SUBJECTIVE AND METRICAL DEPTH OF THE SUBORBITAL FOSSA

by

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I. INTRODUCTION

The maxilla, a vascular bone with numerous arteries and a rather large sinus, is a paired bone situated in the anterior portion of the skull. Singularly, it articulates with more bones (nine) of the skull than any other. Its anterior surface, which faces forward and laterally, presents several anatomical landmarks. Among these are (a) the ridges produced by the roots of the canine and lateral incisor teeth which give rise to the nasalis muscle. Superior and lateral to the canine ridge is (b) the depression known variously as the canine fossa or the suborbital fossa (Hrdlicka 1952:158; Boule-Vallois 1957:288; Howells 1959:356). The caninus muscle (levator anguli oris) arises from this depression. At the apex of the suborbital or canine fossa and near the margin of the orbit is (c) the infraorbital foramen through which the infraorbital branch of the fifth cranial nerve (trigeminal) and the infra-orbital artery pass. These appear in the face beneath the quadratus muscle (levator labii superioris), which runs from the lower orbital border to the upper lip, and above the caninus muscle which runs from the fossa to the angle of the mouth. The medial margin of the anterior surface is deeply concave, forming (d) the nasal notch which is the lateral boundary of the nasal aperature (Fig. 1).

Ossification

Ossification of the maxilla takes place from two centers located in the membrane covering the cartilaginous nasal capsule. These appear during the sixth to eighth week of intra-uterine life and give rise to two components that compose the bone at full growth -- the premaxilla and postmaxilla (Morris 1953:174-178). The postmaxilla center of ossification appears at a spot corresponding to the future external bony covering of the alveolar process. "From that point a plate of bone grows rapidly upward upon the wall of the nasal capsule, the ascending process, downward as the external alveolar plate, and backward in the floor of the orbit . . ." (Morris 1953:178). The premaxilla (Fig. 2) occurring anteriorly and medially from the postmaxilla, forms the interior inferior border and part of the lateral border of the nasal aperature (Montagu 1960:134). The postmaxilla and premaxilla, which rapidly unite into one bone, constitute the ascending process and can be distinguished up to the stage of 60 mm. or about 2.6 to 3.1 fetal months (Morris 1953:41). However, portions of a premaxilla have been noted in the facial aspect of human crania as late as the fifth year (Montagu 1960:136).

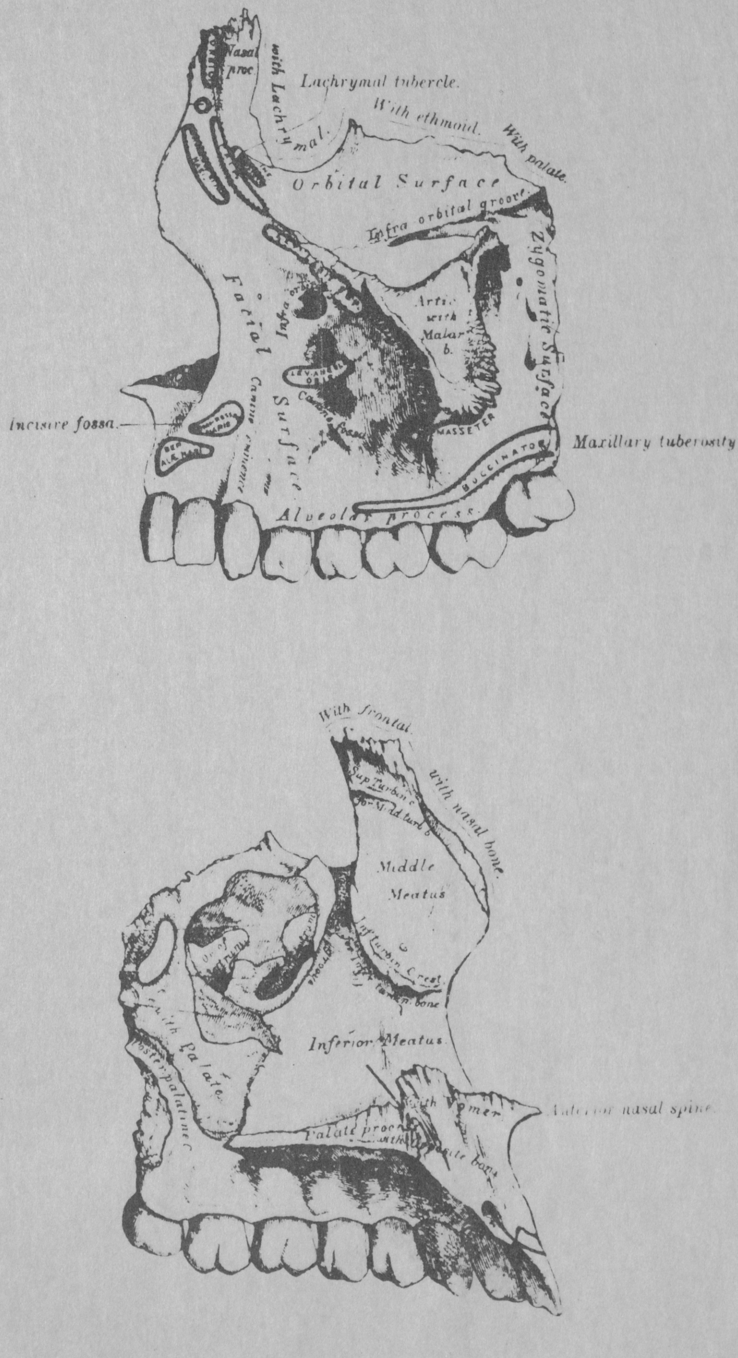

Fig. 1. Lateral and medial views of the left maxilla showing the canine (suborbital) fossa and other landmarks. (After Gray 1896).

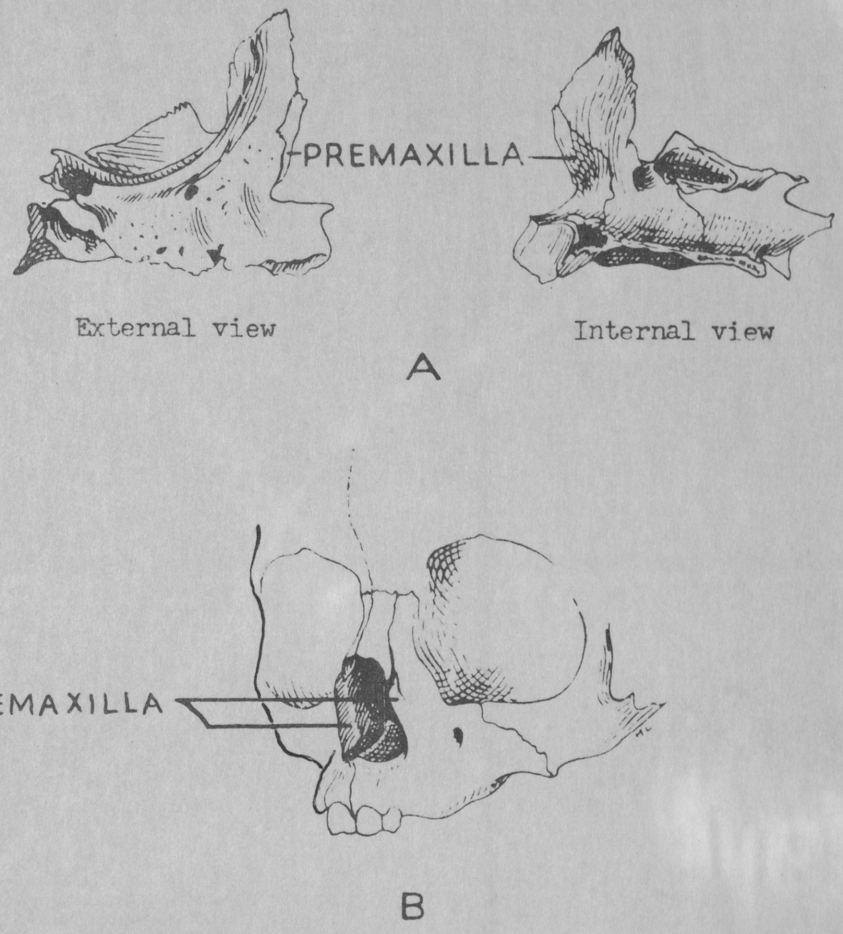

Fig. 2a and b. Premaxillae occuring in immature individuals. a, newborn; b, infant aged 11 months. (After Montagu 1960).

Evolutionally, the suborbital fossa appeared before the advent of Homo sapiens. Indeed, it appears to pre-date any species of Homo, though Coon states that it occurs in ". . . most but not all human maxillae, and no others . . ." (1962:206). However, both Proconsul of the Miocene period and the Fort Ternan primate of the Early Pliocene had this fossa (Coon 1962:201-206), while the Rhodesian and typical Neanderthal crania, generally considered in the genus Homo, lack it (Howells 1959:209) as do those crania from Mount Carmel (Comas 1960:521). But according to Montagu, it is in the Early Neanderthals of the third interglacial that ". . . there is a tendency to (italics mine) the formation of a canine fossa" (1960:199) while in the Later Neanderthals of the fourth glacial period there is an absence of such a depression (Montagu 1960:199-201).

Though "patterns and rates of growth are better known for the face than for any other part of the human skeleton, due primarily to the keen interest and elegant methods of the orthodontists" (Landauer 1962:239), little has been found in the literature about the depth of the suborbital fossa and its significance in a skeletal population.

Most authors have treated the problem of depth as a subjective classification rather than as an actual measurable feature. Coon (1962:201) mentions a "small depression" in the Proconsul fossil already described above. Boule and Vallois (1957:461) speak of a "deep canine fossa" when discussing the Florisbad crania from the late Lower Paleolithic and the somewhat later Grimaldi material. Hrdlicka (1952:158) has classified the concavity as slight, medium (+), or pronounced. Montagu (1960:613) does not list a preferential system of his own, but rather incorporates into his work the classification of none, slight or + used by Dr. J. L. Angel. Wilder (1920) and Anderson (1962) do not attempt any subjective classification for the fossa. Some early workers in the field of Biometrics such as Woo and Morant (1934) and Pearson and Woo (1935), have devoted much time to the study of the flatness and morphometrics of the skeletal face. As late as 1962, Oschinsky (1962) was dealing with this same problem area in his work on Arctic mongoloid material. Though the above, and others have established cords, planes and angles surrounding the fossa, none have attempted measurements of so conspicuous a depression.

However, Bass (1961), in his measurements of approximately 4000 skeletons from the Plains, incorporated (but did not report) not only subjective classifications, but also a system of direct measurement. The literature examined up to the present time has not yielded any other attempt at direct measurement.

Therefore, it is the purpose of this study to (1) ascertain if there are geographic or local race (Garn 1961:14-19), sex, or age differences in the depth of the suborbital fossa as defined subjectively, (2) establish, by metric methods, an objective classification, index and range for depth of the fossa, (3) see if the subjective classification can be objectified, and (4) determine if there are geographic or local race (Garn 1961:14-19), sex or age differences in the depth of the fossa as defined objectively from our samples.

II. MATERIAL

The skeletal material for this study consists of adult crania representing 160 individuals (93 males, 67 females). Table 1 shows a break-down of the sample by probable cultural affiliation and sex.

Table 1.--Study sample by group and sex.

Group	Males	Females	Total (male and female)
Arikara	43	31	74
Central Plains	13	10	23
Pawnee	17	8	25
Hasanlu	7	3	10
Crow	6	2	8
Totals	93	67	160

The measurements and other data on all of the individuals were collected by William M. Bass between 1958 and 1962. Designations of cultural affiliations, with the exception of the Crow, were recorded from the archaeologists' reports.

The Arikara group is composed of 52 individuals (33 males, 19 females) from the Sully site, 39SL4, and

22 individuals (10 males, 12 females) from the Lower Cheyenne River site, 39ST1. Both are putative Arikara (Bass 1961:37) sites along the Missouri River in South Dakota. Both sites appear to be protohistoric in age (Wedel 1961:195) and were occupied prior to the Lewis and Clark Expedition in 1804.

The Central Plains (Aksarben) group is composed of skeletal material from three sites in Nebraska. There are 19 individuals (11 males, 8 females) from an unnamed site, 25DK13, 3 individuals (2 male, 1 female) from the Sondegaard Ossuary, 25HW3 and one individual (female) from the Christensen site, 25HW8. These sites were classified as prehistoric Central Plains by Bass (1961:37).

The Pawnee group, except for two crania (one male, one female) from the Burkett site, 25NC1 and four male crania from Nebraska material housed at the Smithsonian Institution, were also listed by Bass (1961:37). These include 4 male and 3 female skulls from the Linwood site, 25BU1, one male from the Clarks site, 25PK1 and 11 individuals (7 males, 4 females) from the Hill site, 25WT1.

The Hasanlu group is the only non-Amerindian sample available for this study. It consists of 7 male and 3 female crania excavated by the University of Pennsylvania at the Hasanlu site, Iran, between 1958 and 1960. It is included in this study in order that comparisons may be made between a Caucasoid element and the American Indian groups. The Hasanlu material is thought to date from 1250 B.C. to Islamic times (Dyson; personal communication on file with the skeletal material).

The putative Mandan skeletal material comes from eight different sites in North Dakota. The specimens from each site are listed in Table 2. Will and Hecker (1944) describe each of these sites and place them within a Mandan cultural context.

Table 2.--Mandan sites and number of selected cranial material by sex[a].

Site no.	Name	Page Refer.[b]	No. of Males	No. of Females	Total
32BL8	Double Ditch	82	1	1	2
32BL9	Larson	82	2	-	2
32MO11-12	Huff-Jennie Graner	94-96	1	1	2
32MO26	Slant Village	98	1	8	9
32MO29	Motsiff	100	-	2	2
32MO37	Boley	103	-	1	1
32OL11	Lower Sanger	108	2	-	2
	Totals		7	13	20

[a]Table is based after Bass and Birkby (1962:173).

[b]The page references in Will and Hecker (1944) are listed here for convenience.

The putative Crow sample, represented by 8 individuals (6 males, 2 females), are all from Montana and are housed in the American Museum of Natural History in New York. These were listed by the Museum as being possibly Crow, but without coming from a particular site. They were collected from scattered finds or as donations over a period of years.

No attempt has been made to incorporate infants, children or subadults into this study. It was felt that the adult material would give greater variance, if such existed, than would younger, immature individuals.

The material for this study was "selected" solely on the basis of whether both the metric and the non-metric observations for the depth of the canine fossa were available. Those individuals lacking either one or the other observation were excluded.

III. METHODS OF MEASUREMENT

Two older standardized points, as well as two newer instrumentally determined points, were used in taking measurements for the establishment of the depth of the suborbital fossa. These points are (see Figs. 3, 4 and 5):

1. Basion (Ba) — The median point on the anterior margin of the foramen magnum.
2. Alare (Ala) — The most lateral point on the lateral edge of the nasal aperature.

3. Lateral (Lat)* (New measurement) The most anterior point on the malar bone when measured from point Basion. Instrumentally determined.

4. Medial (Med)* (New measurement) A point on the surface of the maxilla within the suborbital fossa which is the shortest distance from point Basion. Instrumentally determined.

Three different measurements incorporating these points were recorded whenever available on the cranial data sheets at the time the initial metric observations were made on a skull. These measurements were:

1. Basion to Alare (Ba-Ala)
2. Basion to Medial (Ba-Med)
3. Basion to Lateral (Ba-Lat)

These three measurements were all taken with the standard sliding caliper and were recorded to the nearest whole millimeter. They were restricted, whenever possible, to the left side of the skull.

Non-metrical observations were noted and recorded on each skull for a subjective classification of the depth of the suborbital fossa. These depths were recorded as either none, shallow, medium or deep. There

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*Established by Dr. William M. Bass

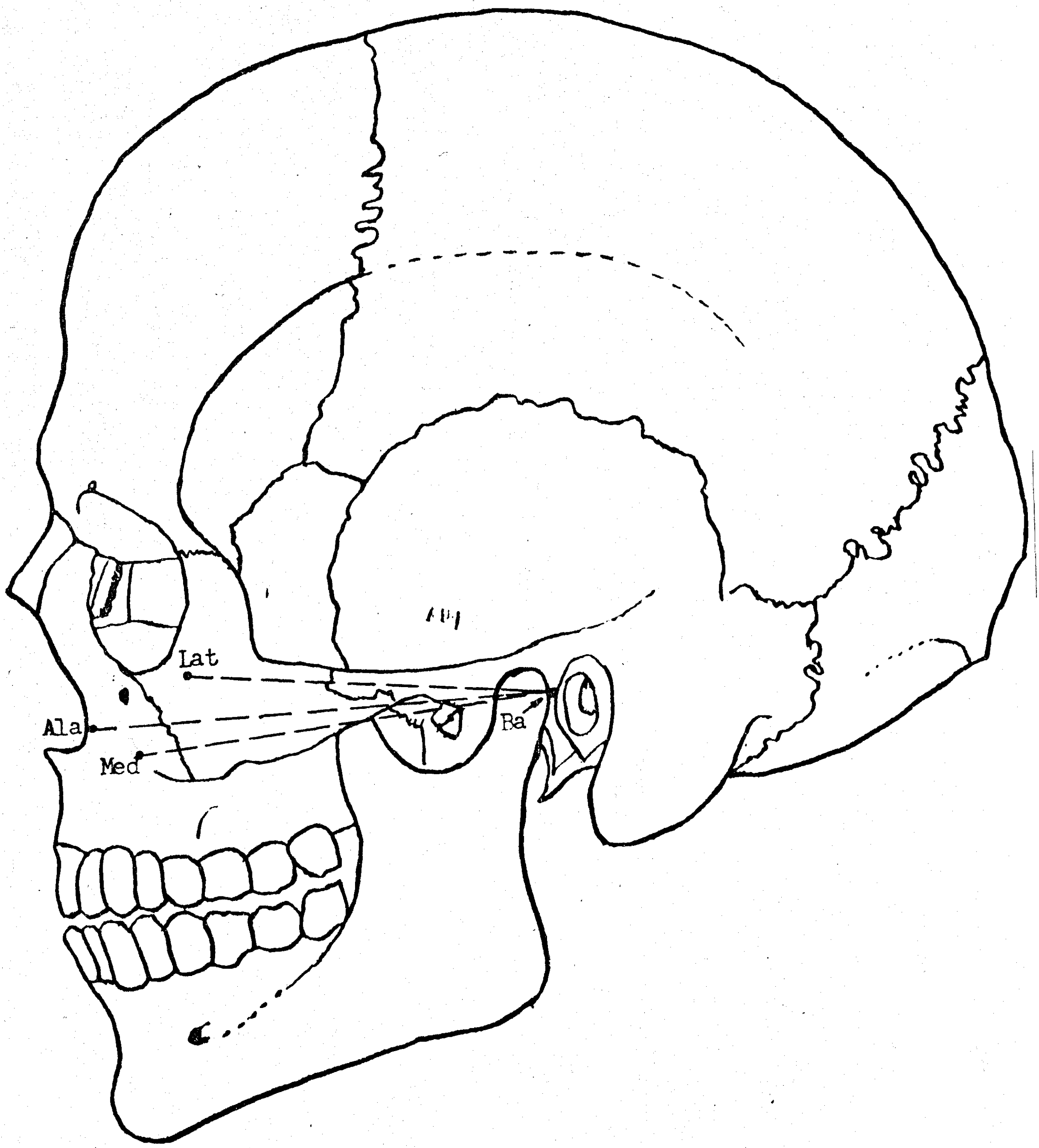

Fig. 3. Lateral view of skull showing the four involved points used in the description and calculation of the depth of the suborbital fossa.

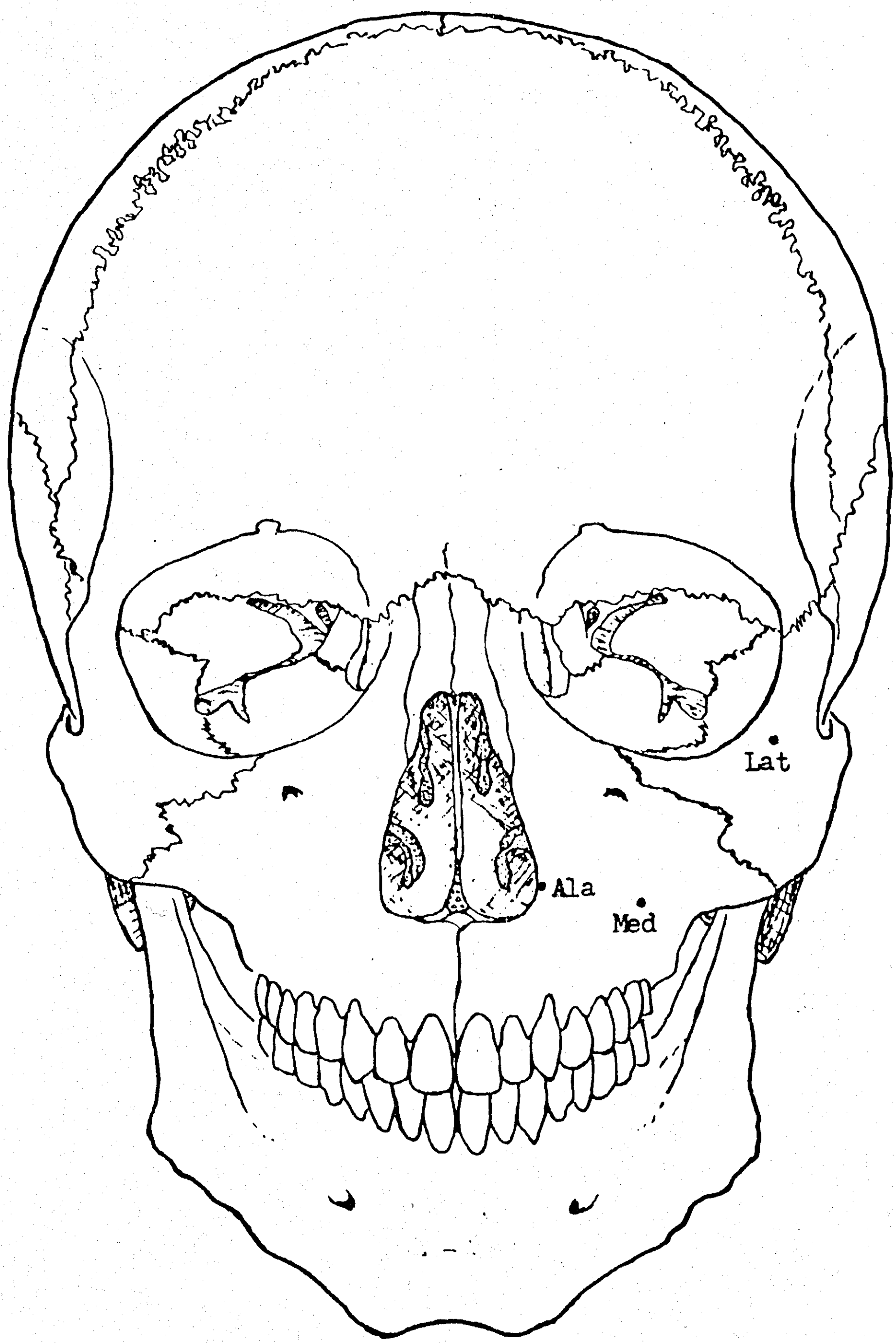

Fig. 4. Frontal view of skull showing the anterior points used in the description and calculation of the depth of the suborbital fossa.

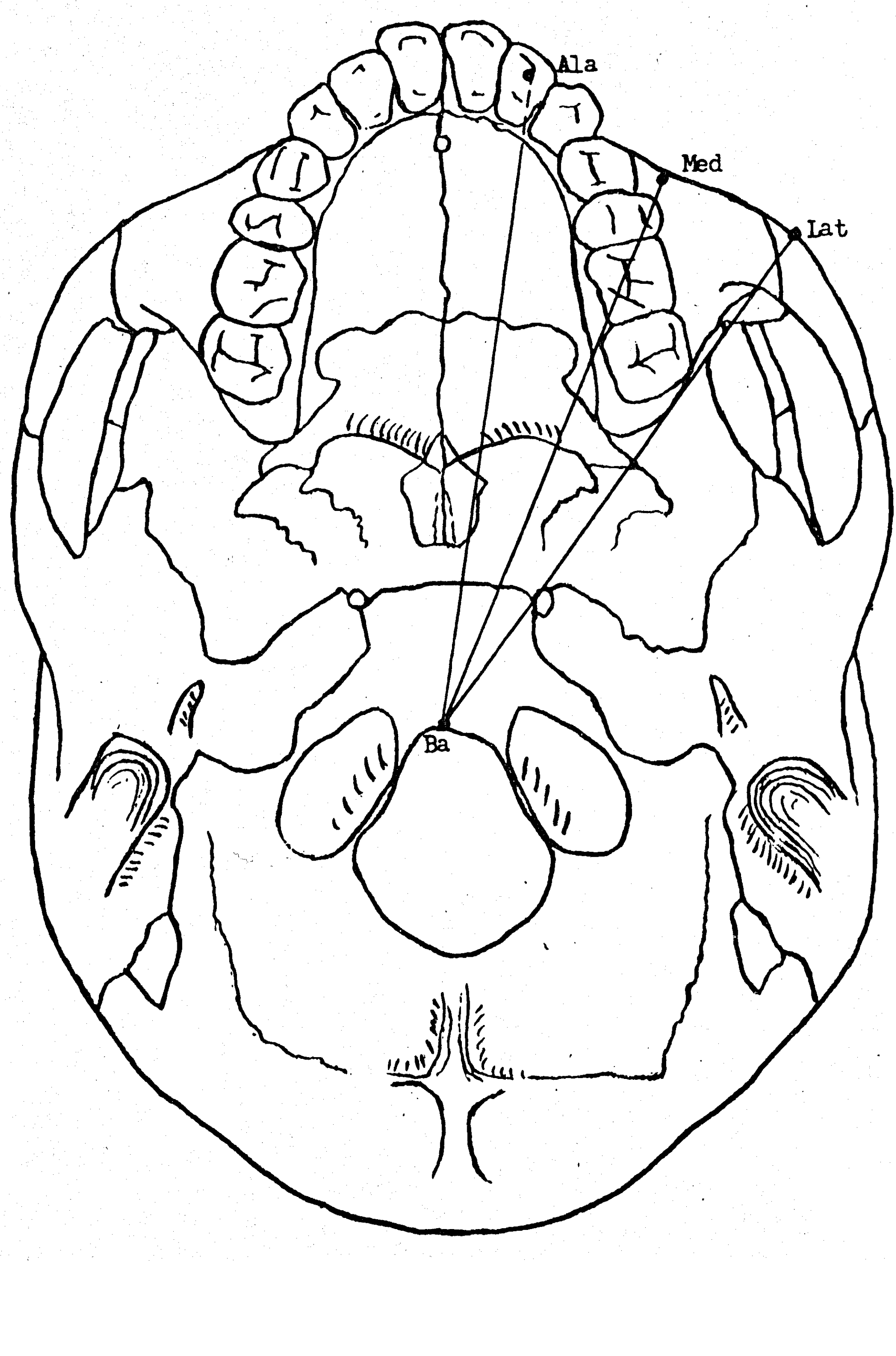

Fig. 5. Basilar view of skull showing the four involved points used in the description and calculation of the depth of the suborbital fossa.

was no consistent pattern in observing the skulls as far as starting or ending with metric or non-metric observations. That is, not all skulls were measured prior to making non-metric observations, nor were all of the skulls given non-metric observations before starting the measurements. The pattern, therefore, was quite variable.

All measurements and observations on the skulls were made by the same person, Dr. William M. Bass. In this way, it was possible to hold to a minimum the individual variation in reading or handling the instruments.

Originally, the three measurements (Ba-Ala, Ba-Med and Ba-Lat) were to establish a plane over the fossa and were also to yield angles as well. However, examination later revealed that not enough information was given to compute angles by trigonometric means. Hence, the original idea of the establishment of a plane over the fossa was abandoned, though the three points (Ala, Med, and Lat) on the anterior of the face were retained. In retaining these three anterior points and their measurements which originate at point Basion, it was possible to establish a mathematical formula which provides data from which the depth of the fossa may be measured and defined. The formula referred to is

$$\frac{(\text{Ba-Ala}) + (\text{Ba-Lat})}{2} - (\text{Ba-Med}) = d$$

where d is the depth in millimeters. This is schematically represented in Fig. 6.

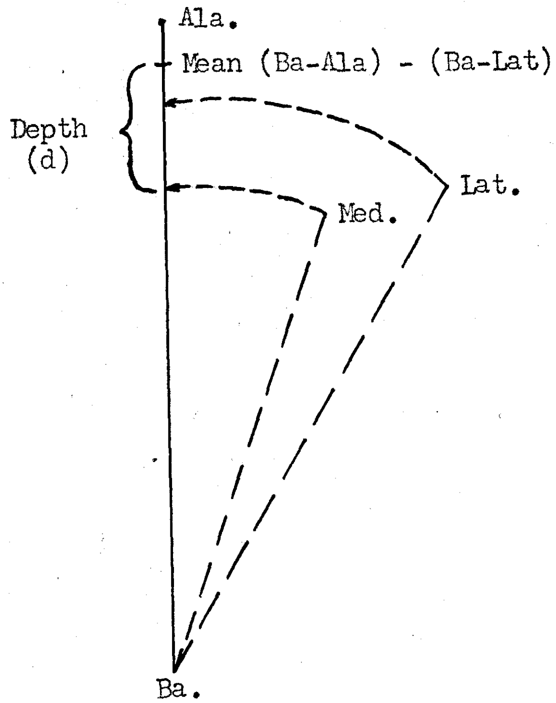

Fig. 6. Schematic representation of the formula $\frac{(Ba\text{-}Ala) + (Ba\text{-}Lat)}{2} - (Ba\text{-}Med)$ to describe depth of the suborbital fossa.

The above formula for depth (d) of the suborbital fossa, since it is definitive, does not take into account sexual dimorphism and the individual variations in size of the skulls themselves. Therefore, it was necessary to devise an <u>index</u> (I) for depth. The index formula is as follows:

$$\text{Index (I)}^{*} = \frac{d}{(Ba\text{-}Ala) + (Ba\text{-}Lat) = (Ba\text{-}Med)} \times 100$$

where d is the depth computed from the first formula

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*Formula established by Dr. Charles Himmelberg, Department of Mathematics, The University of Kansas.

and each parenthetical element of the denominator is a line from point basion to the three anterior points on the skeletal face.

IV. ANALYSIS OF MATERIAL

Initially, it was necessary to determine whether the six cultural groups (Arikara, Central Plains, Pawnee, Mandan, Crow and Hasanlu) could have been drawn from any single population on the basis of their measurements alone, even though they are archaeologically distinct. That is, is each group distinct in its measurements from each of the other five groups -- distinct enough to rule out the possibility that they could all represent random sampling from the same population or universe?

In order to answer that question, an analysis of variance was employed (Table 3) using the measurements for depth of the suborbital fossa (d) calculated from the above formula (p. 15). This offers a method of testing significance of differences between all six group means at once. According to Hagood and Price (1957:382), "it does this by separation of the total variation displayed by the [measurements] into two parts -- the variation arising from the varying of [measurements] around their respective [group] means and variation arising from the varying of [group] means around their 'grand mean' . . .," i.e., a mean of means or the mean of <u>all</u> the individual measurements.

Table 3.--Analysis of variance of the suborbital fossa depth of 160 skulls (93 males and 67 females) obtained from six cultural groups.

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square Variance	F
Total	606.38	159		
Between-group	82.18	5	16.44	4.83
Within-group	524.20	154	3.40	

$P[F_{5,154} = 4.83] \quad .001$

In Table 3, the "sum of squares" (sum of squared deviations) is split into two parts (between- and within-group) which when divided by their respective degrees of freedom, yield two mean square variances. The ratio of the between-group vaiance to the within-group variance is called F. The probability (P) of getting an F ratio of 4.82 based on 5 and 154 degrees of freedom, as shown in Table 3, is less than .001. Stated another way, there is less than one chance in a thousand that the differences exhibited between the six groups and within the six groups could have occurred by chance alone if they were from the same universe.

The groups were next divided into their respective male and female components and tested with the analysis of variance to see what role sex might play in the combined-sex variance of Table 3. These results are shown in Tables 4 and 5 where the male probability of occurrence by random sampling is less than .1 percent while the female probability is not significant since it exceeds the 5 percent level.

Table 4.--Analysis of variance of the suborbital fossa depth of 93 male skulls from six cultural groups.

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square Variance	F
Total	304.31	92		
Between-group	65.15	5	13.03	4.75
Within-group	239.16	87	2.74	

$P[F_{5,87} = 4.75]$ .001

Table 5.--Analysis of variance of the suborbital fossa depth of 63 female skulls from four* cultural groups.

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square Variance	F
Total	256.15	61		
Between-group	26.80	3	8.93	2.26
Within-group	229.35	58	3.95	

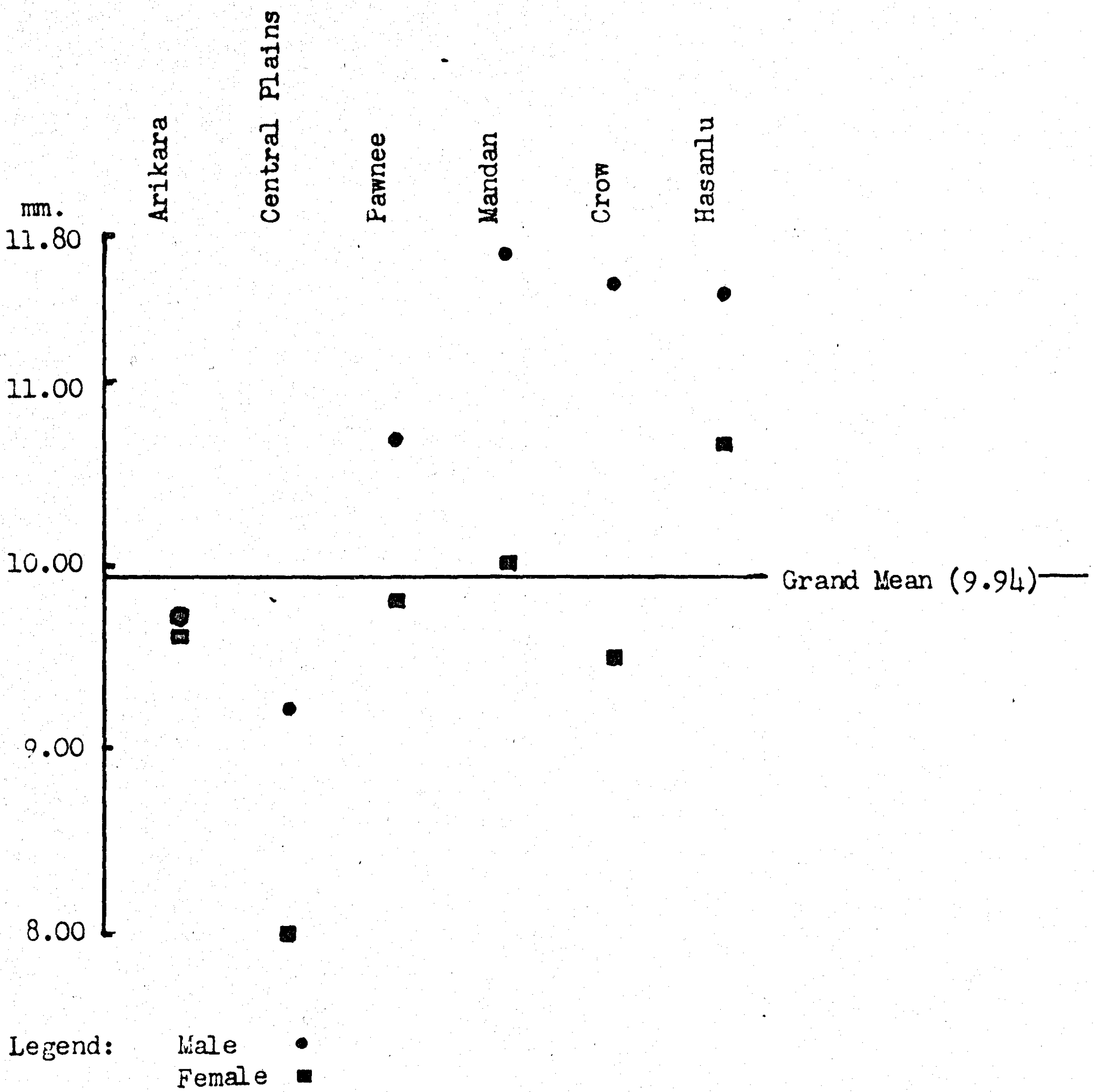
$P[F_{3,58} = 2.26]$ .05

*Crow and Hasanlu not included because of small sample size -- N = 2 and 3 respectively.

Because it cannot be concluded that the female group variations are significantly different from the random variation (Table 5), one might assume that other sources of variation are responsible (Hagood and Price 1957:385-386). While this statement may be true, a logical reason for this occurrence might be due to the smallness of the female group deviations around the grand mean of the sample. This is graphically and numerically illustrated in Figure 7 which shows that the females are more nearly alike than are the males. The total numerical deviation from the grand mean is slightly more than 3 units greater for the males. Diagrammatically, the female variation <u>within</u> groups is not much different from their variation <u>between</u> groups, with the possible exception of the Central Plains sample which varies considerably.

If one can accept the above explanation for the apparent lack of female significance (Table 5), then regardless of the sex, the six groups were not drawn from the same universe. Thus they may be used to test for local or larger racial unit (Garn 1961:14-19) differences in the depth of the suborbital fossa.

One other analysis of variance is necessary before work can commence on the establishment of a metric system of classification for the suborbital fossa depth. This is the analysis of variance of the suborbital fossa index (I) which was formulated on page 16. Even though the six groups have been shown by depth (d) not to be from the same universe (Table 3), the new formula might inadvertantly change them to such an extent when it is applied. However, the index (I) has <u>no</u> deleterious effect on the six groups, as illustrated in Table 6. The probability of occurrence by chance alone for the indices



Group	Male Group Means (in mm.)	Female Group Means (in mm.)	Numerical Deviation from Grand Mean (9.94) Male	Female
Arikara	9.73	9.61	.21	.33
Central Plains	9.23	8.00	.71	1.94
Pawnee	10.70	9.81	.76	.13
Mandan	11.71	10.00	1.77	.06
Crow	11.58	9.50	1.64	.44
Hasanlu	11.50	10.67	1.56	.73
		Total	6.65	3.63

Fig. 7. Male and female group means for depth (d) of suborbital fossa divergence around the grand mean of the samples.

of the six groups is much less than .1 percent and could not have been drawn by random sampling from the same universe.

Table 6.--Analysis of variance of the suborbital fossa index of 160 skulls (93 males, 67 females) obtained from six cultural groups.

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square Variance	F
Total	168.57	159		
Between-group	167.57	5	33.5	5150
Within-group	1.00	154	.0065	

$P[F_{5,154} = 5150]$ .001

Therefore, it is reasonably certain that the index (I), just as the depth (d) already discussed, is valid and may be used to test for local or geographic racial (Garn 1961:14-19) differences, and for sex and age differences in the suborbital fossa. Since the index tends to take into account the variation between sise of the skull measurements due to sexual dimorphism, it is probably the better of the two methods.

The preceding considerations have established that the total sample (N = 160), by depth or by index, has not been drawn from the same population. Therefore, an attempt can now be made to find out if there is any correlation between the depth and index of the suborbital fossa and the degree of the non-metric <u>subjective</u>

classification, i.e., none, shallow, medium or deep as established by visual inspection.

The mean depths and indices of the fossa for males and females, given in Table 7, were computed from the three basic measurements within each degree of subjective classification. It should be noted that for both males and females the depths and indices numerically increase with each increase in the subjective classification. This strongly suggests that there is a correlation between the method of classification and the calculated depth and index. Hence, it is now possible to objectify the subjective classifications. From Table 7, it can also be seen that the greater percentage of both males and females fall within the "shallow" range of classification.

Table 7.--Total male and female mean measurements for each non-metric subjective classification with its corresponding mean suborbital fossa depth and index and the percentage of individuals possessing each classification.

Subjective Classification	Ba-Ala (mm.)	Ba-Med (mm.)	Ba-Lat (mm.)	Depth (mm.)	Index	No.	%
Males (N = 93)							
None	89.78	82.33	91.44	8.28	3.15	9	9.68
Shallow	90.55	81.57	91.09	9.71	3.69	42	45.16
Medium	88.37	78.59	90.78	10.98	4.27	27	29.03
Deep	90.53	79.80	92.07	11.50	4.40	15	16.13
Females (N = 67)							
None	87.80	80.00	88.60	8.20	3.20	5	7.46
Shallow	86.17	78.33	88.17	8.83	3.51	36	53.73
Medium	85.93	76.87	86.93	9.57	3.82	15	22.39
Deep	86.91	75.64	88.91	12.27	4.89	11	16.42

Although the objectification of the subjective classification (Table 7) is a highly desirable characteristic, it is not altogether realistic when the sexes are analyzed by their cultural groups in Tables 8 and 9. The Arikara males and females, and the female Mandan are the only ones which show a progressive increase in the depth and index with increases in the degree of subjective classification.

Table 8.--Male mean measurements by group for each non-metric subjective classification with its corresponding mean suborbital fossa depth and index and the percentage of individuals possessing each classification.

Subjective Classification	Ba-Ala (mm.)	Ba-Med (mm.)	Ba-Lat (mm.)	Depth (mm.)	Index	No.	%
			Arikara (N = 43)				
None	89.00	81.75	91.25	8.38	3.20	4	9.30
Shallow	90.62	82.04	91.75	9.15	3.46	24	55.81
Medium	88.11	79.11	91.22	10.56	4.09	9	20.93
Deep	91.83	80.50	92.67	11.75	4.44	6	13.95
			Central Plains (N = 13)				
None	88.50	80.50	91.00	9.25	3.59	2	15.38
Shallow	91.00	84.28	95.28	8.86	3.30	7	53.85
Medium	87.50	78.75	89.75	9.88	3.86	4	30.77
Deep	---	---	---	---	---	---	---
			Pawnee (N = 17)				
None	89.50	82.50	89.50	7.00	2.67	2	11.76
Shallow	89.50	78.75	91.00	11.50	4.44	4	23.53
Medium	89.40	79.60	91.00	10.60	4.09	5	29.41
Deep	90.17	79.67	91.83	11.33	4.36	6	35.29

Table 8--Continued

Subjective Classification	Ba-Ala (mm.)	Ba-Med (mm.)	Ba-Lat (mm.)	Depth (mm.)	Index	No.	%
Mandan (N = 7)							
None	---	---	---	---	---	---	---
Shallow	99.50	82.50	94.00	11.75	4.34	2	28.57
Medium	93.67	82.33	94.33	11.67	4.32	3	42.86
Deep	87.00	76.50	89.50	11.75	4.65	2	28.57
Crow (N = 6)							
None	---	---	---	---	---	---	---
Shallow	89.00	80.50	98.00	10.50	3.99	2	33.33
Medium	85.67	74.33	88.33	12.67	5.10	3	50.00
Deep	92	83	95	10.50	3.89	1	16.67
Hasanlu (N = 7)							
None	96	88	97	8.5	3.02	1	14.28
Shallow	88.67	75.33	86.00	12.00	4.80	3	42.86
Medium	86.00	75.67	89.33	12.00	4.77	3	42.86
Deep	---	---	---	---	---	---	---

Table 9.--Female mean measurements by group for each non-metric subjective classification with its corresponding mean suborbital fossa depth and index, and the percentage of individuals possessing each classification.

Subjective Classification	Ba-Ala (mm.)	Ba-Med (mm.)	Ba-Lat (mm.)	Depth (mm.)	Index	No.	%
Arikara (N = 31)							
None	84	77	86	8.0	3.24	1	3.22
Shallow	86.13	78.33	87.93	8.70	3.45	15	48.39
Medium	85.22	76.55	86.11	9.11	3.66	9	29.03
Deep	85.83	74.00	88.00	12.92	5.22	6	19.35

Table 9--Continued

Subjective Classification	Ba-Ala (mm.)	Ba-Med (mm.)	Ba-Lat (mm.)	Depth (mm.)	Index	No.	%
Central Plains (N = 10)							
None	88.00	79.50	87.50	8.25	3.23	2	20.00
Shallow	87.67	81.33	90.33	7.67	2.95	6	60.00
Medium	86.50	78.50	88.00	8.75	3.46	2	20.00
Deep	---	---	---	---	---	---	---
Pawnee (N = 8)							
None	---	---	---	---	---	---	---
Shallow	83.00	75.20	85.80	9.20	3.80	5	62.50
Medium	86.00	75.00	86.00	11.00	4.46	2	25.00
Deep	90	80	91	10.5	4.02	1	12.50
Mandan (N = 13)							
None	89.50	82.00	91.00	8.25	3.15	2	15.38
Shallow	86.20	78.60	88.80	8.90	3.53	5	38.46
Medium	88.50	78.50	92.50	11.00	4.28	2	15.38
Deep	87.75	77.00	89.75	11.75	4.63	4	30.77
Crow (N = 2)							
None	---	---	---	---	---	---	---
Shallow	86.50	77.50	87.50	9.50	3.78	2	100.00
Medium	---	---	---	---	---	---	---
Deep	---	---	---	---	---	---	---
Hasanlu (N = 3)							
None	---	---	---	---	---	---	---
Shallow	88.33	77.67	88.33	10.67	4.23	3	100.00
Medium	---	---	---	---	---	---	---
Deep	---	---	---	---	---	---	---

It is apparent from Tables 8 and 9 that while the subjective estimate of depth of the fossa is close to the objective depth, it is still too variable. That is, it depends too much upon the individual observer's classifications which may vary from one day or week to the next. It is also possible that the total facial morphology of the skull may influence the selection of the subjective classification for depth. Thus it is necessary to establish a more reliable objective or metrical system which will give an index range for each of the four degrees of classification.

What is felt to be a more reliable objective system was established in two broad steps.

1. The average numerical distance between the combined male and female means for depth (d), taken from Table 7, was used as the true range limits of depth for each degree of classification. This is graphically illustrated in Figure 8 which shows a depth range in the sample of from 5.0 mm. to 8.76 mm. for the classification "none," 8.77 mm. to 9.77 mm. for the classification "shallow," 9.78 mm. to 11.07 mm. for "medium," and a range of 11.08 mm. to 15.0 mm. for the "deep."

The distribution curves in Fig. 8 show considerable overlap, but the means (also shown in Table 7) are sufficiently separated to establish again the objectification of the subjective classification. The number and percentage of individuals who fall in each classification

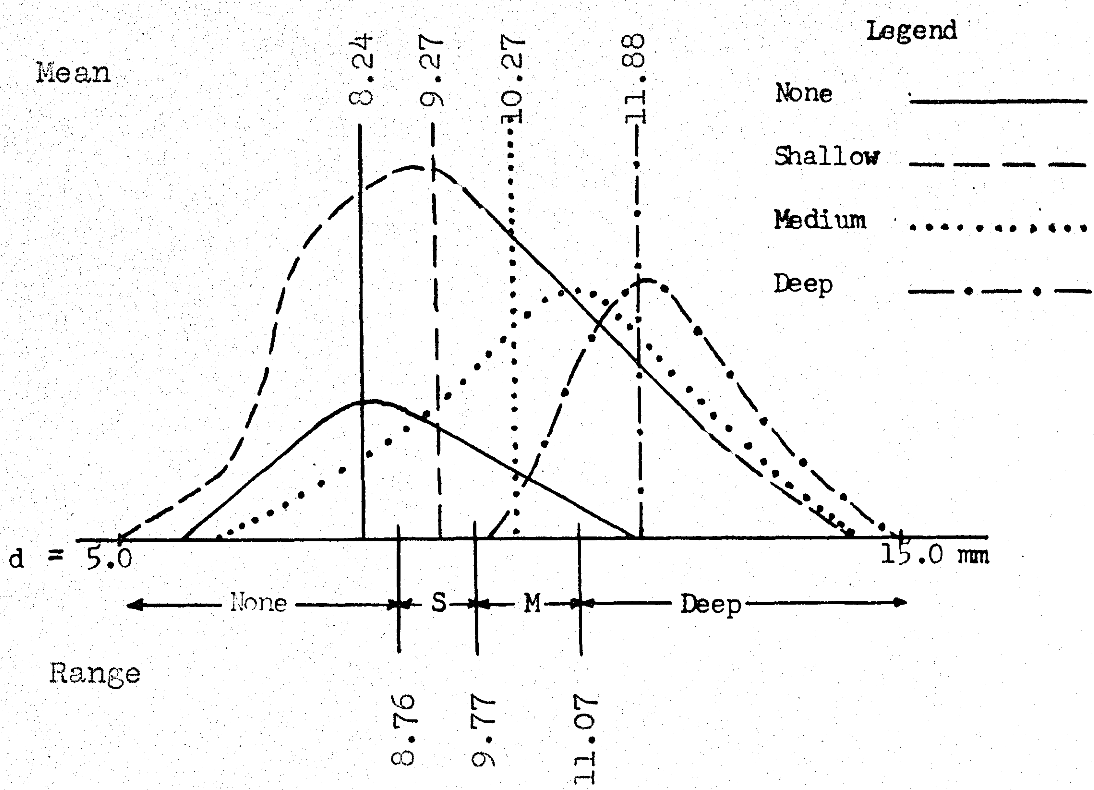


Fig. 8. Subjective classification distribution curves for the suborbital fossa depth (d), their means and the ranges proposed for the objective classification. For both sexes of all groups.

are given in Table 10. It is interesting to note that the prehistoric Central Plains group, which has the highest incidence of occurrence in the category of "none," has almost a 43.5 percent drop between "none" and "deep." It is not known whether this is a significant finding in this study. However, Bass (1961) found in his study of Plains Indians that the Central Plains group appeared to be morphologically different from the Arikara, Pawnee and Mandan (Bass and Birkby 1962:175), particularly in the cranial index, length height index and the mean height index. Table 10 also shows a high rate of incidence (70.0 percent) in the "deep" classification among the Caucasoid Hasanlu group. This may be due to the sample size (N = 10), though it may be attributed to the different racial stock.

Table 10.--Percent of individuals, by cultural group, falling within the established ranges of objective classification for the depth of the suborbital fossa. Based on data from Fig. 8.

Group	None		Shallow		Medium		Deep	
	N	%	N	%	N	%	N	%
Arikara (N = 74)	26	33.78	13	17.57	17	22.97	18	25.60
Central Plains (N = 23)	11	47.83	7	30.43	4	17.39	1	4.35
Pawnee (N = 35)	4	16.00	4	16.00	8	32.00	9	36.00
Mandan (N = 20)	5	25.00	2	10.00	5	25.00	8	40.00
Crow (N = 8)	--	--	2	25.00	2	25.00	4	50.00
Hasanlu (N = 10)	2	20.00	--	--	1	10.00	7	70.00
Total	48	30.00	28	17.50	37	23.12	47	29.38

2. The average numerical distance between the combined male and female means for the index (I) taken from Table 7, was used as the true range limits of the index for each degree of classification. Thus, as shown in Fig. 9, the index range for the sample runs from 2.22 units to 3.40 units in the classification of "none," 3.41 units to 3.82 units for "shallow," 3.83 to 4.34

units for "medium," and 4.35 to 5.99 units for the objective classification of "deep." The distribution curves in Fig. 9, just as in Fig. 8, show considerable overlap, though the means are sufficiently separated. The number and percentage of individuals who fall in each objective category of classification are given in Table 11. Just as in the previous table, the prehistoric Central Plains group has the highest occurrence (56.5 percent) in the classification of "none" and steadily decreases by almost 46 percent at the "deep" category. The Hasanlu Caucasoid group remains numerically unchanged from Table 10.

Table 11.--Percent of individuals, by cultural group, falling within the established ranges of objective classification for the index of the suborbital fossa. Based on data from Fig. 9.

Group	None		Shallow		Medium		Deep	
	N	%	N	%	N	%	N	%
Arikara (N = 74)	26	35.1	15	20.3	17	23.0	16	21.6
Central Plains (N = 23)	13	56.5	5	21.7	3	13.0	2	8.7
Pawnee (N = 25)	4	16.0	3	12.0	9	36.0	9	36.0
Mandan (N = 20)	4	20.0	3	15.0	4	20.0	9	45.0
Crow (N = 8)	--	--	3	37.5	1	12.5	4	50.0
Hasanlu (N = 10)	2	20.0	--	--	1	10.0	7	70.0
Total	47	29.38	29	18.13	35	21.87	47	29.38

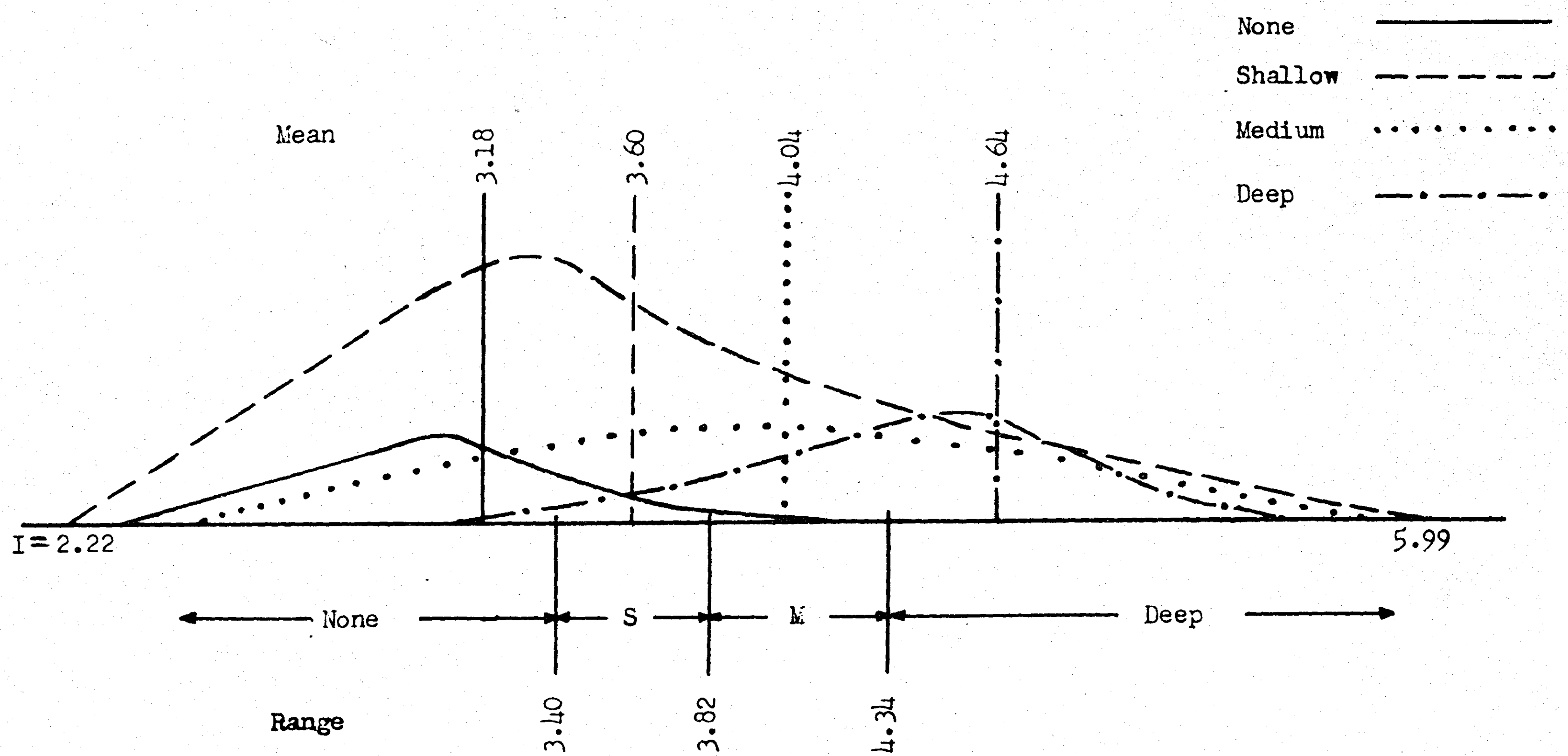


Fig. 9. Subjective classification distribution curves for the suborbital fossa index (I), their means, and the ranges proposed for the objective classification. For both sexes of all groups.

The index (I) value of each individual was then plotted and classified in accordance with the objective classification ranges established in Fig. 9. The results of this regrouping of the indices into their proper objective classification are shown for each sex in Table 12. Here, as in Table 7, there are progressive numerical increases in the depth and the index as the degrees of classification increase from "none" to "deep." The percentage of individuals possessing each degree of classification, when compared with Table 7, has been moderated to the extent that no one classification is excessively predominant over the others. The depths of the fossa in Table 12 also show a wider separation from one classification to the next.

Table 12.--Mean male and female measurements, depths and indices of the suborbital fossa arranged according to the suggested classification range established from Fig. 9.

Objective Classification	Ba-Ala (mm.)	Ba-Med (mm.)	Ba-Lat (mm.)	Depth (mm.)	Index	No.	%
Males (N = 93)							
None	91.04	84.13	92.91	7.85	2.93	23	24.73
Shallow	90.12	81.62	91.37	9.44	3.58	16	17.20
Medium	90.04	80.42	92.04	10.62	4.05	24	25.81
Deep	88.60	77.17	90.06	12.17	4.76	30	32.26
Females (N = 67)							
None	86.42	79.73	88.19	7.58	2.98	26	38.80
Shallow	85.92	78.15	88.31	8.96	3.55	13	19.40
Medium	86.36	76.73	88.00	10.45	4.16	11	16.42
Deep	86.59	74.82	87.65	12.29	4.94	17	25.37

Tables 13 and 14 are a break-down of Table 12 into its component cultural groups. The index (I) values of the individuals in each group were plotted and classified according to the objective classification ranges established in Fig. 9. For each group there are progressive numerical increases in the means of the depth and index as the degrees of classification increase -- there being no exceptions. This differs considerably from the findings for each group in Tables 8 and 9 where the means of the indices and depths were ranged by <u>subjective</u> classification. There, only a minority of the groups showed increases in the depth and index as the degrees of classification increased.

Table 13.--Mean male measurements, depths and indices of the suborbital fossa for each group, arranged according to the suggested classification range established from Fig. 9.

Objective Classification	Ba-Ala (mm.)	Ba-Med (mm.)	Ba-Lat (mm.)	Depth (mm.)	Index	No.	%
Arikara (N = 43)							
None	90.07	82.93	91.57	7.89	2.98	14	32.56
Shallow	90.89	82.11	92.44	9.55	3.60	9	20.93
Medium	90.58	80.92	92.58	10.66	4.04	12	27.90
Deep	88.62	77.50	89.87	11.75	4.59	8	18.60
Central Plains (N = 13)							
None	93.00	86.83	96.50	7.92	2.87	6	46.15
Shallow	83.67	76.33	87.00	9.00	3.64	3	23.08
Medium	90.50	81.00	93.50	11.00	4.15	2	15.38
Deep	87.00	77.00	90.50	11.75	4.61	2	15.38

Table 13--Continued

Objective Classification	Ba-Ala (mm.)	Ba-Med (mm.)	Ba-Lat (mm.)	Depth (mm.)	Index	No.	%
Pawnee (N = 17)							
None	89.50	82.50	89.50	7.00	2.66	2	11.76
Shallow	96.00	87.00	97.50	9.75	3.47	2	11.76
Medium	89.67	79.50	90.33	10.50	4.04	6	35.29
Deep	88.00	77.14	90.43	12.07=	4.73	7	41.18
Mandan (N = 7)							
None	---	---	---	---	---	---	---
Shallow	94	84	93	9.5	3.51	1	14.28
Medium	90.00	80.50	92.00	10.5	4.01	2	28.57
Deep	92.50	80.00	93.25	12.87	4.85	4	57.14
Crow (N = 6)							
None	---	---	---	---	---	---	---
Shallow	87	80	91	9.0	3.49	1	16.67
Medium	92	83	95	10.5	3.89	1	16.67
Deep	87.00	76.00	90.00	12.5	4.94	4	66.67
Hasanlu (N = 7)							
None	96	88	97	8.5	3.02	1	14.28
Shallow	---	---	---	---	---	---	---
Medium	83	76	90	10.5	4.22	1	14.28
Deep	88.20	75.40	87.20	12.30	4.90	5	71.43

Table 14.--Mean female measurements, depths and indices of the suborbital fossa for each group, arranged according to the suggested classification range established from Fig. 9.

Objective Classification	Ba-Ala (mm.)	Ba-Med (mm.)	Ba-Lat (mm.)	Depth (mm.)	Index	No.	%
Arikara (N = 31)							
None	85.08	78.42	86.92	7.58	3.03	12	38.71
Shallow	85.33	77.33	86.83	8.75	3.51	6	19.35

Table 14--Continued

Objective Classification	Ba-Ala (mm.)	Ba-Med (mm.)	Ba-Lat (mm.)	Depth (mm.)	Index	No.	%
Medium	84.20	75.20	87.20	10.50	4.26	5	16.13
Deep	88.00	75.50	88.50	12.75	5.07	8	25.81
Central Plains (N = 10)							
None	87.14	80.43	88.57	7.43	2.90	7	70.00
Shallow	88.50	81.50	92.50	9.00	3.43	2	20.00
Medium	88	78	88	10.0	3.94	1	10.00
Deep	---	---	---	---	---	---	---
Pawnee (N = 8)							
None	85.50	79.50	89.50	8.00	3.14	2	25.00
Shallow	83	76	87	9.0	3.66	1	12.50
Medium	86.00	76.00	86.33	10.17	4.09	3	37.50
Deep	82.50	71.50	88.50	11.50	4.89	2	25.00
Mandan (N = 13)							
None	88.50	81.50	90.00	7.75	2.98	4	30.77
Shallow	86.00	79.00	90.00	9.00	3.53	2	15.38
Medium	91.50	81.00	92.50	11.00	4.15	2	15.38
Deep	85.80	75.20	88.20	11.80	4.74	5	38.46
Crow (N = 2)							
None	---	---	---	---	---	---	---
Shallow	86.50	77.50	87.50	9.50	3.77	2	100.00
Medium	---	---	---	---	---	---	---
Deep	---	---	---	---	---	---	---
Hasanlu (N = 3)							
None	91	84	91	7.0	2.63	1	33.33
Shallow	---	---	---	---	---	---	---
Medium	---	---	---	---	---	---	---
Deep	87.00	74.50	87.00	12.5	5.03	2	66.67

There does not appear to be much difference between the sexes as far as the depths and indices are concerned. This is borne out in Table 12 and in the distribution curves of Figs. 10 and 11. The slight differences which are shown may be due to the sample number of each sex, the males being greater in number (N = 93, females N = 67).

There appears to be no sex differences in the depth or the index for each cultural group given in Tables 13 and 14. The slight variations which do occur are erratic, i.e., the males may have a numerically greater depth of index in one degree of objective classification while the females of the <u>same</u> group exhibit a greater depth or index in another degree of the objective classification. There appears to be no group differences in these two tables, even when the sexes are combined. Again, as in Table 12, the variations are erratic. Tables 7, 8 and 9 are equally fruitless in the establishment of sex or group differences in a <u>subjective</u> classification.

The means of the three basic measurements, from which depths and the indices were established, are summarized in Table 15. The means of the three basic measurements do not show much variation between the six groups. The difference between the mean low (87.50 mm.) and mean high (89.10 mm.) of the Basion-Alare measurement is only 1.60 mm.; that between the mean low (77.40 mm.)

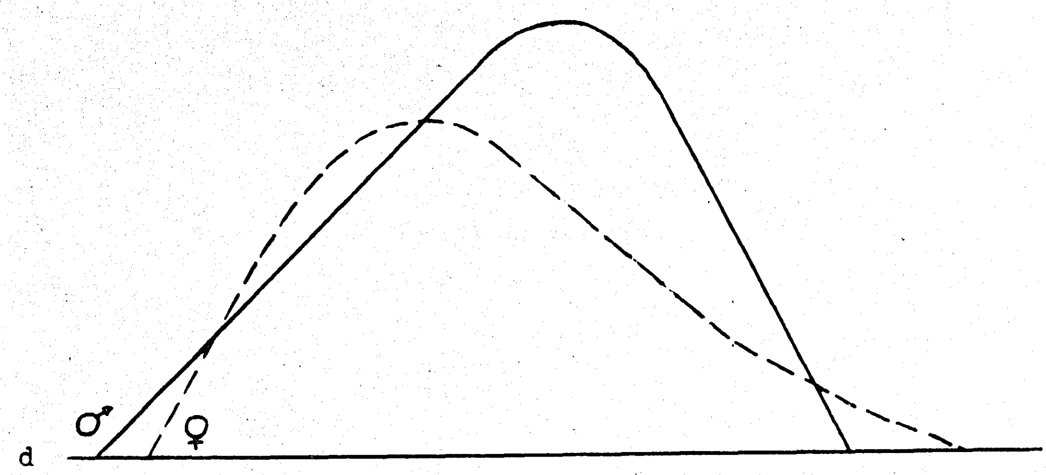


Fig. 10. Sex distribution curves plotted from the suborbital fossa depth (d).

Table 15.--Group means and range in millimeters of the three basic measurements from point basion to the anterior of the skeletal face.

Group	Ba-Ala			Ba-Med			Ba-Lat		
	Low	High	Mean	Low	High	Mean	Low	High	Mean
Arikara (N = 74)	79	99	88.28	68	88	79.40	79	100	89.89
Central Plains (N = 23)	80	98	88.65	75	92	81.30	83	100	91.35
Pawnee (N = 25)	80	99	88.08	70	90	78.48	81	101	89.64
Mandan (N = 20)	83	96	89.10	72	84	79.35	86	97	90.80
Crow (N = 8)	82	92	87.50	74	83	77.75	84	95	90.12
Hasanlu (N = 10)	83	96	88.50	72	88	77.40	82	97	88.80
Mean Range			87.50-89.10			77.40-81.30			88.80-91.35

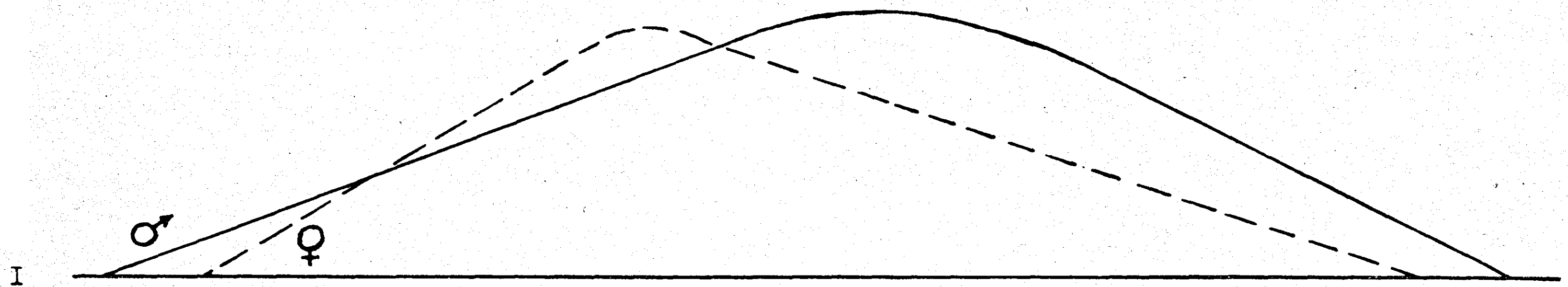


Fig. 11. Sex distribution curves plotted from the suborbital fossa index (I).

and high (81.30 mm.) of the Basion-Medial measurement is 3.90 mm.; and the Basion-Lateral measurement differs between its mean low (88.80 mm.) and high (91.35 mm.) by 2.55 mm. Metrically, these are very small differences. Measurements, for comparative purposes, on any two individuals from any of the six groups could easily vary by the above amounts.

The age of an individual has no bearing on the index (and consequently, the depth) of the suborbital fossa. This is shown by the scattergram in Fig. 12 where the mean skeletal age of each individual was plotted against his index. The plotted points show a random patterning, and it can be reasonably concluded from this fact that the fossae do not increase in depth with advancing years after young adulthood.

Tooth-loss, though not shown in the body of this paper, appears on gross examination to have no correlation when compared with the subjective and objective degrees of classification. Completely edentulous individuals have degrees of classification ranging from "none" to "deep," just as do those individuals with complete dentitions.

V. CONCLUSIONS

On the basis of this study, it has been shown for the first time that there is a metrical justification for the subjective classification of the depth of the suborbital fossa.

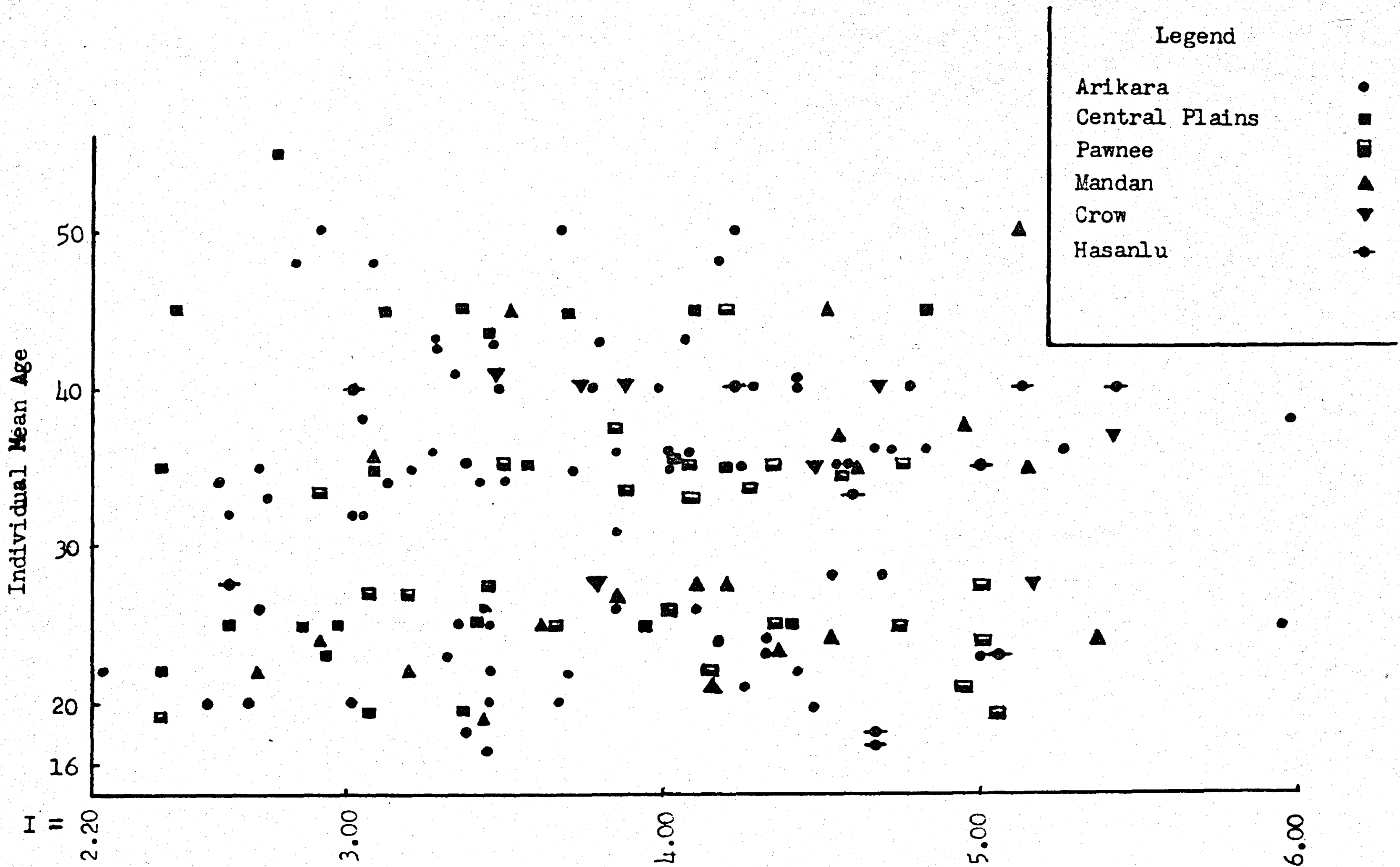


Fig. 12. Scattergram of individual mean age plotted against the index (I) of the suborbital fossa.

It was possible on the basis of this metrical analysis to establish four degrees of objective classification ranges for the depth of the fossa and its indices. They are as follows:

Classification	Depth	Index
None	x - 8.76 mm.	x - 3.40
Shallow	8.77 - 9.77 mm.	3.41 - 3.82
Medium	9.78 - 11.07 mm.	3.83 - 4.34
Deep	11.08 - x mm.	4.35 - x

The measurements, depths, indices and classifications were used to determine if there were any differences in the depth of the fossae of the six groups studied. It was found that there were no significant differences in the depths of the fossa within or between any of the groups with regard to sex, age or geographical areas of habitation.

Therefore, from these findings it would not be possible to use the suborbital fossa depth as a criterion in the establishment of sex, age or local and geographic racial units in unknown skeletal material. This does not rule out the possibilities that (1) there may be measureable areas of the fossa, other than those given herin, which would show these differences and (2) the measureable areas used in this study might show geographical or local racial unit differences if the sample had not been limited by the material available to the five Plains Indian groups and one Middle Eastern Caucasoid group.

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