. Rations of oak pollen increased significantly in eastern Japan, while evergreen oaks expanded in the west. In Tohoku, areas on the Pacific coast which had been moderately populated in Jomon 1 merged and spread west toward the mountains and the Japan Sea coast. All of Kanto and Chubu, the mountainous areas of Hokuriku, and eastern Tokai were integrated into a single occupation zone. In western Japan, however, site numbers declined. In Kyushu a continuous expanse of Jomon 1 occupation was separated into two smaller clusters. This tendency toward site proliferation and a real expansion in the east and contraction in the west continued into Jomon 3 and the beginning of a cooling trend. All tracts in eastern Japan filled to medium density.

Strong preference for a mountainous environment is explicitly demonstrated by clusters of densely populated grid units from southern Tohoku to the border of Kinki, except for the traditional core grid units on the Pacific Ocean side. In Kyushu population clusters became smaller and are divided into three areas, all of them shifting towards the coast.

Jomon 3 pottery types divide the archipelago into five distinctive subculture areas [KAMAKI 1965], but the characteristics of decoration techniques, combination of vessel shapes, and components of tool kits indicate that the basic cultural border can be drawn along the same line as in Jomon 2.

JOMON 4

An intensification of the Jomon 3 cooling trend produced, during the following period, a reversal of site distribution tendencies in the two major geographical sections. The mountainous areas in the deciduous forest zone seem to have been affected most seriously. This was undoubtedly connected with the retreating oak forest on the mountain slopes [TSUKADA 1974]. On the slope of Mt. Yatsugatake in Nagano Prefecture, for example, only a few of the numerous Jomon 3 settlements lasted into Jomon 4 [FUJIMORI 1974].

In the West, some clusters of medium occupation density appear in this period. In Kyushu this tendency is more explicit, and dense grids appear in the mountain areas.

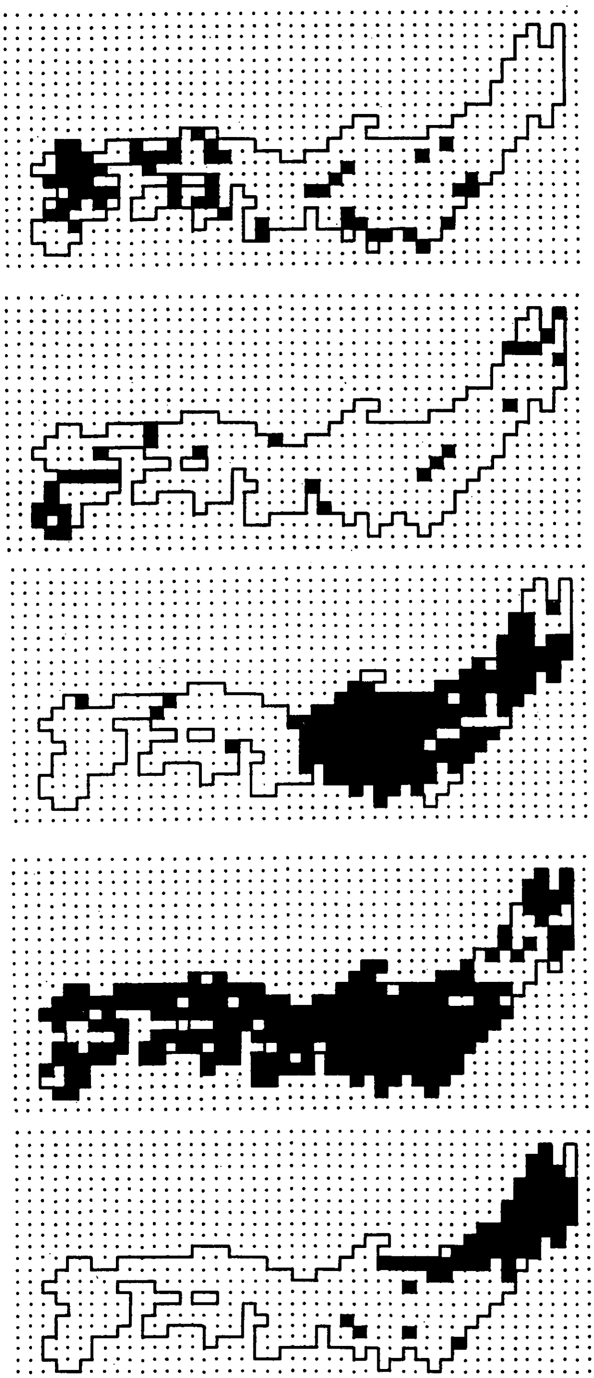
The reversal of site distribution trends in east and west can be demonstrated by comparing the number of sites at two different periods in each grid unit (Figure 10). From Kinki to Kyushu virtually all grid units show increases. In Chubu and Kanto, the traditional core areas, all decline in population. In Kanto, however, most of the grid units of Chiba and Ibaragi Prefectures gain population. This area is characterized by the formation of especially large shellmounds during Jomon 4. Both the southern and northern extremes of Tohoku exhibit increasing site numbers. In these areas, too, large shellmounds are formed.

The pottery of Jomon 4 bears a distinctive feature throughout Japan; the feature, "zoned cord marking", is considered to have originated in eastern Japan and then spread to the west. According to Watanabe [1975], the chipped hoeaxe and the milling stones which characterize the eastern Jomon 4 subculture became important in western sites during this period.

JOMON 5

The terminal phase of the Jomon period is characterized by a general decline in site numbers, except in the Tohoku region, while the borderline between the eastern and western areas (which was at about the middle of the archipelago until Jomon 4) shifts further north. Kanto and Chubu remain relatively densely occupeid, but the actual decrease in site numbers is drastic. Northern and central Kyushu retain a strong Jomon 5 population. However, rice grain imprints are often reported on pottery sherds from this area, indicating that the subsistence base was changing substantially from that of previous Jomon periods.

The pottery types of Jomon 5 again show a sharp contrast between east and west. Pottery vessels in the west have plain surfaces and simple shapes, while those of the east are heavily decorated by cord marking and have diversified shapes.



Jomon 1 to Jomon 2

Jomon 2 to Jomon 3

Jomon 3 to Jomon 4

Jomon 4 to Jomon 5

Jomon 5 to Yayoi

Figure 10. Change of area utilization between sub stages

■ number of sites decreased

□ number of sites increased or unchanged

YAYOI

The distribution of Yayoi sites is almost complementary to that of Jomon 5, being dense in the west and thin in the east and further north. This is mainly due to the character of the major cultigen, rice, which had evolved in a warm climate. The Yayoi period is often described in three stages based on changing pottery styles. Early Yayoi settlers quickly occupied western Japan where western Jomon 5 had been distributed. In the middle stage they spread into central Japan. By the late Yayoi period settlements had reached the northern tip of Honshu. The Yayoi settlement pattern in eastern Japan is very similar to that of Jomon 1 and 2, and may indicate a heavier emphasis on native food resources in an area unfavorable to rice cultivation.

In Transect 3 at Yamaguchi prefecture, it was shown that Yayoi sites began to penetrate the evergreen forests which had not attracted their Jomon predecessors. Yayoi exploitation of such areas was apparently not related to hunting and gathering, however, since palynological evidence indicates extensive forest clearing activity beginning in this period.

POPULATION

Concerning the actual population size of the Jomon period, there is no good source other than the number of sites. The earliest demographic record in Japan dates to the eighth century (Haji period) and is estimated from the rice production, recorded as provincial tax allocations [SAWADA 1927]. The relationship between Haji site numbers and this eighth century population record is used here as a basis for estimating the size of prehistoric populations.

Computational Procedure

The Haji period lasted from 250 to 1150 A.D. or, allowing for a slight margin of error, approximately 1,000 years. The eighth century falls at about the midpoint of this period. Our assumption here is that the total number of Haji sites resulting from a 1,000 years' accumulation could be an indicator of population size at a given time, in this case the midpoint of the period.

If this assumption holds, the average population of a Haji site is defined through computation of the total population over the total number of sites,

$$VH = POP_{8c} \div T_h$$

where

VH = average village population in Haji.
POP_{8c} = eighth century population
T_h = total of Haji sites

Once this value is defined, the population size of any other period, Jomon 3 for instance can be obtained by

$$POP_{j3} = VH \times T_{j3} \div T_h$$

where

POP_{j3}=Jomon 3 population
T_{j3}=total of Jomon 3 sites.

This formula holds only when the two compared periods are (1) equal in duration and (2) equal in average site population, therefore in each comparison a constant should be defined according to these factors. The formula for determining Jomon 3 population size

$$POP_{j3}=C \times VH \times T_{j3} \div T_{h}$$

where C is the constant. The Jomon 3 population will be computed in the following section because it is the best known of the Jomon periods.

Due to problems of archaeological data quality outside the Kanto region, the estimates are given only for the Kanto. A merit to this is that in Kanto both Jomon and Haji cultures developed to maximum levels, unlike some other areas where one or the other attained only scattered populations.

The duration of Jomon 3 is defined by radiocarbon dating as 1,000 years (see Chapter 1), which is equivalent to that of the Haji period.

Since the type of subsistence in Jomon and Haji is different, and this is reflected in diverging settlement patterns, then the population per site differs in the two periods. Assuming an equivalent site value for the two would only lead to erroneous results. Thus the constant will be defined by evaluating Jomon 3 sites against those of the Haji period in the following discussion.

Site Size

Quantative data about site sizes are presently available only in the suburban Tokyo area where systematic surveys have been carried out in recent years [Tokyoto Kyoiku Iinkai 1974]. In order to procure unbiased values, only the dimensions of single component sites are used (Table 31). These data indicate a relatively constant mean site size throughout the Jomon period. Mean sizes of Yayoi and Haji sites are inflated by single exceptionally large examples in each case. If the Haji deviate in excluded, the mean and SD converge to 42.5 ± 56.4 in site size. A t-test, then, shows no significant difference between mean size of Jomon 3 and Haji sites ($t=.69$, $df=72$, $p>1.0$).

Table 31. Changes in site area in Tokyo

Period	N	Range ($100\ m^2$)	$\bar{X}$	SD
Jomon 1	16	4 – 50	21.9	14.6
Jomon 2	43	3 – 500	43.1	97.1
Jomon 3	38	4 – 357	49.3	75.6
Jomon 4	2	7 – 50	28.2	21.5
Jomon 5	—	—	—	—
Yayoi	3	1–1600	683.6	800
Haji	35	1–1000	68.6	171.2
	(33)		(42.5)	(56.4)

PIT DWELLINGS

Both Jomon and Haji villages are characterized by pit dwellings dug into the hard loam to a depth of 20 to 50 cm, and provided with four or more post holes. Flannery [1972] points out that reliance on immobile structures correlates with community sedentarism. The size of house pits indicates energy input onto the site via dirt removal and erection of upper structures. It is also related to how many people could live in one dwelling. More than 200 Jomon 3 pit dwellings have been excavated and measured in Kanto [KATO 1975]. Records of about 100 Haji structures are available [ICHIKAWA SHISHI HENSANKAI 1970]. Means and SDs for each type are:

Jomon 3	23.5 ± 9.1 m^2 (N=225)
Haji	26.6 ± 12.2 m^2 (N=110)

The difference in means is significant ($t=7.96$, $df=\infty$, $p<.001$).

Assuming an average house pit has a depth of 30 cm, the total volume of dirt removed for a Jomon 3 structure is 7.0 m^3, while that of Haji is 7.9 m^3. This difference is equivalent to almost a metric ton in weight. Although efficiency of tools in the two periods—Jomon small stone digging sticks vs. Haji iron hoes—must be considered, the difference of 3 m^2 in area in dwellings is somewhat suggestive, because the size is roughly equivalent to space needed for an additional person [ASO 1965].

NUMBER OF PIT DWELLINGS PER SITE—A VILLAGE PLAN

A typical Jomon village was planned in a horseshoe shape: a row of houses forming a circle with the central portion unoccupied. In Haji settlements dwellings are usually divergent village plans, the number of pit dwellings per site contrasts markedly in the two cultures. For example, according to recent records of large-scale excavations which have cleared almost all portions of a settlement, the total number of pit dwellings for Jomon sites are 69 (Takanekido, Chiba), 50 (Minamibori, Kanagawa), 35 (Mukodai, Chiba), 28 (Kainohana, Chiba), 25 (Imashimada, Chiba; approx. 1/2 excavated), etc. For Haji sites, corresponding records are 350 or more (Uenodai, Chiba), 302 (Funada, Tokyo), 133 (Nakada, Tokyo), 71 (Omori, Chiba), 70 (Komuro, Chiba; excavation incomplete) and so forth. The data are as yet too fragmentary and incomplete for satisfactory quantification, but we may assume a 1:5 Jomon:Haji ratio as far as number of pit dwellings are concerned. The above numbers of pit dwellings do not necessarily represent contemporaneous households because many of them overlap spatially.

The following considerations are satisfied for comparing the number of sites between Jomon 3 and Haji.

1) Pit house characteristics suggest a strong sedentary trend for Jomon 3 sites, almost equivalent to that of Haji sites.
2) Jomon 3 and Haji site sizes do not differ significantly.
3) The size of Haji pit dwellings is about 10% larger than Jomon 3 structures.
4) The number of houses per site is greater in Haji settlements than in Jomon 3 sites by a probable ratio of 5:1.

From these conditions we can assume a 1:5 to a 1:7 ratio between the values of Jomon 3 and of Haji sites. Therefore the constant in the formula will be given a value of 1/5 or 1/7 for computation pruposes.

Kanto yielded a total of 3,977 Jomon 3 sites and 5,549 Haji sites. The eighth century population of this area is calculated at 943,300. Therefore, the value of a Haji site is 170 (VH=943,000÷5,549). The ratio of Jomon 3 to Haji site is .71 ($T_{j3} \div T_h$=3,977÷5,549). If we assume an equal value for Jomon and Haji sites, the population of Jomon 3 in Kanto becomes 676,068 (.71×943,300). Since a Jomon 3 site is actually valued at 1/5 or 1/7 of a Haji site, the maximum population, when 1/5 is used as the constant, is 135, 214.

The population in other regions then can be calculated by using the ratio of the sites there against those in Kanto. Thus the formula is

$$POP_{region} = POP_{kanto} \times T_{region} \div T_{kanto}$$

where

POP_{region}=population in a region
POP_{kanto}=population in the Kanto
T_{region}=total of sites in a region
T_{kanto}=total of sites in the Kanto.

So far, the information on Jomon 3 sites in regions outside Kanto is too poor to establish independent constant values, particularly in the absence of Haji information. The value of a site in other regions then is tentatively assumed to be equivalent to that of Kanto, and regional estimations are calculated on this basis (Table 32).

The computation shows 370,261 when a value 1/5 of the Haji site value is used for Jomon 3, and 262,566 when the constant is 1/7. Population density is then 1.25 per km² for the former or (more plausibly) 0.89 for the latter. Population density varies greatly according to region, and is especially low in western Japan. However, the figures are actually inflated because Jomon sites in such regions are much smaller than those in Kanto—a fact obscured by use of the same constant for both areas.

Table 32. Jomon 3 population

Regions	Constant 1/5	Density (km²)	Constant 1/7	Density (km²)
Tohoku	66,130	1.00	46,680	.71
Hokuriku	34,884	1.42	24,624	1.00
Kanto	135,123	4.19	96,581	3.00
Chubu	101,830	3.66	71,880	2.58
Tokai	18,700	1.50	13,200	1.06
Kinki	4,012	.12	2,832	.08
Chugoku	1,734	.05	1,224	.04
Shikoku	340	.02	240	.01
Kyushu	7,508	.18	5,305	.13
Total	370,261	(1.25)	262,566	(.89)

Observation and Analysis

Population Change

Assuming that 262,500 is a reasonable estimate of the Jomon 3 population, the population of the other periods can be computed for comparison and to examine patterns of population change. The same formula and procedure will be used with an adjustment of constant for each period.

Jomon 1 (8,100 B.P.) sites are smaller with fewer structures. Pit dwellings were not made until the very end of this period. Thus the constant is designated as 1/20.

Jomon 2 (5,100 B.P.) sites generally show a strong sedentary trend. Some excavated settlements are reported to be almost equivalent in size and context to Jomon 3. The mean size of sites in the Tokyo suburban area shows no significant difference. The land utilization pattern is virtually the same as in Jomon 3, so the ratio is held at 1/7.

Jomon 4 (3,300 B.P.) is basically identical in archaeological context with Jomon 3, so again 1/7 is retained as the constant.

Jomon 5 is excluded from computation because the chronological difference with Jomon 4 is not significant. Also a sharp decline in the number of sites which occured only in Kanto and Chubu may not indicate what happened in other areas.

The Yayoi period (1,900 B.P.) is usually divided into three stages by pottery chronology. In Kanto it began to flourish only after the middle stage. The Yayoi settle-

Table 33. Prehistoric population estimates for Japan, by region

Periods(Constant) Regions	J1(1/20)	J2(1/7)	J3(1/7)	J4(1/7)	Yayoi(1/3)	Haji(1)	Edo(1)
Tohoku	2,100	19,200	46,700	43,800	33,800	288,600	2,473,000
	(.03)	(.29)	(.71)	(.66)	(.50)	(3.5)	
Kanto	10,300	43,300	96,600	52,100	100,100	943,300	4,295,700
	(.31)	(1.3)	(3.0)	(1.6)	(3.2)	(29.2)	
Hokuriku	400	4,200	24,600	15,700	21,000	491,800	2,307,600
	(.01)	(.17)	(1.0)	(.64)	(.85)	(20.0)	
Chubu	3,200	25,300	71,900	22,000	85,100	289,700	1,694,200
	(.12)	(.91)	(2.59)	(.79)	(3.07)	(10.4)	
Tokai	2,400	5,000	13,200	7,600	55,900	298,700	1,792,200
	(.19)	(.40)	(1.06)	(.61)	(4.50)	(24.0)	
Kinki	300	1,700	2,800	4,400	109,400	1,217,300	4,941,300
	(.00)	(.05)	(.08)	(.13)	(3.33)	(32.4)	
Chugoku	500	1,300	1,200	2,700	59,400	839,400	3,067,900
	(.02)	(.04)	(.04)	(.08)	(1.80)	(29.9)	
Shikoku	600	400	200	2,700	30,500	320,600	1,760,500
	(.03)	(.02)	(.01)	(.14)	(1.61)	(17.0)	
Kyushu	2,100	5,600	5,300	10,000	106,300	710,400	3,300,700
	(.05)	(.14)	(.13)	(.24)	(1.56)	(17.4)	
Total	21,900	106,000	262,500	161,000	601,500	5,399,800	25,633,100
	(.07)	(.36)	(.89)	(.55)	(2.04)	(18.6)	

( )=population density per km^2.

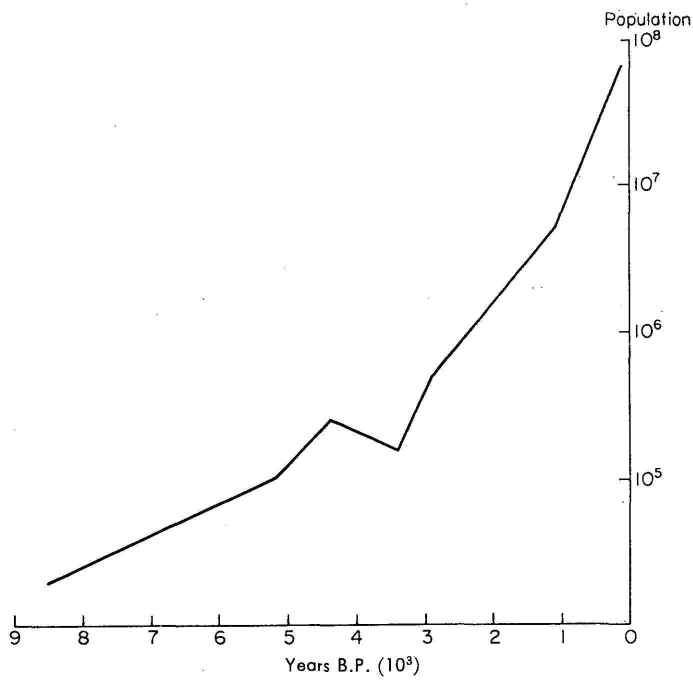


Figure 11. Population trends in Japan for past 8,000 years

ment pattern is to some degree transitional from Jomon to Haji, but is closer to the Haji pattern. Considering these two points, 1/3 is given as the constant value.

The results, summarized in Table 33, and Figure 12, illustrate population trends in Japan for the past 8,000 years. This graph defines three periods of demographic change in Japan during this time:

1) The period from the appearance of the Jomon culture to about 4,000 B.P. (Jomon 3) is marked by a relatively rapid and stable population growth (approx. 1.07% per year).
2) Stagnancy or population-decline characterizes the following periods.
3) Sharp population growth (1.7% per year) accompanies the introduction of wet agriculture around 2,000 B.P.

The difference in growth rate before and after 2,000 B.P. provides strong support for the hypothesis of this paper: that the Jomon people were hunters, fishers and gatherers, while the Yayoi and succeeding people engaged in agriculture.

Regional Patterns

Population density variation correlates (differently) with vegetational zones during the Jomon and Yayoi periods. Three different regional patterns are evident (Figure 12). Kinki, Chugoku, Shikoku and Kyushu, all in the evergreen forest zone, show a unanimous pattern of weak development or low population density throughout the Jomon occupation, followed by a sudden jump in the Yayoi period. Chubu,

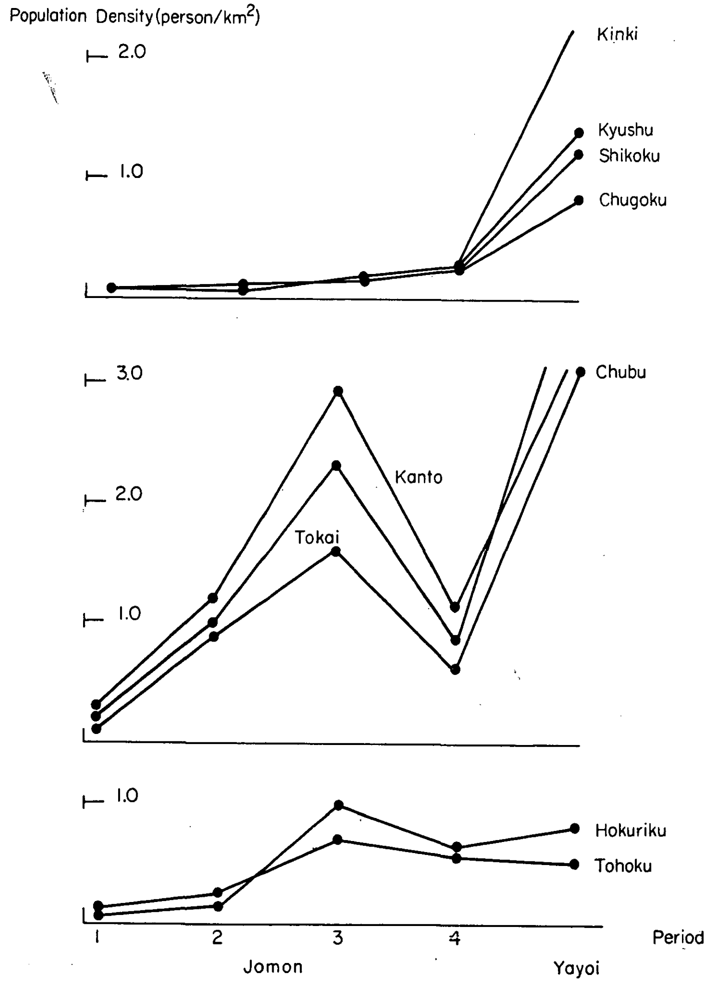


Figure 12. Patterns of change in population density by regions

Tokai and Kanto regions, which belong to the area where two vegetation zones meet, all show a high population density from 5,000 to 4,000 B.P., followed by a sharp decline. This presumably reflects the inability of formerly abundant wild food resources to adapt to a colder climatic regime. The mountain area of the Chubu region in the boundary ecozone was the most susceptible to such change. Over population may have contributed to the decline.

In the cold deciduous forest zone of the Tohoku and Hokuriku regions, the population density has always been low. The pattern is typified by slow population growth or stability over long periods, apparently unaffected by either climatic or technological change.

A Multiple Regression Analysis: Population and Landform

Baumhoff [1963] demonstrated that native population levels in protohistoric

California were determined by the distribution of food resources whose value could be measured from the size of the land units which yielded them. The given land values as composite variables regress linearly with the size of the population, hence providing equations for estimation of population size.

In Chapter 4 the land use pattern within three trasects during each period was discussed. Within every transect Yayoi and Haji rice farmers utilized primarily "lowland" areas, especially near the coast; while their Jomon predecessors preferred other landforms, particularly "upland areas, because their important food resources were more abundant in such places. Therefore, if the estimated population figures of the previous chapter are valid and if the present model of Jomon subsistence is accurate, we may expect a relationship between population figures and landform unit sizes, from which equations can be derived which predict the size of population from landform distributions in given areas.

Accordingly, a stepwise multiple regression analysis was carried out utilizing the program in the *Statistical Package for the Social Sciences* [NIE et al. 1970]. The size of mountain, hill, upland, lowland and coastal areas, as well as river milages, in each region are plotted against previously obtained population figures by periods.

The equations obtained are:

$$POP_{j1}=1.5\ (\text{Upland})-0.3\ (\text{Coast})-1.2\ (\text{Lowland})+0.05\ (\text{Mountain})$$
$$+0.1\ (\text{Hill})+0.01\ (\text{River})+36.8$$

$$POP_{j2}=7.6\ (U)-2.1\ (C)-7.8\ (L)+0.8\ (M)+2.4\ (H)-0.4\ (R)+188.9$$

$$POP_{j3}=18.4\ (U)-6.5\ (C)-21.6\ (L)+2.5\ (M)+5.1\ (R)+154.6$$

$$POP_{j4}=7.8\ (U)-2.8\ (C)+1.0\ (M)+4.4\ (R)-6.2\ (L)-2.0\ (H)-170.1$$

$$POP_{yayoi}=0.1\ (U)-25.0\ (R)+4.1\ (C)+22.2\ (H)-1.1\ (M)+7.0\ (L)+1886.0$$

$$POP_{8th}=-48.3\ (M)+320.5\ (L)-322.6\ (R)+286.5\ (H)+60.0\ (C)$$
$$-93.3\ (U)+23850.1$$

R^2, the squared value of the multiple correlation coefficient, which explains percent of variance in the equation, are very high (more than .98) for all Jomon periods and high (more than .86) in the Yayoi and eighth century periods.

The order in which variables enter into the equation as well as the signs and magnitude of regression coefficients demonstrate a similar pattern among the five Jomon periods, where mountains and upland are generally important. During the Yayoi and Haji periods the lowland area becomes a strong factor.

CONCLUSION

The Jomon period has long been identified as a hunting and gathering period by most archaeologists, but the details of this adaptation have never been systematically defined. Possible staple foods of the Jomon period are reconstructed here through the examination of archaeological remains and ethnographic records. All are wild food resources: walnuts, chestnuts, acorns and root crops constitute impotant plant foods; deer, boar and bear are the main animal species; shellfish and marine and anadromous fishes also served as major protein sources.

The importance of Jomon fishery (including shellfish collecting) is especially apparent. The beginning of the period is marked by the formation of shellmounds; these proliferate rapidly and are unmatched in number or size by those of any other period. Yet, most of the known fishing tools appeared in the earliest stage of the culture [OKAMOTO 1965: 293] and, except within a limited area in the Tohoku region [WATANABE 1973: 204], fishery technological development was not significant. This pattern of technological stability affects hunting as well. Although bows and arrows span the eight millenia of the Jomon tradition, arrowheads are generally consistant in shape from beginning to end. The only sign of change is that sites of the early stages generally yield more arrowheads than do later ones [FUJIMORI 1970: 194] a sign of lessening reliance on hunting rather than of advances in its efficiency.

Evidence of significant technological development is available only for plant foods, notably in processing. The most common plant remains known from Jomon 1 are walnuts which need virtually no processing before eating. Acorns from evergreen oaks are also reportedly edible without processing, and their remains appear relatively early in western Japan. Acorns from deciduous oaks, which require leaching, become important only in Jomon 3. Buckeyes, which require the addition of ash and heating besides leaching, do not become common until Jomon 4. This gradual adoption of plants requiring more involved processing is most explicitly observed in the Tohoku region.

Intensified utilization of root crops may be deduced from the explosive increase in the quantity of digging tools at sites in Chubu and Kanto during Jomon 3. During Jomon 4 this emphasis spread toward warmer areas in the west, correlating with increases in site numbers. Plant foods are therefore considered the major resources of the Jomon period.

The nature of the Jomon adaptation becomes particularly clear in comparison with that of the agriculturalists of the Yayoi and Haji periods:

1) *Land use.* Jomon people preferred mountain and upland areas where wild food resources were abundant. In the agricultural periods the sites concentrate in the lowlands where wet rice farming was most productive.

2) *Population distribution.* The Jomon population was densest in the deciduous or evergreen-deciduous mixed forests of eastern Japan, but thin in the evergreen forest area of western Japan—matching the expected distribution of food resources. The population of the historic periods reverses this concentration due to the better rice crops in the warm wet climate of the west.

3) *Population growth.* In eastern Japan, the Jomon core area, population growth was smooth during the hypsithemal warming trend, but was hard hit by the following climatic cooling. The best example of this occurs at the border, between *Quercus* and subalpine forest area in the Chubu region—a prominant Jomon 3 habitat suddenly depopulated in early Jomon 4 [FUJIMORI et al. 1965: 114], almost certainly as a result

of the retreat of the *Quercus* forest. The later agricultural population grew more rapidly and was relatively unaffected by climatic change. Instead, population expanded continually into less favorable areas. Farmers, who manipulated the environment heavily in any case, were less affected than wild plant collectors by changes in climate.

4) *Population size and density*. The peak population of the Jomon period is estimated here at 262,600 (Jomon 3), or a density of 0.89 per km². However population sized and density varied greatly according to region. Densely populated regions were Kanto (3.0) and Chubu (2.6), while Shikoku (.01) and Chugoku (.04) were lightly populated. A few archaeologists [FUJIMORI 1950] have suggested the possibility of agriculture during Jomon 3 based upon the dense distribution of large sites in Kanto and Chubu. Although the people of this period may well have practiced kitchen garden horticulture or limited chestnut pomology [SAKAZUME 1957], the present estimate of three persons per km² is not particularly high, even among hunting and gathering societies. In California, for example, the Wiyot (lower Klamath province) and northern Hill Yokuts (California province) had estimated protohistoric densities of more than four persons per km² [BAUMHOFF 1963: 231].

The population of northern Tohoku, which was relatively stable from Jomon 3 to the Yayoi period, was comparable to that of the premodern Ainu in southern Hokkaido (an environmentally very similar area) who were basically hunters and gatherers. The Hokkaido Ainu population was recorded as 21,149 in 1882—a density of 0.25 persons per km² [WATANABE 1972: 1]. Density varied from region to region on that island, and in southern Hokkaido it generally approximated 0.65, which is close to that estimated for Jomon and Yayoi Tohoku.

The transition from Jomon to Yayoi, or from hunting and gathering to agriculture, was prompt and smooth in Japan except in some parts of the Tohoku region. Differences in osteological characteristics between Jomon and Yayoi populations are reported at sites in western Japan. Kanazeki [1966: 462] argues that such differences would be best explained by an invasion of new peoples, while Suzuki [1963: 108] suggests that they might result from the improvement in subsistence. In either case, a prompt shift from collecting to farming was caused by the difference in subsistence potentials. Elements of the Jomon tradition, however, such as the practice of hunting, fishing and collecting wild crops, were continued by the Yayoi and persist even today, particularly in marginal areas such as Hokkaido, Tohoku and the Central mountains.

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