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NUMERICAL ANALYSIS OF ARCHAEOLOGICAL *CUCURBITA PEPO* SEEDS FROM HONTOON ISLAND, FLORIDA

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ABSTRACT.— Numerous well-preserved cucurbit seeds were recovered from water-saturated deposits at Hontoon Island, Florida. These deposits indicate a continuous occupation at the site from approximately 500 B.C. through A.D. 1750. Visual examination as well as numerical analysis of the seeds suggest that while some seeds represent cultivated forms of *Cucurbita pepo*, others resemble wild members of the species (ssp. *ovifera* var. *texana*). Temporal changes in the seed remains suggest *in situ* developments in some cases and introductions in other cases.

INTRODUCTION

In 1980, excavations began at a shell midden site on Hontoon Island (8-VO-202) on the St. Johns River in northeastern Florida (Purdy and Newsom 1985; Newsom 1986). Ceramic chronology and radiocarbon dates indicate that the excavated deposits range from approximately 500 B.C. to A.D. 1750 (Newsom 1986). Plant remains, including over 1500 squash seeds, were recovered from water-saturated deposits over a five year period. The squash seeds, identified as *Cucurbita pepo* L., were uncharred though tannin-stained. Both the quantity and excellent preservation of these seeds provided the opportunity to examine temporal variation in *C. pepo* remains and make comparative analyses with modern material, both domesticated (*C. pepo* ssp. *pepo* and *C. pepo* ssp. *ovifera* (L.) Decker var. *ovifera* (L.) Alef.) and wild (*C. pepo* ssp. *ovifera* (L.) Decker var. *texana* (Scheele) Decker) (Decker 1986, 1988).

Of particular interest was the possible affinity of the Hontoon Island seeds with those of var. *texana*. Viewed alternately as a feral escape and as progenitor to domesticated forms, var. *texana* always has been considered wild or weedy, while the rest of the species consists wholly of cultivars and landraces. The variety *texana* traditionally has been considered endemic and restricted to Texas (Correll and Johnston 1979). Although spontaneous populations of *texana*-like plants occurring beyond Texas (e.g., Alabama, Arkansas, Illinois, and Missouri) are usually considered cultivar escapes, recent evidence suggests they may represent remnants of original wild populations in an area northeast of Texas (Decker 1986; Decker and Wilson 1986, 1987). The existence of archaeological remains that may represent var. *texana* could have great impact on this controversy.

A recent study of modern domesticated and wild *C. pepo* seeds (Decker and Wilson 1986) has provided a methodological framework for testing the affinities between the archaeological and modern material.

MATERIALS AND METHODS

Although various units, trenches, and columns have been excavated at Hontoon Island, this study focuses on the 1980 Unit and 1982 Column. These had fairly good stratigraphic control and together covered the earliest known cultural level at the site through the Spanish Period (Newsom 1986). The 1980 Unit was a 3 m square excavated stratigraphically to about 150 cm below the surface. The uppermost and lowermost zones, one and five respectively, were devoid of cultural artifacts. The Spanish Period is represented by Zone 2 and the top of Zone 3 (Newsom 1986). Two radiocarbon dates of A.D. 1190 and A.D. 1220 were associated with Zone 4 (Newsom, unpubl. data). The 1982 Column was excavated to a depth of 140 cm. Levels were arbitrarily defined at 10 cm intervals from the surface. Levels 1 through 4 lacked cultural artifacts even though some cucurbit remains were found in Level 4 (Newsom 1986). The earliest radiocarbon date associated with Level 14 was A.D. 800. Level 10 was dated to approximately A.D. 1470, while 17th century dates begin to appear in Level 8 (Newsom, unpubl. data).

Most of the complete or nearly complete squash seeds from these two excavations were examined. A total of 253 seeds were measured using the digitizing hardware and image analysis software previously employed to measure modern seeds (Decker and Wilson 1986). Information recorded from the face view of the seed included whole image measurements such as length and width, as well as measurements based on division of the seed from bottom (seed scar) to top by 10 equidistant diameters to produce partial areas and widths (Decker and Wilson 1986: Fig. 1).

Data from Decker (1986) and Decker and Wilson (1986) served as modern comparative material. *Cucurbita pepo* cultivars were chosen that represented the range of variation in the species, including members from both subspecies. *Cucurbita pepo* ssp. *pepo* was represented by pumpkins (PJO 71, PSU 72), zucchinis (MBZ 206, MGZ 46), 'Vegetable Spaghetti' (UVS 50), Mexican accessions (XCC 163, 172, XV? 225, X?I 124), and one ornamental gourd cultivar (OWO 56). Accession codes and corresponding cultivar names are listed in Decker (1986) and Decker and Wilson (1986). Infraspecific classification of cultivars follows Decker (1986, 1988). *Cucurbita pepo* ssp. *ovifera* var. *ovifera* was represented by various ornamental gourds (OBB 3, OEN 1, OEW 62, OFS 55, OPB 10, OPS 18, OPW 60, OSB 46), a crookneck (CYE 118), and a scallop squash (SWB 61). Populations of *C. pepo* ssp. *ovifera* var. *texana* were included in the analyses also (TEX 1, 2, 3, 4, 5, 6, 10, 17, 31, 36). Ten accessions (10 seeds per accession) from each of the three infraspecific taxa were used to establish two canonical discriminant functions. Each archaeological seed was subsequently classified to one of the three taxa on the basis of the discriminant functions.

Analyses focused on a small but important subset of the original characters. Temporal analysis of the archaeological seeds was based primarily on overall width and length measurements. For the discriminant procedure (subprogram DISCRIMINANT in SPSS (Klecka 1975)), a stepwise selection technique based on Wilks' lambda (procedure STEPDISC in SAS (Ray 1982)) was used to choose five characters that could best discriminate the three taxon classes: width (W), length (L), RCPWD, RCRWD, and REPAR. RCPWD and RCRWD are ratios of the widths CP and CR over the overall width (W), respectively. The width CP was measured at 1/9 the length of the seed from the seed scar, while CR was measured at 3/9 the length. REPAR is the ratio of the second partial area up from the seed scar (EP) over the entire face view area of the seed. Together, these three ratios characterize the size and shape of the small sinuses on either side of the seed near the seed scar.

The discriminating power of the five characters was tested by defining two discriminant functions on the basis of nine of ten seeds randomly chosen from each accession. The remaining seeds served as a test group. Observations were classified on the basis of posterior probabilities of group membership, or P(G|X). For classification of the archaeological seeds, the discriminant functions were redefined on the basis of all the modern seed material. Four of the original 253 seeds were not classified because of aberrations in these seeds near the seed scar.

RESULTS

Width and length statistics are presented in two plots (Fig. 1 and 2) and in Table 1. Among the seeds recovered from the 1980 unit, one seed from Zone 2 is much larger than the other seeds (Fig. 1). The remaining seeds show a decrease in size from older

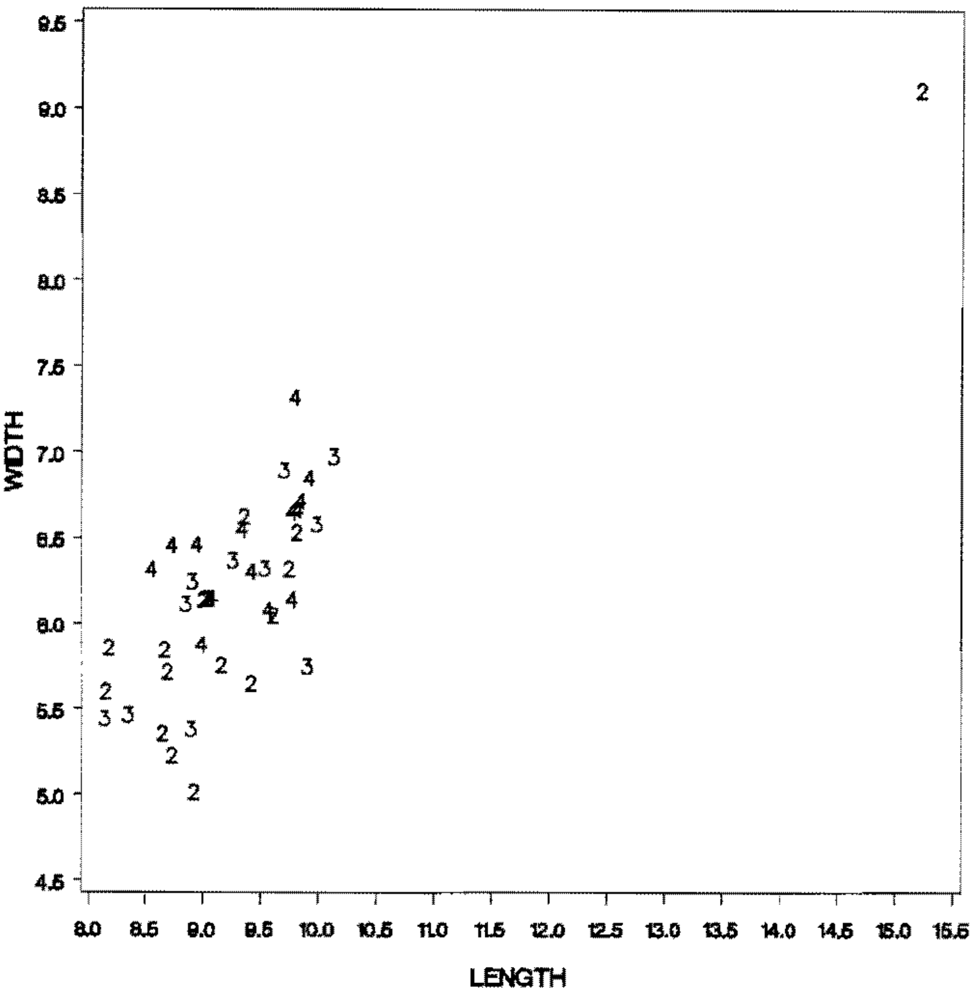

FIG. 1.—Width by length plot of the archaeological cucurbit seeds from the 1980 Unit at Hontoon Island. Numbers indicate the zone in which a seed was found. Units are mm.

TABLE 1.—*Width and length statistics for the archaeological seeds from Hontoon Island, var.* texana, *and 20 cultivars of* C. pepo. *Data on modern seeds are from Decker (1986) and Decker and Wilson (1986).*

Excavation/ Taxon	Level[1]/Zone/ Cultivar	N	WIDTH Mean[2]	WIDTH S.D.[3]	LENGTH Mean	LENGTH S.D.	W/L
80	2	16	6.05	0.93	9.39	1.63	0.64
80	2A	15	5.85	0.46	9.00	0.51	0.65
80	2B	1	9.10	.	15.22	.	0.60
80	3	12	6.13	0.54	9.22	0.64	0.66
80	4	14	6.46	0.37	9.39	0.46	0.69
82	4	1	5.90	.	8.93	.	0.66
82	5	25	6.11	0.45	9.07	0.67	0.67
82	6	50	7.10	0.79	10.35	1.18	0.69
82	6A	24	6.37	0.42	9.28	0.71	0.69
82	6B	26	7.76	0.33	11.33	0.41	0.68
82	7	40	6.38	0.44	9.43	0.53	0.68
82	8	24	6.47	0.50	9.63	0.85	0.67
82	8A	23	6.42	0.45	9.54	0.75	0.67
82	8B	1	7.64	.	11.68	.	0.65
82	9	13	6.10	0.52	9.55	0.75	0.64
82	10	21	6.14	0.55	9.36	0.51	0.66
82	11	16	6.18	0.44	9.14	0.53	0.68
82	12	16	6.30	0.50	9.07	0.34	0.69
82	13	3	6.10	0.36	9.01	0.86	0.68
82	14	2	6.62	0.18	9.94	0.04	0.67
var. *texana*	TEX	100	6.11	0.43	9.44	0.67	0.65
var. *ovifera*	CYE 118	10	7.05	0.53	11.66	0.74	0.60
var. *ovifera*	OBB 3	10	5.20	0.29	9.73	0.63	0.53
var. *ovifera*	OEN 1	10	6.63	0.55	10.80	0.74	0.61
var. *ovifera*	OEW 62	10	5.91	0.35	9.59	0.80	0.62
var. *ovifera*	OFS 55	10	5.84	0.56	9.83	0.69	0.59
var. *ovifera*	OPB 10	10	5.60	0.34	8.97	0.62	0.62
var. *ovifera*	OPS 18	10	5.53	0.42	8.94	0.74	0.62
var. *ovifera*	OPW 60	10	5.89	0.67	8.80	0.85	0.67
var. *ovifera*	OSB 46	10	5.16	0.44	8.13	0.63	0.63
var. *ovifera*	SWB 61	10	7.87	0.71	12.62	1.39	0.62
ssp. *pepo*	MBZ 206	10	8.03	0.39	12.16	0.48	0.66
ssp. *pepo*	MGZ 46	10	8.88	0.60	14.06	0.92	0.63
ssp. *pepo*	OWO 56	10	7.03	0.73	12.09	0.78	0.58
ssp. *pepo*	PJO 71	10	8.98	0.81	16.04	1.40	0.56
ssp. *pepo*	PSU 72	10	8.36	0.90	14.37	1.46	0.58
ssp. *pepo*	UVS 50	10	9.01	0.47	13.74	0.98	0.66
ssp. *pepo*	XCC 163	10	9.19	0.65	20.36	1.99	0.45
ssp. *pepo*	XCC 172	10	8.39	0.51	19.52	1.88	0.43
ssp. *pepo*	XV? 225	10	8.95	0.55	19.96	1.31	0.45
ssp. *pepo*	X?I 124	10	8.72	0.59	17.82	0.83	0.49

[1]Values were calculated for all seeds of a level or zone first. When width x length plots (Fig. 1 and 2) revealed the presence of outliers or more than one grouping, then values were recalculated for the new groups, designated A and B.

[2]Units are mm.

[3]Standard deviation.

to younger deposits (Fig. 1, Table 1). Additionally, the width to length ratios (W/L) indicate that at least some seeds near the top of the unit (Zone 2) are relatively thinner. The exceptionally large seed has a particularly low value for this ratio (Table 1).

The plot of the 1982 data (Fig. 2) reveals a small group of seeds somewhat removed from and larger than all other seeds. This group consists of about half the seeds from Level 6 and one seed from Level 8. A few seeds from Levels 6 through 9 occur in the transition zone between these larger seeds and the numerous smaller seeds. Interestingly, some of the smallest seeds from the column are also from the upper strata. Most of the seeds from the column are within the size range for the var. *texana* seeds used in this study (width = 5.07 to 7.52 mm; length = 7.86 to 10.91 mm). However, the seeds representing var. *ovifera* have similar ranges in width (4.60 to 8.77 mm) and length (7.16 to 14.30 mm). Only the largest seeds from the column fall within the size range of ssp. *pepo* seeds (width = 6.15 to 10.60 mm; length = 10.80 to 23.20 mm). Average W/L ratios among levels in the column are about the same except for the somewhat lower values in Levels 4 and 8 through 10 (Table 1). Among individual seeds, some from Level 12 have values as high as 0.80, while others from Level 10 have values as low as 0.57 (Fig. 2).

In both the 1980 Unit and 1982 Column, there appears to be more diversity in seed size in the younger deposits. This can be tested by calculating a unitless statistic of

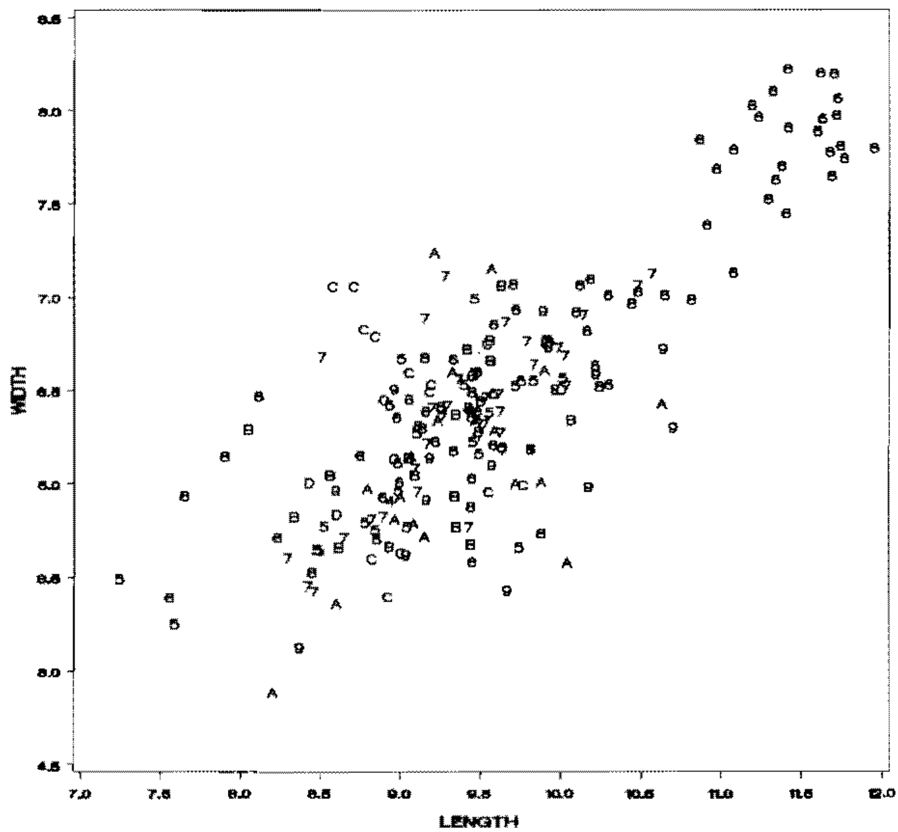

FIG. 2.—Width by length plot of the archaeological cucurbit seeds from the 1982 Column at Hontoon Island. Numbers and letters indicate the level in which a seed was found (letters A-E represent Levels 10-14, respectively). Units are mm.

variability, called the coefficient of variation (C.V. = 100 x S.D./mean), from values listed in Table 1. In the 1980 Unit, Zone 4 has the lowest coefficients of variation for width (C.V. = 5.72) and length (C.V. = 4.91), while Zone 2 has the highest values (width C.V. = 15.31; length C.V. = 17.36). The highest coefficients of variation in the 1982 Column are for Level 6 (width C.V. = 11.18; length C.V. = 11.39).

On the basis of width, length, and W/L, the majority of small seeds from Hontoon Island most resemble seeds of var. *texana*. Among the modern accessions reported here, pumpkins, especially those from Mexico, have the lowest values for W/L, while var. *texana*, 'White Pear' (OPW 60), 'Black Zucchini' (MBZ 206), and 'Vegetable Spaghetti' (UVS 50) have the highest values (Table 1). Values for most of the archaeological material are even higher. Relatively high values for W/L are not uncommon for *C. pepo* seeds from eastern U.S. sites (King 1985). Among the Hontoon Island seeds, the very large and relatively narrow seed in Zone 2 has a much lower value. Its measurements place it within ssp. *pepo*. In contrast, the large seeds of Levels 6 and 8 are most similar in their dimensions to the scallop, a member of var. *ovifera*. Thus, all three infraspecific taxa appear to be represented by the archaeological seeds. This was tested further via the discriminant analysis.

Classification of the test group was 89% accurate. After the discriminant functions were redefined using all of the modern seeds, both the modern and archaeological seeds were classified (Table 2). The percentage of correctly classified modern seeds was somewhat lower (86.3%) than predicted by the test group due to a few accessions that did not fit well into their respective taxa. Parallel evolution within the two domesticated lines is not surprising given that seed characters are influenced by human selection pressures.

Over half of the archaeological seeds were classified as var. *texana* (Table 2). In fact, the majority of seeds in all zones and levels, except Levels 4, 5, and 14 were placed into the var. *texana* group. Although the Level 14 seeds were classified as var. *ovifera*, both seeds had P(X|G) (probability that a seed that far from the centroid actually belongs to the group) values of less than 27% and actually fell closer to the var. *texana* centroid (Fig. 3). They were not identified as var. *texana* because their positions were slightly beyond the range for var. *texana* seeds. In Level 6, the majority of small seeds were categorized as var. *texana*, while most of the larger seeds fell into the var. *ovifera* group. The larger seeds also exhibited an affinity for ssp. *pepo*; the second highest P(G|X) was for this subspecies for about 40% of those seeds. One of the seeds was primarily classified as ssp. *pepo*, even though it had a P(G|X) of only 56% and a P(X|G) of 2%. Only one of the archaeological seeds (the large seed from Zone 2) was well-classified as ssp. *pepo*.

Placement of the Hontoon Island seeds in the space defined by canonical discriminant functions one and two is illustrated in Figure 3. Taxon centroids, as well as ranges for each taxon along the discriminant functions, are plotted also. Again, only the large seed from Zone 2 (1980 Unit) lies significantly close to the ssp. *pepo* centroid. Most of the other seeds lie well within the ranges of var. *ovifera* and/or var. *texana*. In fact, many of the seeds occupy the region between these taxon centroids. A few archaeological seeds occur beyond the ranges defined by the modern material. This suggests that they may belong to cultivars or wild populations not represented by the modern accessions chosen to define the discriminant functions.

DISCUSSION

Most of the archaeological cucurbit seeds from the 1980 Unit and 1982 Column at Hontoon Island resemble those of modern *C. pepo* ssp. *ovifera* var. *texana* (Fig. 4, top row). Others are small and narrow like ornamental gourd seeds, some resemble scallop seeds (Fig. 4, center row), and at least one seed approached the dimensions of a pumpkin

TABLE 2.—*Classification results for wild populations and cultivars of* C. pepo *and the archaeological seeds from Hontoon Island.*

Taxon/ Excavation	Accession[1]/ Level / Zone	Predicted Group Membership[2] T	O	P
var. *texana*	TEX 1	9	1	
	TEX 3	8	2	
	TEX 5	9	1	
	TEX 6	8	2	
	TEX 17	6	4	
	TEX 36	9	1	
var. *ovifera*	CYE 118		5	5
	OEN 1	1	8	1
	OFS 55	1	9	
	OPB 10	1	9	
	OPS 18	3	7	
	OPW 60	3	7	
	SWB 61		4	6
ssp. *pepo*	OWO 56		8	2
	PSU 72		1	9
80	2	10 (.63)	5 (.31)	1 (.06)
	3	7 (.58)	5 (.42)	
	4	10 (.71)	4 (.29)	
82	4		1 (1.0)	
	5	10 (.40)	15 (.60)	
	6[3]	28 (.58)	19 (.40)	1 (.02)
	7	31 (.77)	9 (.23)	
	8	15 (.63)	9 (.37)	
	9	9 (.69)	4 (.31)	
	10	13 (.62)	8 (.38)	
	11	13 (.81)	3 (.19)	
	12[3]	10 (.71)	4 (.29)	
	13	2 (.67)	1 (.33)	
	14		2 (1.0)	
Summary—				
var. *texana*		89	11	0
var. *ovifera*		9	79	12
ssp. *pepo*		0	9	91
Hontoon Island		159 (.64)	88 (.35)	2 (.01)

[1]Only accessions with misclassified seeds are listed.

[2]T = var. *texana*, O = var. *ovifera*, P = ssp. *pepo*. Percentages are in parentheses.

[3]Two seeds with broken margins were not analyzed.

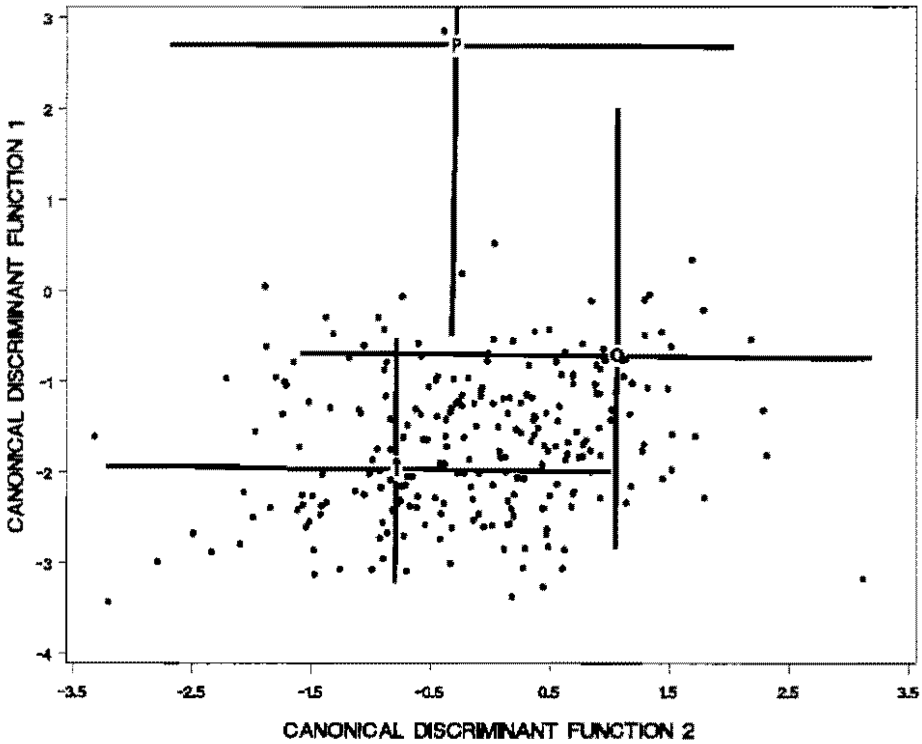

FIG. 3.—Plot of the archaeological seeds from Hontoon Island along canonical discriminant functions 1 and 2. Also shown are centroids and ranges for *C. pepo* ssp. *pepo* (P), var. *ovifera* (O), and var. *texana* (T). The upper range for ssp. *pepo* along the first discriminant function extends to 5.8.

seed. Not all of these seed types appear to be *in situ* developments. Continuity among the majority of the small seeds throughout the unit and column suggests that there was at least one local and persistant form. Particularly small and narrow seeds, resembling those of some ornamental gourds, do not appear until historic times (Zone 3 and Level 10). Seeds similar to those of the modern scallop squash are first detected in Level 8 and are relatively abundant in Level 6. A few seeds in Levels 6 through 9 that appear intermediate between the majority of small seeds and the scallop-like seeds indicate that the latter could have been an *in situ* development. Likewise, this type of squash may have been traded to Florida Indians from groups to the north. In either case, the historic use of scallop squashes by tribes of southeastern U.S. has been documented (Speck 1941). A more certain introduction to the Hontoon Site are pumpkin-like seeds. While only one such seed was found in the 1980 Unit (Zone 2) and none in the 1982 Column, 1985 excavations have uncovered many of these, ranging in size from approximately 7 to 10 mm wide and 12 to 18 mm long (Fig. 4; Newsom 1986). All were found in historic strata, usually associated with Spanish remains (gold coins, etc.). There is no evidence of any intermediate forms. Similar seeds have been found at archaeological sites in Mexico (Cutler and Whitaker 1967; Whitaker *et al.* 1957). Perhaps the Spanish brought pumpkins from Mexico to the Hontoon Island inhabitants.

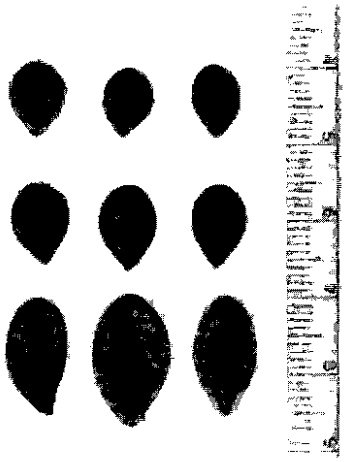

FIG. 4.—Archaeological *Cucurbita pepo* seeds from Hontoon Island. Top row: 1980 Unit, Zone 4, small seeds, abundant type; center row: 1982 Column, Level 6, larger scallop-like seeds; bottom row: 1985 Square No. 59, pumpkin-like seeds. Units of scale are cm.

From the data presented here, it is difficult to ascertain whether two small-seeded varieties (var. *ovifera* and var. *texana*) coexisted at Hontoon Island, or if a single type existed which produced seeds whose varying dimensions covered parts of the ranges of variation we see in wild populations and some ornamental gourds today. In the latter case, the intermediate nature of the seeds might indicate that the Hontoon Island populations were less divergent from either var. *ovifera* or var. *texana* than these taxa currently are from each other. In either case, the affinity of the archaeological material to var. *texana* is evidence that wild, weedy, encouraged, or even cultivated populations of *texana*-like plants existed in northeastern Florida between approximately A.D. 800 and A.D. 1750. The riverine environment at Hontoon Island could have provided habitats suitable for wild populations similar to those in Texas (Correll and Johnston 1979). This supports a hypothesis based on isozyme data that var. *texana* once inhabited an area north and east of its currently recognized distribution in Texas (Decker 1986; Decker and Wilson 1987). This possibility necessitates consideration of var. *texana* when dealing with *Cucurbita* remains in eastern U.S. Whether or not these remains indicate domestication should be questioned also. These considerations are vital to hypotheses concerning the origin of horticulture in eastern U.S.

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