HOUSEHOLD SIZE OF PREHISTORIC WESTERN PUEBLO INDIANS[1]

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KNOWLEDGE OF GROUP SIZE is one of several important considerations for precise quantitative analysis of human biological microevolution. In order to evaluate the relative effects of evolutionary processes (natural selection, mixture, mutation, and genetic drift) approximations of population size, composition, and stability are required. A typical procedure for estimating the size of past populations or villages is to project backward the knowledge obtained from living populations of the number of persons per room. H. S. Colton has estimated the size and growth of prehistoric populations in the Anasazi culture area of northeastern Arizona by this method (Colton 1936a, 1960).

This paper presents a trial method of estimating Anasazi household size, independent of ethnographic or census observations, by the use of the ratio of the capacities of individual serving bowls and cooking jars belonging to the Kayenta branch (Western Pueblo of E. Reed 1955) between A.D. 500 and 1900. (By household is meant the number of persons usually dependent on food preparation around a single fire hearth. This would include the biological family plus any married, unmarried, or widowed relatives who habitually ate meals with the biological family.)

The Southwest culture area, and particularly that part in northeastern Arizona, was chosen to test this method because of the availability and abundance of excellently dated whole vessels already excavated from a great number and variety of archaeological sites and because of our interest in the physical anthropology of this region. Knowledge about the cultures, populations, and ecology of living Western Pueblo Indians is abundant and excellent (see Dozier 1964). Similarly, archaeologists have established a long and uninterrupted cultural sequence for the Western Pueblo. The sequence begins even before the earliest pottery making (late Basketmaker) and continues through the Developmental and Great Pueblo periods to the descendant 5000 present-day Hopi Indians occupying twelve villages along the

1 Support for this study was provided by the Society of the Sigma Xi and the University of California Committee on Research. R. H. Thompson, Director of the Arizona State Museum of Tucson, granted permission to examine the Museum's pottery collections. W. Kaemlein and E. Leavitt, Jr. assisted there. At the Museum of Northern Arizona, Flagstaff, E. B. Danson, Director, permitted study of that institution's pottery collections. There, W. Smith, G. Gumerman, and A. J. Lindsay, Jr. kindly assisted us. A. Brower, University of California, helped edit this report. D. A. Breternitz, University of Colorado, permitted use of his newly revised tree-ring dates for pottery types of the Kayenta Anasazi. A preliminary test of our hypothesis was made, using the Southwest pottery collection of the University of California Lowie Museum.

southwestern border of Black Mesa (Reed 1955:56). From about the beginning of the Christian era to the present day maize was a major Pueblo foodstuff. The prehistoric Western Pueblo probably prepared it in ways similar to living Hopi and Zuni, who have at least ten basic maize recipes with stew forms ranked high (Cushing 1920; Whiting 1939). The cultural sequence includes a continuous and uninterrupted developmental ceramic sequence (Colton 1956). Biological continuity has also been established (Reed 1963; Seltzer 1944). Pueblo population density was as great as that of other large American groups north of Mexico (Kroeber 1939:142).

The earliest regular archaeological collecting in the Western Pueblo region began in the first decade of this century with the explorations and diggings by John Wetherill and Byron Cummings (Beals, Brainerd, and Smith 1945:2; Turner 1962). Problem-oriented archaeology, however, characterizes present-day studies (Euler 1963; Lindsay and Ambler 1963; Olson 1963). Students of Pueblo prehistory have established that in northeastern Arizona fired pottery-making began about A.D. 500 (Fig. 1). Even the very earliest fired pottery shows evidence of remarkably competent ceramic skills. With time, technical improvements apparently were developed in pottery firing that resulted in slightly stronger vessels. Especially strong were the late prehistoric Hopi wares, some of which Colton (1936b:61) feels were fired with coal mined from sources near the villages. Early cooking and storage jars tended to be slightly smaller on the average than later jars (Fig. 2). The average size of individual serving bowls remained nearly unchanged from A.D. 500 to 1600 (Fig. 2).

Jars of more than 8000 cc capacity first occur between A.D. 700 to 900 and increase in number with time, the earliest showing little sign of technical inferiority when compared with similarly large jars of later time periods. Our knowledge of this trend in jar size led us to suspect some relationship between it and a trend in family or household size. It was reasoned that if prehistoric Western Pueblo population size had increased through time, as many archaeologists believe (see Colton 1960), then some part of that increase would necessarily have been due to increased family size. The greater capacity of later cooking jars probably reflects the potters' need for larger vessels rather than solely the potters' increased ceramic skills.

To test the idea that cooking jar capacity was related to household size we needed to know the amount of an average individual serving or portion, so that we might obtain a ratio between this average and the average volumetric capacity of the cooking jars of different time periods. Generally speaking, Southwestern archaeological literature lacks volumetric measurements of whole vessels.

THE SAMPLE: TIME PERIODS AND VESSEL ORIGINS

A total of 542 vessels (156 cooking jars, 347 individual serving bowls, and 39 ladles) were measured for volumetric capacity and identified as to type or variety (Table 1). The types and varieties have all been previously dated by their association with tree-ring materials (Colton 1952, 1955, 1956, 1958; Abel 1955; Breternitz

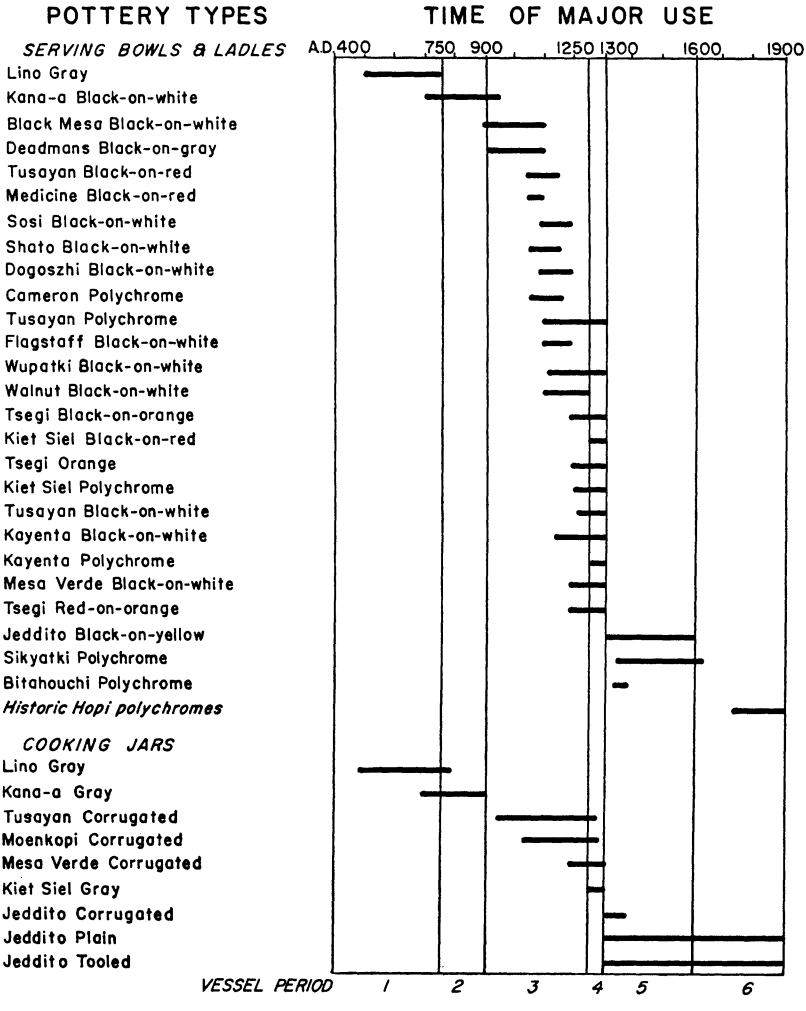

FIG. 1. Vessel periods and associated pottery types and varieties.

1965). Dates for the types are shown in Fig. 1. The time spans of the cooking jar types were used for setting up the vessel periods (Fig. 1 and 2). With the exception of vessel periods 3 and 4, the other periods correspond approximately to previously established cultural periods. The time span of vessel period 1 (A.D. 500-750)

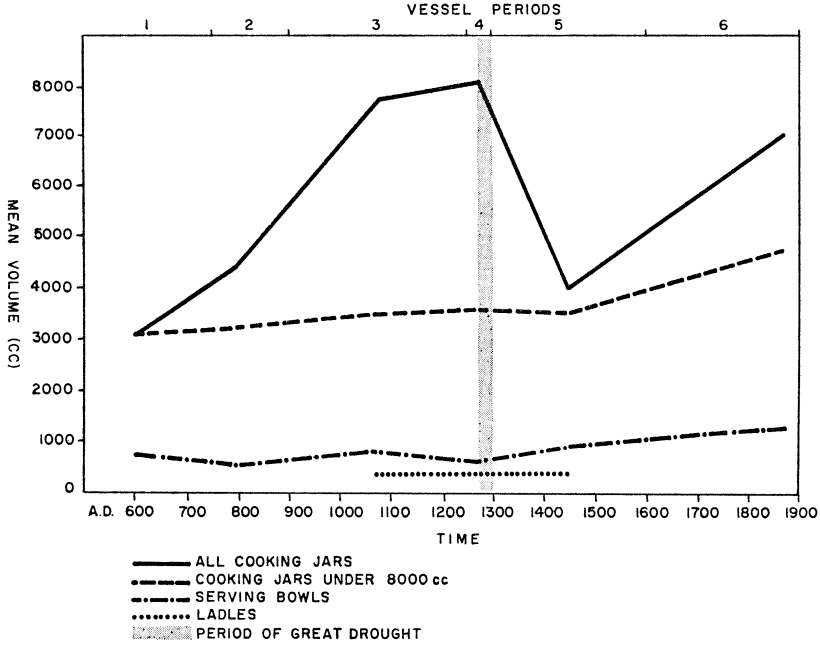

FIG. 2. Mean volumes of cooking jars, serving bowls, and ladles of the prehistoric Western Pueblo and historic Hopi Indians.

corresponds largely to that of Basketmaker III (500-700); period 2 (A.D. 750-900) is about that of Pueblo I (700-900); period 3 (A.D. 900-1250) includes Pueblo II (900-1100) and part of Pueblo III (1100-1300); period 4 (A.D. 1250-1300) includes late Pueblo III; period 5 (A.D. 1300-1600) corresponds to Pueblo IV; and period 6 (A.D. 1600-1900) corresponds to Pueblo V. Table 2 shows statistical attributes of the jars, bowls, and ladles by vessel period. The mean capacities of each vessel form for each vessel period mean date are plotted in Fig. 2.

The source area of the sample is contained within a boundary that starts at about Jerome, Arizona, on the extreme southwest, goes eastward to Holbrook, turns northward through Lukachukai, and up to Blanding, Utah. Westward from Blanding, the boundary roughly parallels the San Juan and Colorado rivers to

TABLE 1
Inventory of Whole Vessels Examined: Types and Forms

Vessel period	Type or variety	Jars No.	Jars %	Bowls No.	Bowls %	Ladles No.	Ladles %
1	Lino Gray	18	100.0	45	100.0	0	0.0
2	Kana-a Black-on-white	0	0.0	5	100.0	0	0.0
	Kana-a Gray	6	100.0	0	0.0	0	0.0
3	Tusayan Corrugated	53	70.7	0	0.0	0	0.0
	Moenkopi Corrugated	21	28.0	0	0.0	0	0.0
	Mesa Verde Corrugated	1	1.4	0	0.0	0	0.0
	Deadman's Black-on-gray	0	0.0	3	1.5	0	0.0
	Black Mesa Black-on-white	0	0.0	19	9.6	1	5.5
	Tusayan Black-on-red	0	0.0	18	9.1	2	11.1
	Medicine Black-on-red	0	0.0	2	1.1	0	0.0
	Shato Black-on-white	0	0.0	4	2.0	0	0.0
	Cameron Polychrome	0	0.0	1	0.5	0	0.0
	Sosi Black-on-white	0	0.0	8	4.1	0	0.0
	Dogoszhi Black-on-white	0	0.0	1	0.5	0	0.0
	Walnut Black-on-white	0	0.0	70	35.5	7	38.9
	Flagstaff Black-on-white	0	0.0	37	18.8	2	11.1
	Tusayan Polychrome	0	0.0	9	4.6	5	27.8
	Wupatki Black-on-white	0	0.0	25	12.7	1	5.5
4	Kiet Siel Gray	22	100.0	0	0.0	0	0.0
	Mesa Verde Black-on-white	0	0.0	0	0.0	1	5.9
	Tsegi Black-on-orange	0	0.0	4	7.7	1	5.9
	Kiet Siel Polychrome	0	0.0	2	3.8	1	5.9
	Tusayan Black-on-white	0	0.0	27	51.9	8	47.1
	Tsegi Red-on-orange	0	0.0	1	1.9	1	5.9
	Kiet Siel Black-on-red	0	0.0	1	1.9	0	0.0
	Tsegi Orange	0	0.0	8	15.4	5	29.4
	Kayenta Black-on-white	0	0.0	6	11.5	0	0.0
	Kayenta Polychrome	0	0.0	3	5.8	0	0.0
5	Jeddito Corrugated	2	18.2	0	0.0	0	0.0
	Jeddito Plain	5	45.4	0	0.0	0	0.0
	Jeddito Tooled	4	36.4	0	0.0	0	0.0
	Bitahouchi Polychrome	0	0.0	19	86.4	4	100.0
	Jeddito Black-on-yellow	0	0.0	19	86.4	0	100.0
	Sikyatki Polychrome	0	0.0	1	4.5	0	0.0
6	Jeddito Plain*	22	91.7	0	0.0	0	0.0
	Jeddito Tooled*	2	8.3	0	0.0	0	0.0
	Historic polychromes*	0	0.0	25	100.0	0	0.0
	Total vessels: 542	156		347		39	

* Dated ethnographically; one vessel still in use as late as 1930.

about Desert View Point in Grand Canyon National Park. Turning south, the western boundary runs approximately midway between Williams and Flagstaff, Arizona. One exception outside this area is a collection of 37 Basketmaker III

TABLE 2
Measurements of Jars, Bowls, and Ladles

Vessel period	Mean capacity (cc)	Standard error	Standard deviation	Range (cc)	Number
			Cooking Jars		
1	3107	312.2	1325	1560-6580	18
2	4473	1344.6	3293	1310-10,200	6
3	7680	534.7	4631	1300-17,000	75
4	8115	1019.6	4782	1710-17,000	22
5	3988	596.3	1978	1880-8380	11
6	7163	820.5	4020	1520-17,000	24
			Serving Bowls		
1	718	76.3	512.0	150-2250	45
2	496	66.4	148.4	340-760	5
3	791	35.2	497.3	140-3300	199
4	619	53.6	382.9	170-1650	51
5	832	65.3	306.4	360-1390	22
6	1381	148.9	744.5	310-3600	25
			Ladles		
1	—	—	—	—	0
2	—	—	—	—	0
3	386	44.7	189.8	80-700	18
4	336	41.9	172.9	90-680	17
5	347	—	—	210-520	4
6	—	—	—	—	0
Totals:	156 Jars 347 bowls 39 ladles 542 vessels				

vessels from near Durango, Colorado. These vessels showed no statistically significant size differences from northern Arizona Basketmaker III vessels. The remaining 505 vessels were originally found within the area outlined above. Nearly 50 per cent (266/542) of all vessels are from the heartland of the Kayenta Anasazi culture area. This is usually considered to be the area bounded on the north by the Colorado and San Juan rivers, on the east by the Chinle Wash, on the west by the Little Colorado River, and on the south by the Little Colorado and Puerco rivers. Eight per cent (44/542) of the sample lacked exact geographical proveni-

ence other than having certainly been manufactured within the Kayenta Anasazi area. With the exception (in addition to the Colorado Basketmaker vessels) of one Mesa Verde Black-on-white ladle and one Mesa Verde Corrugated cooking jar, both found in the Kayenta area, all vessels belong to, or are associated with, the Kayenta branch of the Anasazi culture area (prehistoric Western Pueblo).

MEASURING PROCEDURE

Three types of vessels were chosen for measurement—painted and plain individual serving bowls, ladles (dippers), and plain or corrugated cooking jars (Fig. 3). Any small bowl-shaped vessel, without a recurving rim, was classified as an individual serving bowl. Large mixing or family-serving bowls of more than about 3000 cc capacity were not considered. Bowl size was shown to have a very marked bimodal distribution. There was practically no overlap in the distribution between (1) individual serving bowl capacity, and (2) mixing or family-serving bowl capacity (historically, other Hopi uses for large bowls include parching, drying, piki-making, and indigo-dye preparation). Ladles were defined by their possession of a long horizontal solid or hollow handle. Plain gray or corrugated jars with smoke-blackened exterior surfaces were identified as cooking jars in contrast to similarly constructed vessels without blackening that might have served as storage or water jars.

To measure volume, we poured dry mustard seed into cooking jars and serving bowls, filling them to exactly one inch below the rim of each vessel. In individual serving bowls this measurement of one inch was the level at which painted design elements often ended (see Fig. 3) or where a horizontal line was painted suggesting the level of content. Ladles were filled entirely level with seed. We carefully avoided packing the seed by following a uniform procedure of measuring. The seed from each vessel was transferred to, and measured in, a 2000 cc capacity graduate cylinder calibrated in 20 cc intervals.

AN ESTIMATE OF THE PREHISTORIC UNIT OF MEASURE

The difference between mean ladle capacity in vessel periods 3 and 4 is not statistically significant. The number of ladles (four) in vessel period 5 is too small for testing, but both the mean and the range of period 5 ladles fall between the means and within the ranges of periods 3 and 4. No ladles were available for periods 1, 2, and 6. According to Colton (1955, 1956) ladles have been found, but they are rare (for periods 1 and 2). Table 2 and Fig. 2 show that mean ladle capacity is nearly identical for the three periods between A.D. 1100-1450, and we

suspect that it was the same as far back in time as ladles were manufactured. It should be noted, however, that the standard deviations for periods 3 and 4 are relatively large. The mean ladle capacity of periods 3, 4, and 5 is 360 cc or approximately 1½ cups English measure (1 cup = about 230 cc).

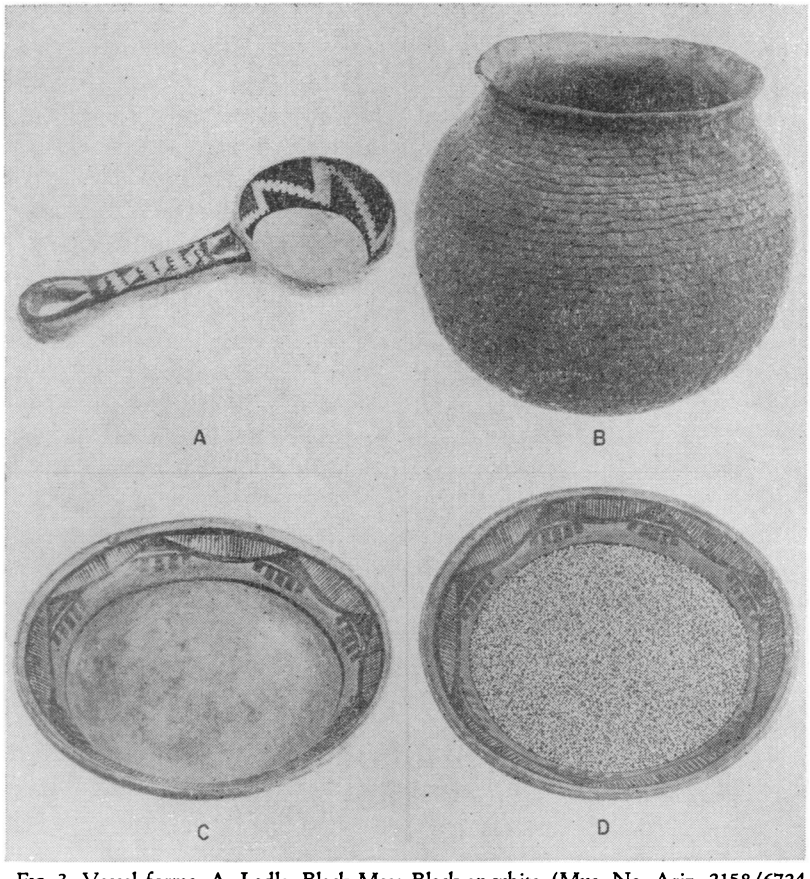

FIG. 3. Vessel forms. A. Ladle, Black Mesa Black-on-white (Mus. No. Ariz. 2158/6724.1), 26.5 cm length, 310 cc capacity. B. Cooking jar, Tusayan Corrugated (Mus. No. Ariz. 1116/A756), 19 cm height, 3630 cc capacity. C. Serving bowl, historic Hopi (Mus. No. Ariz. 255/993), 21.5 cm diameter, 590 cc capacity. D. Same as C but filled with seed to exactly one inch below rim.

The mean bowl capacity for periods 1 to 5 is 691 cc, almost exactly three cups, or two average ladles full. The mean number of cups per average cooking jar (excluding jars of more than 8000 cc capacity) by vessel period is: period 1, 13.5

cups; period 2, 14.4 cups; period 3, 15.4 cups; period 4, 15.6 cups; period 5, 15.4 cups; and period 6, 21.1 cups. Tests of mean bowl capacities for all combinations of the six vessel periods showed statistically significant differences between period 6 and all other periods, and between periods 2 and 3. The significant difference between period 2 and 3 bowls is charged to the inadequate sample of period 2 vessels (there are only five bowls for period 2). The increased mean capacity (and very large standard deviation) of the historic-period bowls is obviously not entirely a sampling error and is attributed partly, if not chiefly, to European influence on bowl shape. The main reason for the marked differences between historic Hopi bowls and the prehistoric bowls is the addition of a large flaring rim to most of the historic bowls, increasing their capacity by as much as 100 per cent over the mean prehistoric bowl capacity. The uniformity of mean individual serving-bowl capacity in periods 1 to 5 and the uniform ladle capacity in periods 3, 4, and 5 would make it appear that some ideal, or standard, or unit of measure existed in the minds of the prehistoric Western Pueblo potters that was apparently discontinued by the historic Hopi. This ideal measure was evidently, on the average, 360 cc (1½ cups English measure), although deviation from this average was appreciable (Table 2). One and one-half cups is about the amount that can be held with the hands cupped together.

Until A.D. 1600 mean individual serving-bowl size was a multiple of two times the mean ladle capacity. This ratio did not change until after the entry of Europeans into the Southwest in 1539. We believe that the size of prehistoric cooking jars was influenced by the average number of persons who ate from them.

ESTIMATING HOUSEHOLD SIZE

In order to use the ratio between bowl and cooking-jar capacities for the estimating of household size one correction of the cooking-jar statistics is necessary. Cooking jars in excess of 8000 cc capacity need to be excluded for two reasons.

First, as can be seen in Fig. 4, there appears to be a bimodal curve in the frequency distribution of cooking-jar capacities. The break between the peaks of the two curves occurs at about 8000 cc. It seems that there were two classes of cooking jars. Smaller jars occurred more frequently; less frequent were jars in excess of 8000 cc and as much as 17,000 cc in capacity. Because larger vessels probably do not preserve intact as well as do smaller vessels, we feel the present sample is deficient in a representative number of larger vessels. Differential preservation between large and small cooking jars is evidenced by the fact that nearly all large jars are severely cracked, whereas smaller jars often lack even minor cracking. If preservation had

been equal in both the large and small jars, the bimodal curve would probably be much more pronounced, that is, there would be many more vessels represented at about the 11,000 cc peak. Second, the earliest occurrence of a cooking jar of 8000

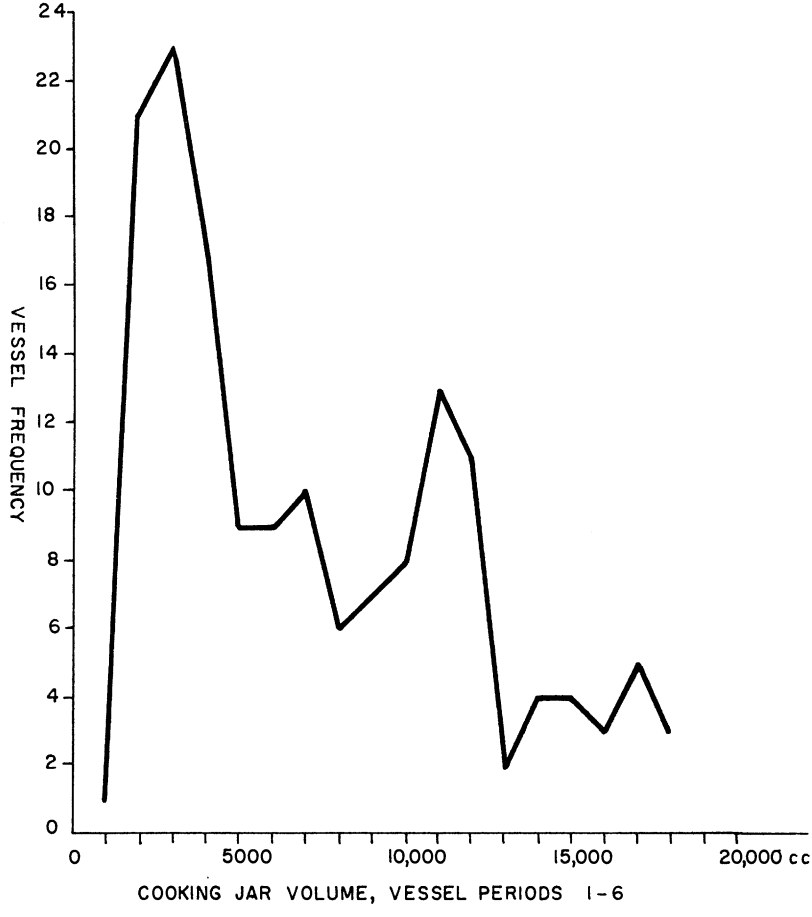

FIG. 4. Frequency and volume of cooking jars for all vessel periods.

cc capacity dates between A.D. 700 and 900 (vessel period 2) or between 200 and 400 years after pottery making began in northern Arizona. Only one of these large vessels was found in the collections studied. After A.D. 900, vessels in excess of 8000 cc capacity occur almost as frequently as vessels less than 8000 cc. It is likely that the large vessels were not used solely by single households but were made

especially for large gatherings of people. Given an average serving of 691 cc, a jar of 8000 cc or larger would be a serving for eleven or more people. Few families with eleven members are known ethnographically for the American Southwest (Pearl Beaglehole (1935:42) found 4 out of 51 households, or 8 per cent, of Second Mesa Hopi to have as many as eleven members).

It is generally felt that at the time of vessel period 3 (A.D. 900-1100) the Anasazi ceremonial structure (kiva) was evolving (Smith 1952:162). From this time on, larger congregations of people than single households must have been a common occurrence in all settlements. However, buildings clearly designed for the gathering of larger numbers of people than single families occurred during A.D. 700-900 (vessel period 2). One such large structure is known at Juniper Cove, a Basketmaker-Pueblo I site in the Kayenta area (Cummings 1953:62). Even before formal kivas had developed, there existed at least one large structure in the heartland of the Kayenta Anasazi region that could hold crowds of as many as 50 people. Feeding a gathering of this sort would have been greatly facilitated by cooking vessels larger than those used by single households. The finding of one cooking jar in excess of 8000 cc capacity that belongs to the time period, before formal kivas are common, for which there is evidence for large group gatherings, suggests that these large cooking jars relate to this situation rather than to the cooking requirements of single households. Because there is a bimodal distribution for cooking-jar capacity and because the large vessels are common after the kiva has become a regular feature of all prehistoric villages, we believe that only cooking jars under 8000 cc capacity were made to meet most household needs. With this qualification, the average household size estimates for each vessel period are shown in Table 3.

As can be seen in Table 3, the presumed household size increases gradually

TABLE 3

Prehistoric Western Pueblo Household Size Estimates

Vessel period	Time period	Mean cooking jar capacity*	Mean bowl capacity**	Cooking jar/bowl ratio (household size, persons)
1	500-750	3107 cc	691 cc	4.495
2	750-900	3328 cc	691 cc	4.815
3	900-1250	3536 cc	691 cc	5.116
4	1250-1300	3594 cc	691 cc	5.199
5	1300-1600	3549 cc	691 cc	5.134
6	1600-1900	4849 cc	691 cc	7.015

* Excluding jars of greater than 8000 cc capacity.

** Excluding bowls of vessel period 6.

from vessel period 1 to period 4 and falls slightly during period 5. Period 5 postdates the Great Drought of A.D. 1276-1299 (Douglass 1935), and it is of interest that cooking-jar capacities decreased slightly after this extensive and evidently severe climatic event. Household size does not appear to have been seriously affected by the drought, but as can be seen in Fig. 2 the average capacity of all cooking jars of period 5 fell greatly. It is worthwhile to consider the possibility that after the drought there was a marked reduction in the frequency or size of social gatherings in which food was prepared in large amounts, or perhaps there were no longer large amounts of food to prepare. There are many other possible interpretations of cooking-jar size fluctuations as evidence for various historical events, including the arrival of the Athapaskans at this time (Jett 1964; Brugge 1963; Turner 1963).

The estimates for the presumed household sizes found by the ratio of bowl-jar capacities are quite similar to ethnographic estimates of family and household size. Brainard in 1935 found the average Hopi family to be 4.17 persons (Colton 1960:103). Hrdlička (1908:43) calculated that the average Hopi family at the end of the 19th century was about 5.5 persons; the average Zuni family, 5.7 persons. He personally noted, between 1898-1905, that the Southern Ute had from two to five living children per family. Spier (1928:210) in 1919 found the average household size among the Havasupai of northwestern Arizona to be 4.2 persons. Pearl Beaglehole in 1934 tallied the average household size for two Hopi villages at 6.25 persons (Shipaulovi) and 6.83 persons (Mishongnovi), and she pointed out that these values are larger than those earlier reported by Fewkes and Mindeleff-Stephen (4.8, Shipaulovi; 5.4, Mishongnovi). She compared her findings with those of Kroeber, who found an average of 7.56 persons per household for the Zuni during 1915-16 (Beaglehole 1935:42). Titiev (1944:52) tabulated a total of 147 households at the old Hopi village of Oraibi, which had an average of 5.9 persons per household. The average of these seven Hopi estimates (household and family) is 5.55 persons; the average of the two Zuni estimates is 6.63 persons. In 1960 the average number of persons per household among the Hopi was 5.8; among the Zuni, 7.3 (Hillery and Essene 1963:305). Using Aberle's (1948:90) tabulation of nineteen northwestern New Mexican Pueblo Indian village population sizes and "family group" numbers (presumably biological family) for 1942, we have calculated that the mean family group size for all villages was $4.48 \pm .145$, while the range of village family group means was between 3.66 to 6.12 persons.

It would appear from these few reports that the estimates of prehistoric household size based on the ratio of bowl-jar capacities are well in line with expectation. The historic estimate is greater than, but close to, the Mishongnovi household

average determined by Pearl Beaglehole. As Colton has pointed out, in order for a population to do more than just maintain itself, there must be about five persons per family (Colton 1960:103). To simply hold its own, a population must have on the average at least four persons per family. The values obtained by the bowl-jar ratio never fall below this minimal level. Household size is greatest during late Pueblo II and III times (vessel periods 3 and 4), when maximum population size occurred as estimated by room and ruin counts (Colton 1960:106; Gladwin 1957:235-248; Martin *et al.* 1964:206). Household size falls after the Great Drought but climbs back up again after 1600 to a value similar to those found among both historic Hopi and Zuni.

ESTIMATING POPULATION SIZE

In order to obtain an estimate of total areal or village population, household sizes must be multiplied by either hearth numbers or living room numbers for respective time periods. This requires independent site survey information. Colton's population estimates, shown in Table 4, are the results of such surveys in the Flag-

TABLE 4

A Comparison of Two Prehistoric Population Size Estimates for the Flagstaff, Arizona, Region

Vessel period	Time period	Total families*	Family size (Colton**)	Household size (present report)	Total population (Colton)	Total population (present report)
1	500-700	60	5	4.495	300	270
2	700-900	76	5	4.815	380	366
3	900-1050	175	5	5.116	875	895
3	1050-1120	941	5	5.116	3764	4814
3	1120-1200	2104	4	5.116	8416	10764
4	1200-1300	153	4	5.199	612	795

* Calculated by Colton (1960:104) from archaeological site survey information.
** Calculated from tabular data in Colton (1960:104).

staff, Arizona, region. He assumed a changing family size of 4 and 5 persons through time on the basis of rather limited ethnographic information from the Hopi villages. As can be seen in Table 4, the estimates for total population size, based on the bowl-jar ratio multiplied by family number (calculated by Colton on the basis of room counts) are, in general, similar to Colton's population estimates. However, testing the two sets of estimates shows that there is a significant difference between them (Chi-square with 5 degrees of freedom is 50.2; P is less than

0.01). It is difficult to decide whether Colton's estimates are too low or ours are too high. However, both sets of estimates are similar enough to warrant concluding that the procedure of estimating household size by the ratio of bowl to jar capacities merits further testing in other localities of the Southwest. Especially valuable would be those areas where collections of whole vessels are large and where intensive site surveys have found many or most of the local prehistoric ruins.

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