DISCRIMINANT ANALYSIS OF ROCKER JAW FROM MOKAPU, OAHU

DISCRIMINANT ANALYSIS OF ROCKER JAWS

FROM

MOKAPU, OAHU

By

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ABSTRACT

The major emphasis of the thesis is a study of a particular morpholcgical feature of the mandible known as "rocker jaw". The trait is a characteristic of Hawaiian populations. The framework of the study is the multivariate analysis of the characteristic to determine whether there are associated physical characteristics on the mandible. Also included is a discussion of the social activity of the people, as evidenced by their skeletal remains. A high development of "squatting" facets in the ankle, tibial, and pelvic joints indicate that the individuals spent a good portion of their lives in positions in which the knees were bent. Social and cultural data re-iterate the popularity of the squatting position while at work, eating, and leisure.

Comparative data include Tongan, Easter Island, Eskimo, and Indian (North American). It is concluded, from a comparison of the frequency of rocker jaw, that this trait, in all probability, is predominant in Polynesia and appears to be an isolated genetic trait. The diets of the four comparative populations do not appeat to lend any evidence that the trait is a functional development due to hard foodstuffs and/or chewing habits. There is no evidence that the trait is pathological.

Statistical results show that the rocker jaw does not have any related characteristics on the mandible. The only significant characteristics are the heights of the corpus at the molar and premolar levels. These characteristics are necessarily the only points of rocker jaw determination for visual observation. Thus, the rocker jaw appears to be an independent characteristic of the jaw.

The best predictors of sex on the mandible, as computed by this study, were the length of the mandible andthe molar-premolar chord. These two characteristics were found to have the highest F-ratios (i.e. the most significant) of the sixteen characteristics (or variables) utilized.

The major emphasis of the thesis was a statistical study of the rocker jaw through the use of multivariate analysis. The study concludes with the statement that the rocker jaw has no related characteristics on the mandible (of those measured). It appears that the rocker jaw which has attained a high incidence in certain Polynesian populations, is probably due to genetic drift occurring in small isolated populations.

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SCOPE AND CONTENTS:

The discriminant analysis of Hawaiian mandibles from Mokapu, Oahu to determine any relative characteristics of the Rocker Jaw to both metrical and non-metrical features. The study also attempts to define the social activity of the Mokapu population as it is evidenced by their physical characteristics. Other physical traits examined by this study were squatting facets and the generalized robustness of the individuals. These traits seemed to emphasize the strenuous physical activity of these people and popularity of squatting position while working, eating, and leisure.

Comparative data included within the study were mostly Polynesian because it is in this Pacific Area which the Rocker Jaw predominates, as this study shows. The only exception was the Eskimo and Indian material studied by Oschinsky.

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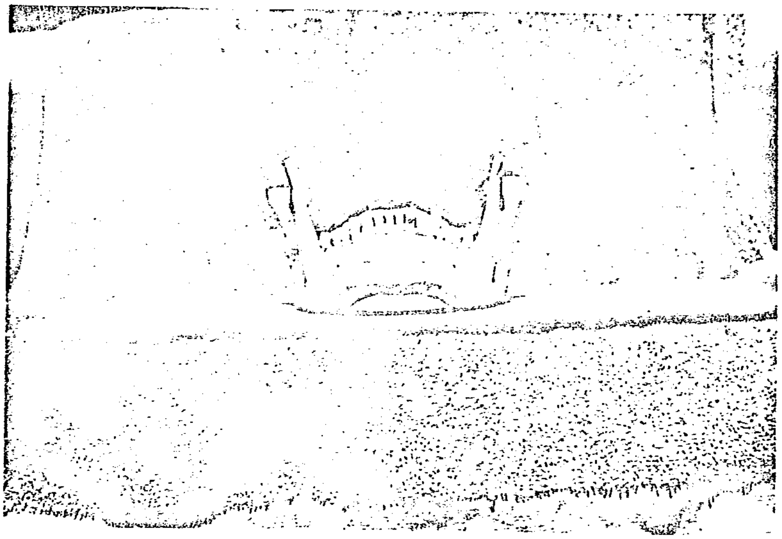
INTRODUCTION

The rocker jaw is characterized by having a rounded bottom (see Photo I). When the mandible is placed on a standard horizontal plane, this trait causes it to rock posteriorly and anteriorly, because, contrary to normal mandibles described in standard anatomy books, the rocker jaw rests on only two points of support; each being a point on the lower border of the corpus. A normal mandible, having three or four points of contact with the standard horizontal plane (see Figure IA), obviously, does not have this "rocking" ability.

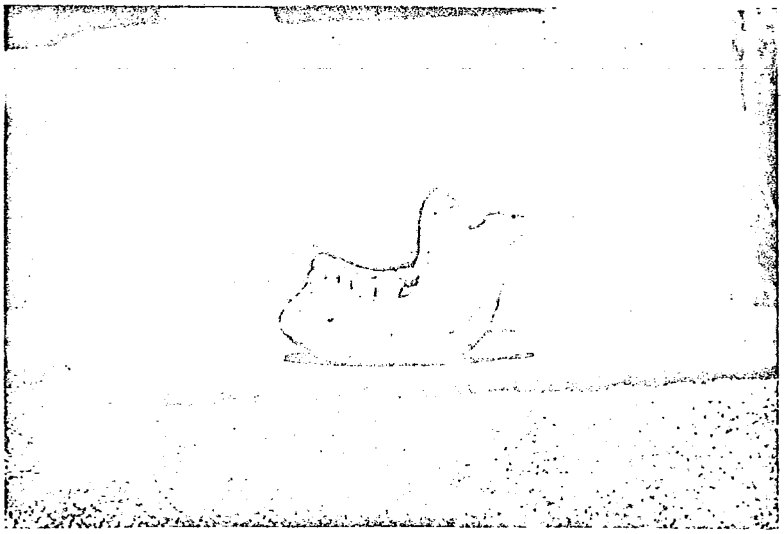
Osteological studies concerning the rocker jaw have been limited to only descriptive statements, at best (see: Murrill: 1968, Oschinsky: 1964; 73 and Pietrusewsky; 1969; 307), because they occur in very small frequencies in most skeletal populations. An exception is the Polynesian remains, specifically those studied by Snow during the years 1955-1957, of the Mokapu skeletal population. In his report, presently in press, Snow reported the frequency of rocker jaw to be 71% in the females and 88% in the males.

The objective of this study is to determine, by use of statistical analysis, the development of the rocker jaw and also to reveal any related characteristics of this trait.

Photograph I



Rocker Jaw - Frontal Aspect



Rocker Jaw - Lateral Aspect

Through the use of stepwise discriminant analysis of metrical and non-metrical data, a descriptive and comparative correlations of the trait with age groups, sex, and the presence of rocker jaw, will be used in the attempt to formulate a valid conclusion.

This study will also explore the possibility that diet and chewing habits may have an effect upon the trait. This will be done in the comparison of populations with frequencies of rocker jaws.

The high incidence of rocker jaw among the Polynesian populations has yet to be studied in a detailed and scientific manner. By this study, I hope to be able to make a valid contribution to the problem in this area of anthropology.

HISTORY OF THE MOKAPU SITE EXCAVATION

Located on the eastern coast of the island of Oahu (see Map 1), the Mokapu site was first excavated in 1932 when Edwin H. Bryan, Jr., of the Bishop Museum was notified of the presence of skeletal material in that area.

In 1937, a resident of the area brought a "story of bones" (Snow, in press) to the museum. Dr. Kenneth P. Emory of the Bishop Museum, found, on investigation, that there existed evidence of an extensive burial place. Together with Dr. Gordon T. Bowles, then teaching at the University of Hawaii, Dr. Emory directed many excavation parties at Mokapu. Thus the collection continued and grew.

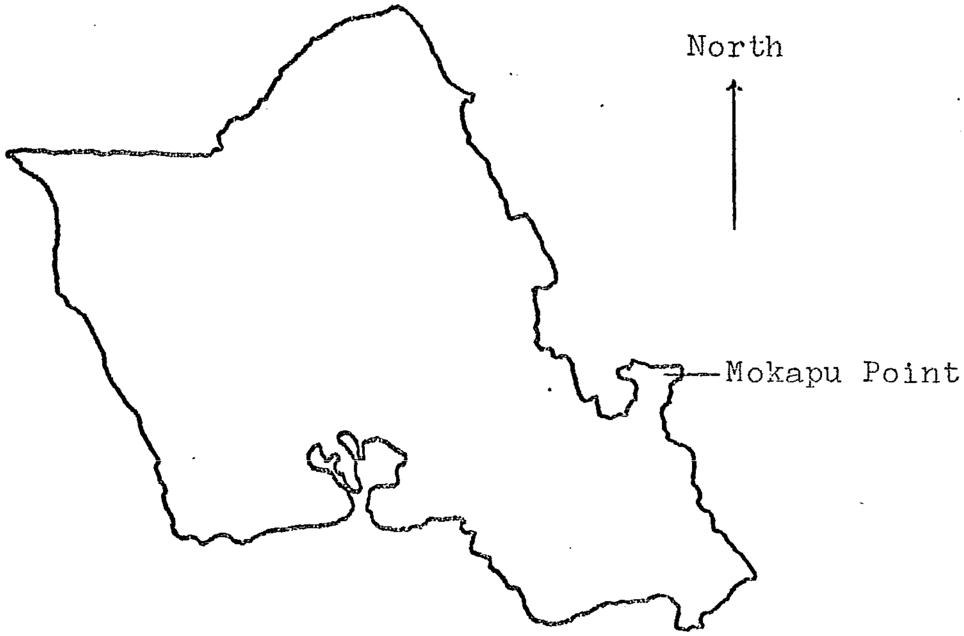
Organized excavation ended with the outbreak of World War II and the subsequent building of the airstrip at Kaneohe Marine Base. But the collection continued to progress as interested individuals with access to the area brought in material unearthed by the bulldozers which leveled some of the sand dunes.

Further excavation initiated with Dr. Charles E. Snow of the University of Kentucky. This excavation started in September 1951 and continued until April 1952, it was then resumed for the summer of 1955 and was completed after a year in 1956-1957.

An additional 139 individuals were excavated from the site in the spring of 1957 by R. N. Bowen.

Map 1

Island of Oahu



The present collection at the Bishop Museum consists of 1504 individuals ranging from foetuses to old adults. Evidence suggests that many more burials remain in the area (Snow, 1957:8).

THE PEOPLE OF MOKAPU PENINSULA

The vast amount of skeletal material collected and the ruins of a Hawaiian billage andtemple area give substantial proff that the Mokapu peninsula was once heavily populated.

There exists evidence that the excavation site comprised a series of beach sections which probably represented family plot divisions of land. These plots were the basic dividions of land in the Hawaiian land system.

The _ahupuaa_ (land district) was the basic unit of land of the larger estate of the chiefs. Though its confines were extremely variable in size, the _ahupuaa_ was generally pie-shaped with its apex initiating in the middle of the island and the two boundaries extending into the sea. These physical boundaries usually consisted of a combination of ridges, streams or gulches. Within its area were usually a sea fishery, a stretch of open cultivable land suitable for the growing of taro and yams, and forest land (Snow: in press). Thus, due to its variation in physical geopgraphy, the people of the _ahupuaa_ were able to support themselves off the products of the land. Mokapu peninsula lies within the areas of three _ahupuaas_.

Ilis were the next smallest subdivisions of land.

These areas were delegated out by the Konohiki (chief steward) who, by doing so, subdivided the ahupuaa. Mokapu peninsula was subdivided into six sections. Snow (in press) states that it appears reasonable to regard these areas as family divisions of the land, with the sand dunes along the sea coast used as a burial place. Thus, evidence suggests that the Mokapu peninsula comprised of six ilis which were, in turn, within the area of three ahupuaas.

Certain physical characteristics may reflect the activity and habits of some populations, Snow in his study describes these characteristics.

The fact that males had larger-than-usual brow ridges and glabellas, and had deep nasal-root depressions were results of the custom of head-shaping. The binding of the moldable heads of infants were evident in many individuals of all ages. The effects of this social custom were a broad and high vault. This flattening was probably reinforced by sleeping on the back with the head resting on a hard surface. (Snow: in press)

Squatting appeared to be a popular position, as evidenced by the tilt of the tibial plateau which reflects the possibility that the knees were habitually bent. Squatting facets on the hip, knee, and ankle joints give evidence that these people squatted with their feet flat on the ground.

Pukui, in Snow's study, states that there were terms for the many positions of squatting. In the _'oku'u_ position the individual squatted with knees apart to facilitate working the soil. This was also an eating position for those trained in the art of '_lua_' fighting, which made springing to the feet much easier and quicker. The _ki'elelei_ position was with the knees closer together in order to facilitate working the soil with short digging sticks. (Snow: in press)

The physical evidence suggests that most of the social activity of these people were carried out in a squatting or kneeling position.

The few bones that were broken during life were found to be perfectly healed and set (Snow: in press). This suggests an adequate knowledge of medicine by the _kahunas_ (doctors).

The physical anthropology of these people reflects their social life style, to a certain extent and coupled with their social anthropology, the Mokapu population was a representative Polynesian society.

Flourine analysis carried out at the University of Kentucky on revelant material dates the sample at 200-800 years B.P. or prior to European contact. The wide range of 600 years, coupled with the relatively small population size indicates caution in the interpretation of the results. No information is available on possible changes in the frequency of the trait through time within the area.

THE MOKAPU SAMPLE

The Mokapu sample, presently catalogued at the Bishop Museum, totals 1504 individuals ranging from foetuses to old adults. Its description follows:

Size of Sample:	1504	
Number of adults:	1171	(77.0%)
Number of sub-adults:	333	(23.0%)

Average adult age at death:	30.5 years
Average adult age of females:	29.0 "
Average adult age of males:	32.0 "

The lack of European trade objects associated with the excavation indicates that this population lived on Oahu before contact with the white man, that is, before the arrival of Captain Cook in 1778 (Snow: in press). Flourine analysis on revelant material dates the sample at 200-800 years ago or before European contact.

The fact that the Mokapu sample is a statistically representative one can be ascertained by its large population and its geographic isolation. As Snow stated:

> "These Hawaiians were a remarkable homogeneous group, as would be expected in view of their geographic isolation. This fact has been established by many measure of variability. They were in many ways quite similar in body build to typical American whites. Men stood five feet seven inches tall and women five feet three inches, virtually identical to living Hawaiians measured in 1920 by Sullivan (1927). To be sure, there was a range of variation as there is today in the

typical American population, and there were some unusual deviants in size and appearance." (Snow: in press)

The sample contained 191 complete mandibles. With each of these mandibles, it was possible to carry out all the measurements required for the study. Thus, the data consisted of complete sets of measurements for each individual.

The preliminary data was:

Total number of mandibles:		191
Total number of adults:		173 (90.6%)
Females:	96 (56.5%)	
Males:	77 (44.5%)	
Total number of sub-adults:		18 (9.4%)
Females:	9 (50%)	
Males:	5 (36%)	
Unknown:	4 (14%)	

Sub-adults were not entered into the calculation for two reasons. First, since their metrical characteristics had significantly smaller values than the adults, introduction of them into the claculation would affect the means, standard deviations, F-values, and, ultimately, the discriminant function score. Secondly, I had observed only one positive rocker among the 18 individuals, which contrasts greatly with the frequency among the adults. This low frequency may be due to either the possibility that the rocker jaw developes after puberty or that the sample size is too small to be valid. Hence, it was decided that better results would occur if the sub-adults were deleted from the calculation.

The frequencies of rocker and non-rocker jaws in males and females were:

Total number of adults:		173
Total number of rocker jaws:		127 (73.4%)
Males:	48 (37.4%)	
Females:	79 (62.2%)	
Total number of non-rocker jaws:		46 (26.6%)
Males:	29 (63.0%)	
Females:	17 (37.0%)	

AGE AND SEX DETERMINATION

AGE

The age and sex of each individual catalogued was determined by Snow. This study has utilized his determinations because it was made in a more complete manner (i.e. using the entire skeleton or what remained) than assessment by the mandible and dentition only.

Snow utilized known age factors observed in normal growth of modern Americans for his criteria of age determination. These markers included dentition (i.e. deciduous or permanent, and wear on the dentition), the size and development of all bones, with emphasis on the skull, spine, limb, shoulder and pelvic girdles. In adults, the completion of the growth pattern after the rapid growth and development of adolescence, and the subsequent degenerative processes were also considered.

Infants' ages were based on tooth formation (calcification) and eruption of the deciduous teeth. The relative size of the major limb bones, the stages of fontanelle ossification, and the degree of union of the chin symphysis were used to classify the ages up to about two years (Snow: in press). Older childrens' ages were based according to the size and development of the major long bones and the degree of wear on the deciduous dentition.

Children between six and twelve years were classed according by the sequence of eruption of the permanent dentition, wear on the deciduous dentition, the stage of epiphyses of the long bones and the corresponding size and development of the major bones.

Teen-agers were assessed by the presence of all teeth except the third molar (M_3). The epiphyses begin to unite with the shafts of the bones, and final growth of all the long bones except the clavicle, the sternum, vertebral bodies, and the hip bones is complete at approximately twenty years of age (Snow: in press).

Besides the markers mentioned previously, adult age was determined by the eruption of the third molar, the union of the sternal epiphysis on the clavicle was used to determine the age of individuals twenty-six years or older. Pubic symphysis was considered as the best criterion of all, concerning this age group.

Arthritic degeneration of joint tissue as well as exostoses (extra bone growth) in the spine are old age assessments. These were coupled with the corresponding degenerative changes in the scapulae and the innonimates to asses old age in certain individuals.

SEX

Sex assessment for infants and children were based on the size of the teeth, contours and nature of the superior orbital edge, the structure of the chin, the width and nature of the sciatic notch, as well as the relative gross size and development of all bones (Snow: in press).

The pelvis served as the ultimate reference and criterion for sex determination of the adults. The following observations or measurements of the hip-girdle structure were made: the contours of the general shape; the size and opening of the pelvic brim; the width and shape of the subpubic angle; the width and depth of the greater sciatic notch; the shape of the obturator foramen; the width between the ischio-tuberosities (pelvic outlet); the ischio-pubic index, which is a diagnostic ratio according to Washburn (1948); the comparative lengths of the pubic and ischiatic bones; and finally, a maximum and minimum diameter and depth measurements of the left acetabulum. From these it was possible to assign the sex of each individual satisfactorily, even if only one hip bone was present. (Snow: in press).

Other sex determinants for adults were the general robustness of the males as opposed to the fineness of features of the females.

I. Metrical Features of the Mandible

A. Measures of size and shape of the ramus

1. Maximum condylar length (cyl)
2. Projective height of left coronoid (crh)
3. Projective height of left ramus (rl)
4. Minimum anteroposterior width of left ramus (rb')
5. Rameal index (100 rb'/rl)

B. Measures of size and shape of the corpus mandibulae

6. Molar-premolar chord (m_2p_1)
7. Projective height of corpus
8. Actual height of corpus (m_1m_2)
9. Actual height of corpus (p_1p_2)
10. Symphyseal height (h_1)

C. Measures of size and shape of the mandible as a whole

11. Maximum bicondylar breadth (w_1)
12. Chord from left gonion to right gonion (gogo)
13. Bicoronial breadth (crcr)
14. Minimum chord between the anterior margins of the mental foramina (zz)
15. Angle between condylar-coronoidal line and the ramus tangent (R∠)
16. Mandibular angle (M∠)
17. Maximum projective length of mandible (ml)
18. Bigonial-bicoronial index (100 gogo/crcr)
19. Bigonial-length index (100 gogo/cpl)
20. Bicoronial-length index (100 crcr/ml)
21. Coronial height-length index (100 crh/ml)

II. Non-metrical Features of the Mandible

1. "Rocker" jaw
2. Gonial eversion
3. Mental foramen
4. Torus mandibularis

DEFINITIONS OF MANDIBULAR METRICAL MEASUREMENTS

The following measurements were taken from Morant's, "Study of the Human Mandible" (Biometrika: vol. 28: 116-122), Olivier's, Practical Anthropology (1969: 189), and Comas', Manual of Physical Anthropology (1960: 79). The definitions presented in the following pages have been condensed from these three publications and if more information is necessary, it is suggested that the above mentioned volumes be consulted.

Some preliminary definitions for reference and orientation are necessary before attempting the definitions of the mandibular measurements.

The definition of the standard horizontal plane given by Morant (1936: 117) is based on the assumption that the majority of mandibles rest of three or four points when placed, teeth uppermost, on a horizontal plane. When vertical pressure is exerted downwards on the second left molar, the mandible is said to be in standard horizontal position. To the 5 per cent of mandibles which he attributes the ability to rotate backwards and forwards (i.e. rocker jaw) when pressured at the second molar, Morant suggests that the intermediate position should be accepted and the observer should resist the inclination to favor one which insures greater stability. (Morant: 1936: 117)

Figure A

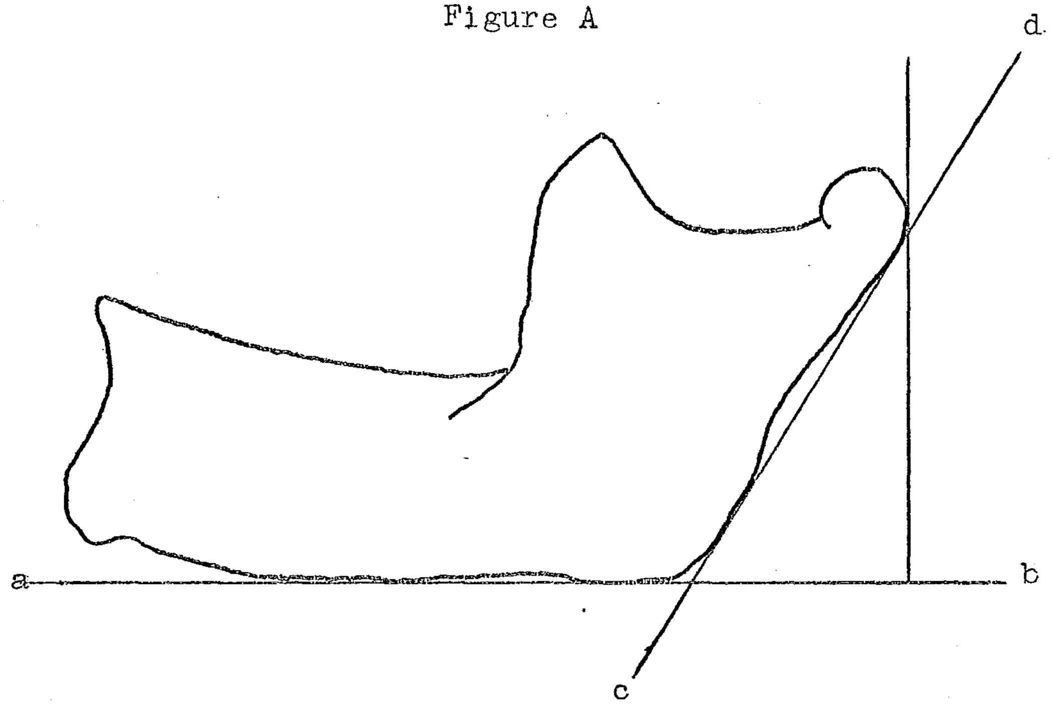
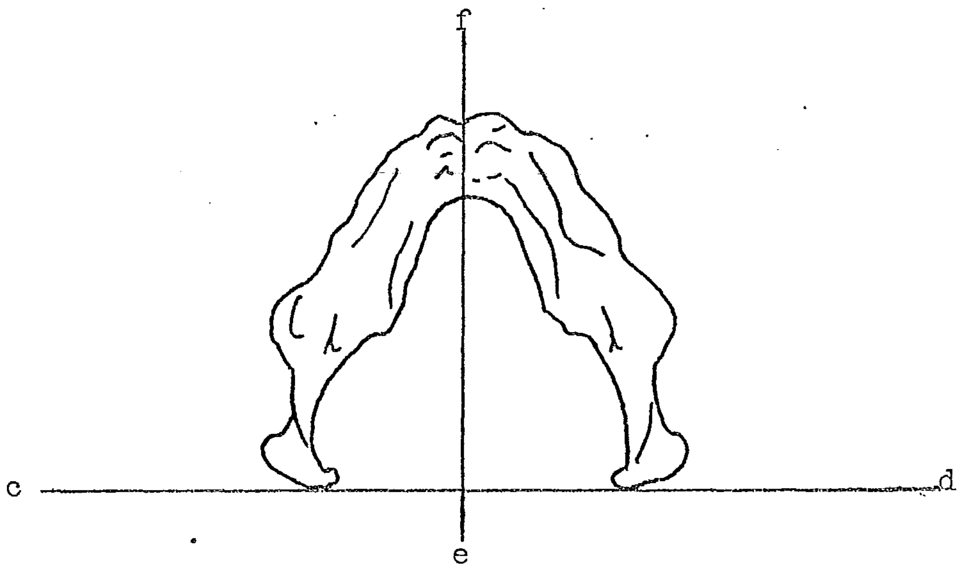
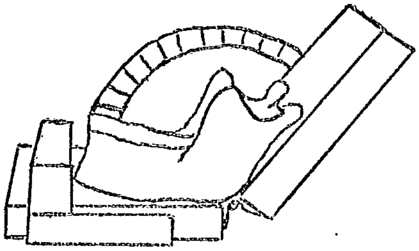


Figure B



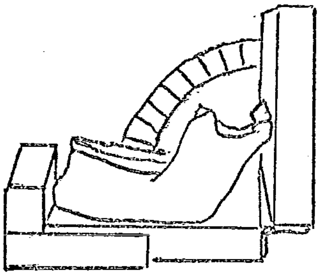
ab = Standard Horizontal Plane
cd = Standard Transverse Vertical Plane
ef = Standard Sagittal Plane of Symphysis

Figure I



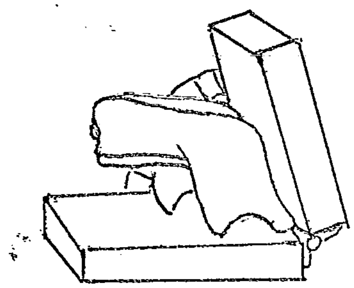
Position I

Figure II



Position II

Figure III



Position III

By standardization, measurements are taken on the left side; the right side may be used if it insures greater accuracy (i.e. the left side is defective) and this fact noted. But in all cases, vertical pressure is still placed on the second left molar or its tooth cavity.

Other definitions necessary for measurement are the standard transverse and the standard sagittal planes. The standard transverse vertical plane is perpendicular to the standard horizontal plane and in contact with the posterior borders of the condylar processes of the mandible. This plane is represented by the rameal wing on the mandibulometer (see Figures A and B). The standard sagittal plane of the symphysis passes through the intradental (i.e. between the central incisors) and is perpendicular to both the standard horizontal and transverse planes. (Morant: 1936; 117)

Therefore, it is to these three definitions which reference is made in the following measurements of the mandible.

The first ten measurements are taken with the aid of a pair of sliding calipers. These measurements do not necessarily involve the orientation of the mandible into any one of the three planes previously described.

<u>w_1</u> The maximum breadth outside the condyles (w_1) may be taken in any direction (i.e. it is not necessarily horizontal nor transverse). The points of contact of this measurement are unquestionably on the condyles, though not necessarily on

their articular surfaces. Excrescences which occasionally occur on the outer surfaces of the condylar processes are not included in the maximum breadth and are avoided in the process of measurement. Mandibles with damaged condyles are not measured nor recorded if it is suspected that they may be more than 1 mm. in error. (Morant: 1936; 117)

<u>cyl</u> The maximum length of the left condyle (cyl) is not normally horizontal or transverse. As in the case of (w_1), excrescences on the condylar process are avoided when the measurement is taken. Measurement may be taken on the right condylar process if the left side is damaged or, for any other reason, proves to be less accurate for measurement. A queried reading is not given if it is suspected that it may be more than 0.5 mm. in error. (Morant: 1936: 117)

<u>rb'</u> The minimum antero-posterior breadth of the left ramus (rb') occurs at any inclination toward the horizontal and about the level of the molar teeth. Occasionally, the posterior border of the ramus descends from the condyles without sufficient inflection to provide a minimum breadth for the measurement at the molar level. In such cases, a point on the posterior border, at least 13 mm. from the gonion, is used to mark the union of the body of the ramus and the angle. At this point the minimum breadth of the ramus is taken. If the left ramus is defective, measurement is taken on the right side and this fact noted. Measurements suspected of being more than 0.5 mm. in error are not recorded. (Morant: 1936; 118)

m_2p_1 The chord between the points on the outer left alveolar margin at the middle of the second molar (or its cavity) and at the middle of the first premolar (or its cavity) is the (m_2p_1) measurement. The points are first indicated by the extremities of pencil lines drawn vertically on the outer alveolar margins. Measurements are taken on the right side if it proves to be more accurate. The measurement is not taken if the positions of the first premolar or second molar appear to have been modified by the ante-mortem loss of any tooth. Measurements suspected of being more than 0.5 mm. in error are not recorded. (Morant: 1936; 118)

h_1 The symphyseal height (h_1) is the distance from the intra- dental to the point farthest removed from it in the symphyseal plane. The determination of the symphyseal plane is through anatomical appreciation and, in the case of asymmetrical specimens, may not coincide with the standard sagittal plane. The tip of the process between the central incisors is defined as the intra-dental, and the measurement is the maximum from this point to the lower border of the mandible and on the symphyseal plane. If the intradental process happens to be absorbed, due to disease, measurement will not be recorded. Readings suspected of being more than 0.5 mm. in error are also not recorded. (Morant: 1936; 118)

The next two measurements are taken from Olivier (1969: 189) and have been incorporated into the study because it deals with the actual (versus the projective of Morant) heights of the areas concerned. Also, the technique of measure-- is quicker and simpler than Morant's.

The technique which Morant suggested consists of measurement from the mandible board (i.e. standard horizontal plane) to the scriber. But in some cases, considering the rocker jaw, the points may not necessarily contact the standard horizontal plane established. In effect, the rocker jaw normally has only two points of contact with the mandibulometer and these specific points vary on the basal border of the jaw.

The two following measurements, (m_2m_2) and (p_1p_2), will consist of the line (i.e. distance) from the alveolar process to the lower basal border: this line being, more or less, vertical to the standard horizontal plane. Thus, these measurements will be the actual, not the projective, heights of their respective regions.

<u>m_1m_2</u> The height of the corpus of the mandible between the first and second left molars (m_1m_2). This measurement is concerned with the height between the alveolar plane and the inferior border of the bone (Olivier: 1969; 189). This line is the actual height and its angle to the basal plane is estimated vertically.

<u>p_1p_2</u> The height of the corpus of the mandible between the two left premolars (p_1p_2) is found in the same way as measurement (m_1m_2) except that the location differs.

zz The minimum chord between the anterior margins of the right and left foramina mentalia (zz) normally presents no problem since the mental foramen has a definite and regular anterior margin. But occasionally a foramen with a more or less well-marked anterior margin will also have a shallow depression anterior to it. In such cases, this depression is not considered as one of the terminals of this measurement. When two or more foramina occur, the largest is used but if they are confluent, the margin of the most anterior of the group is used as a terminal. This measurement is best omitted if uncertainty exists in proper measurement due to anatomical peculiarity. (Morant: 1936; 118-119)

crcr The coronial breadth from the right coronion to the left coronion (crcr) is found by first inverting the mandible and pressing it on a sheet of carbon paper so that both coronia and one or both condyles (depending on the symmetry of the mandible) contact the paper, leaving clear impressions at the points of contact. The centers of the impressions are the coronia and measurement is made from them. If one condyle is missing, the other may be used to give points which can be supposed approximations to the true coronia. If both condyles are missing the coronia cannot be located with sufficient accuracy. Measurements suspected of being more than 1 mm. in error are not recorded. (Morant: 1936; 119) gogo The chord from the left gonion to the right gonion (gogo) is found with small calipers. The landmarks of this measurement are the gonions, or points of the angles formed by the ascending branches with the body of the mandible. The separation of the angles is measured by applying the caliper to their external surfaces. (Comas: 1960; 709). Uncertain measurements are not recorded if suspected to be more than 1 mm. in error.

The following three measurements will be taken with the mandible in position I on the mandibulometer. In this position, the mandible is fixed on the standard horizontal plane. The left ramus of the mandible is in contact with the rameal wing of the instrument at its condyles and above the angle (see Figure I). If the posterior surface of the right condyle or angle is defective, the position can still be approximated with sufficient accuracy. Critical damage to both rami would not allow proper measurement. If the right ramus is intact but the posterior surface of the left condyle or angle is defective, the position can be approximated by making contact between the rameal wing and the two regions on the right and the one which is intact on the left, while maintaining the standard horizontal position by pressing on the second left molar. (Morant: 1936; 120)

M∠ The mandibular angle (M∠) is the angle between the standard horizontal and standard rameal planes, the latter being represented by the rameal wing of the board. The mandible is fixed in position I on the mandibulometer and the angle is read on the semicircular scale. (Morant: 1936; 120)

cpl The projective length of the corpus (cpl) is found by bringing the solid set-square into contact with the most advanced point in the region of the chin, which is not necessarily a point in the symphyseal plane. The mandible is fixed in position I on the mandibulometer and the projective length of the corpus is the distance between the solid set-square and the gonions (the gonions being defined as the points at the angles nearest to the zero axis of the mandibulometer). (Morant: 1936; 120)

rl The projective length of the left ramus (rl) is found by applying the solid set-square to contact with the left condyle. The solid set-square is slid along the scale of the rameal wing of the board with the mandible in position I. If the superior surface of the left condyle is defective the measurement is taken to the right condyle and this fact is noted. (Morant: 1936; 120)

The next two measurements (ml, crh) are taken with the mandible in position II. In this position, the mandible is in the standard horizontal position and the rameal wing of the board is vertical (see Figure II).

ml The maximum projective length of the mandible (ml) is read on the horizontal scale of the board with both condyles in contact with the vertical rameal wing (i.e. position II) and the solid set-square in contact with the most advanced point of the shin. If damage to the mandible does not allow measurement with sufficient accuracy (i.e. within 1 mm.), it is not recorded. (Morant: 1936;120)

crh The projective length of the left coronoid process (crh) is found by placing the left ramus close to and roughly parallel to the vertical rameal wing of the mandibulometer. The solid set-square is positioned on the rameal wing and brought into contact with the process. If the left coronoid process is defective, the measurement is taken on the right side but pressure is still exerted on the second left molar to give the standard horizontal position, as defined previously. Measurements suspected of being more than 1 mm. in error are not recorded. (Morant: 1936; 120-121)

The following measurement consists of having the mandible in position III on the mandibulometer. This position consists of inverting the mandible such that it rests on the left coronoid and condylar processes and on one, or both, of these two on the right (see Figure III). The left posterior border of the inverted ramus is placed in contact with the rameal wing, this angle is then read on the scale.

R∠ The angle of the condylar-coronoidal line with the ramus tangent (R∠) is taken with the mandible in position III on the mandibulometer. If the left ramus is intact but the superior extremity of either the coronoid or condylar processes is defective on the right, then a sufficiently close approximation is ascertainable for the purposes of this measurement. The angle may be taken on the right side, this fact being noted, if it provides more accuracy. Measurements suspected of being more than 1 degree in error are not recorded. (Morant: 1936; 121)

DEFINITIONS OF NON-METRICAL MEASUREMENTS

The definitions of the non-metrical mandibular measurements are listed below. Further information concerning them can be found in their references and in the bibliography of this paper.

Degree of Rocker Jaw

Categorizarion of the rocker jaw will be in three degrees (absent, slight and full). These categories refer to the amount of "rocking" each jaw is capable of when placed on a horizontal surface and deflected with vertical pressure at either the anterior (symphysis menti) or posterior (condylar) regions. Thus, the definitions of the categories are:

1) absent - no rocking occurs when the mandible is depressed anteriorly or posteriorly.

2) slight - unequal pivoting of the convex inferior borders, usually rocking only when deflected at either the anterior or posterior regions. (Pietrusewsky: 1968; 307)

3) full - rocks evenly no matter where it is depressed. (Pietrusewsky: 1968; 307)

Gonial Eversion

Measurement of gonial eversion (i.e. the turning out of the gonions) will consist of two categories, presence and absence.

The Mental Foramen

The mental foramen, through which the mental nerve and blood vessels emerge, will be measured in three aspects (i.e. the number, the direction of opening and the position in relation to the teeth).

a) The Number of Mental Foramina

The number of mental foramina is usually one, in man, though two or more may occur. The accessory foramina (i.e. other than the main mental foramen) are of two types, major and minor. The minor foramen usually is located on or just with the rim of the main foramen and is separated from it by a tongue of bone. The major foramen is always larger than the minor and is well separated from the main foramen. It is situated either antero-superior, postero-superior, posterior or inferior to the main foramen. (De Villiers: 1968; 148)

b) The Direction of the Mental Foramen

The direction of opening of the mental foramen will be measured by the following characteristics used by De Villiers (1968; 151).

1. Superior: there is an absence of a developed margin superiorly but a sharp margin is present anteriorly, posteriorly and inferiorly.
2. Posterior: there is an absence of a developed margin posteriorly but a developed margin anteriorly,

superiorly and inferiorly.

3. Lateral: a clearly defined margin completely encircles the foramen.

4. Anterior and superior: the sharp margin is absent both anteriorly and superiorly.

5. Posterior and superior: the sharp margin is absent both posteriorly and superiorly.

c) The Position of the Mental Foramen in Relation to the Teeth

The position of the mental foramen will be determined by drawing a line through the center of the major foramen parallel with the long axis of the nearest tooth. The tooth or interspace of which this line intersects is recorded. (De Villiers: 1968; 153)

Torus Mandibularis

The torus mandibularis is the occurrence of a bony hyperostosis of normal bone on the lingual side of the mandible near the roots of the canine and premolar teeth above the mylohyoid line. The location of the characteristic is constant but variations occur in its antero-posterior limits. (De Villiers: 1968; 159)

Measurement of this trait will be done with two categories, absence and presence.

MULTIVARIATE ANALYSIS

The general method of computation emplcyed by this study is that of multivariate analysis. This method allows finer distinctions of all sorts than does univariate analysis, including sex and population assignment, allowing such placement objectively when adequate samples of identified populations are available to form the multivariate context. (Howells: 1969; 311)

In terms of a complete analysis based on measurements, univariate statistics are limited because there is no real vector or profile representing either individuals or populations.

In multivariate statistics the individual is not decomposed, but remains a vector of all his measurements taken together, with everything they convey, as to size and shape, via both absolute size and by covariation. The amount of information lost is a univariate treatment is enormous. (Howells: 1969; 313)

Thus, multivariate statistics allows for a more descriptive and analytical study of the material.

DISCRIMINANT ANALYSIS

The specific method of statistical computation chosen for this research is that of the multivariate linear function. This type of analysis attacks the problem of assigning an individual to a sample classified into two or more groups on the basis of some number 'p' variables characteristic of the individuals comprising the sample. Heterogeneous material is not sorted out. The discriminatory function, which is derived by this computational procedure is that linear function most efficaceous (i.e. misclassification, is minimized) in distinguishing the groups.

Multivariate linear discriminatory analysis can be described by first considering regression analyses, which can be defined as the prediction of the value of one variable from the values of other given variables (Giles and Elliot: 1963; 54). Ordinary linear regression involves the straight-line relationship between two variables, one independent and the other dependent. (for an example see Giles and Elliot: 1963; 54). The linear or straight-line relationship between these two variables can be expressed in the form of the simple regression equation:

$$y = a + bx$$

By this formula, 'y' equals the dependent (or resultant) variable, 'x' equals the independent (or causal) variable, 'a' is the constant, and 'b' is the coefficient which provides in prediction. Multiple linear regression is the extension of this simple linear regression formula. In this instance the regression of one dependent variable on several independent variables.

The multivariate linear discriminant function can be looked upon as the solution of a multiple regression problem (Giles and Elliot: 1963; 54). Each group was given an arbitrary value (e.g. in the case of sex, 1 = male and 2 = female). This arbitrary value is the dependent variable (or 'y') in a multiple regression where the anthropometric measurements form the independent variable (or x_1, x_2, x_3....). A combination of these independent variables forms the discriminatory character of the process. A variable which by itself has little discriminatory value may heighten the power of another (Giles and Elliot: 1963; 54).

The final result or formula is the discriminatory function where the 'p' measurements of an individual are replaced by a single measurement called the discriminant function score which is the sum of the 'p' measurements times their calculated coefficients. Thus, the discriminatory function can be mathematically formulated into:

$$y = b_1x_1 + b_2x_2 + b_3x_3 + \ldots b_px_p$$

where 'b_1' through 'b_p' are the calculated coefficients of each variable.

The discriminant function scores are then distributed for the whole series into the groups, predetermined by their arbitrary values, with minimum overlap. The mean value of the discriminant function is then found by taking the mean values of each group's 'p' variables and entering them in their respective discriminant function. The arithemetic mean of the two scores provided the sectioning point to use when membership of an individual into either group or groups cannot be previously established. Thus, the score of any individual falling on either side of this sectioning point (or mean) classifies him into the group he is nearest to, in terms of numerical distance.

SELECTION OF VARIABLES

The selection of the sixteen metrical measurements, defined previously, into the discriminant function score is based on the F-values (i.e. value toward discrimination) of each of these variables. As suggested by Howells (1966; 9), the procedure removes correlation before, rather than after, inclusion of a measurement in a subset. The "best" variables for discrimination are those which contribute most to group separation (i.e. high F-value relative to others) after having been adjusted for correlation with others already selected. The final ranking of the variables and their weights is based on the procedure that each variable is specified and its correlation partialed out for all those remaining, therefore allowing a reflection of each variable's efficiency without being affected by the previous deletion. After computing the required number of F-values to be selected out (in this case, the ten highest), the discriminant function is then constructed.

As stated in the previous paragraph, the number of variables selected for the discriminant function was limited to the ten highest F-values. As there is no way to predict beforehand how effective a given function will be, the selection of variables is still quite arbitrary but in all likelihood perform better than one composed of the same number of variables chosen without regard for the effects of intercorrelation (Giles and Elliot: 1963; 180).

COMPUTER PROGRAM

The computer program utilized is the BMD07M (Stepwise Discriminant Analysis) distributed by the Health Sciences Computing Facility, U.C.L.A.. Basically, this program proceeds in a stepwise manner by forming linear sums of first one, then two, three, etc. variables. At each step the variable added is the one which gives the greatest improvement in the classification. The analysis is of aid in determining the importance of the different variables in distinguishing the groups. (Dixon: 1970; 148)

The number of groups allowed by this program ranges from two through eighty. The number of variables is limited to eighty or less.

The output of the program, as applied to this study, consisted of:

(1) Group means and standard deviation
(2) Within groups correlation matrix
(3) At each step:
  a) Variables included and F to remove
  b) Variables not included and F to enter
  c) U statistic and approximate F statistic to test equality of group means
  d) Matrix of F statistics to test the equality of means between each pair of groups
  e) Discriminant (or Classification) functions
(4) For each case:
  a) The posterior probability of coming from each group
  b) Square of the Mahalanobis distance from each group
(5) Summary table. For each step of the procedure the following are tabulated:
  a) Variable entered or removed

b) F value to enter or remove
c) Number of variables included
d) U statistic

Further explanation on the program is found in <u>BMD: Biomedical Computer Programs</u>, edited by W. J. Dixon.

GROUP DIVERGENCE

Calculation of the data proceeded with the assumption that the sample population involved consisted of a normal distribution. This, in my opinion, is not a totally invalid assumption, due to two reasons. First, and most important, is the fact that the characters normally measured in physical anthropology have distributions which are remarkably close to the normal form (Talbot and Mulhall: 1962; 37). By this, it is meant that there is a plausible theoretical explanation of the normality of these distributions based on the fact that the characters (i.e. measurements) under consideration are each, in themselves, an expression of a large number of more or less independent causes and, thus, should be distributed normally. This is a consequence of the Central Limit Theorem (Talbot and Mulhall: 1962; 37) which basically states that as the sample size increases, the frequency distribution tends to become normal. The second reason for this assumption is that the sample size itself is fairly large, numbering 173 adults or roughly 11.5% of the total number catalogued.

Therefore, this assumption of a normal distribution cannot be dismissed as a "wild guess". There is evidence that even in hybrid populations, although the means of characters are intermediate, if there is a clear distinction between the parent groups, the distributions of the measurements revert to the normal form (Trevor, 1953) - (taken from Talbot and Mulhall: 1962; 37).

ANALYSIS

The calculations were made on three sets of groups:

(1) Sex - Male vs Female
(2) Rocker vs Non-Rocker
(3) Rocker Male vs. Rocker Female vs. Non-Rocker Male vs. Non-Rocker Female Matrix

Though the data collected consisted of non-metrical as well as metrical measurements, the programs were only given the metrical measurements in order that the discriminants be considered equally and accurately as possible. For example, non-metrical characteristics cannot be properly "measured", aside from presence or absence, which are not true measurements but only expressions of their respective categories. To introduce these expressions into the calculations would necessitate a change in their original values into numerical categories, such as; presence = 1 and absence = 2. Thus, means and F-values would not be true means or F-values because these characters would be placed in arbitrary categories and the results would only be reflections of these arbitrary, and probably erroneous, values which would affect the metrical measurements.

Groupings of the sample were made via the non-metrical measurements. Only the Rocker vs. Non-Rocker group need be discussed.

Originally this characteristic was measured in three degrees: Absent/Slight/Full. (Each category being defined in a previous section of this paper) But in categorizing the mandibles it was found that the Slight category was, at best, difficult to distinguish between the possible asymmetrical characteristic of the mandible. This made the categorization somewhat difficult and, at times, more or less subjective on my part. Thus, this category was later reclassified into the peripheral categories for the purposes of groupings. This, in my estimate, would allow for a finer discriminant function score between the two categories and also dismiss the possibility of subjectivity being included into the calculations.

The measurements introduced into the program numbered sixteen, these being: 1) Condylar breadth (w_1), 2) Rameal breadth (rb'), 3) m_2p_1 chord, 4) Length of the condyle (cyl), 5) Symphyseal height (h_1), 6) Height of corpus (m_1m_2), 7) Height of corpus (p_1p_2), 8) Distance between foramina (zz), 9) Coronial breadth (crcr), 10) Gonial breadth (gogo), 11) Mandibular angle ($M\angle$), 12) Length of corpus (cpl), 13) Length of mandible (ml), 15) Height of left coronoid (crh), and 16) Condylar-coronial angle ($R\angle$). The definitions of these measurements were defined previously.

The five indices previously mentioned - 17) Rameal (100 gogo/crcr), 19) Bicoronial-length (100 crcr/ml), 20) Bigonial-length (100 gogo/cpl), and 21) Coronial height-length (100 crh/ml) - were deleted from the program because their values would be expressed in the calculation of the F-values and the discriminant coefficients. This is a better procedure because these values would be expressed in correlation to the other measurements. Also, introduction of these values into the program would, obviously, cause them to double their functional value.

ROCKER DISCRIMINATION

Discrimination between Rocker and Non-Rocker individuals was carried out with the hope of obtaining a significant discriminant function score. As with the other groupings, the discriminant is testing the same case from which it is computed.

The total number of individuals was 173, consisting of 127 rockers and 46 non-rockers. At this point sex was disregarded.

The following weights of discrimination resulted:

Table 1

Function:	Rocker	Non-Rocker
Y = condylar breadth	3.11306	3.01350
+ rameal breadth	1.07647	1.24527
- condylar length	6.36902	6.19658
+ corpus height (m_1m_2)	2.68526	2.30693
- corpus height (p_1p_2)	5.62465	5.17525
+ distance between foramina	0.41561	0.38212
+ gonial breadth	0.76036	0.87186
- rameal length	0.33362	0.41578
+ mandibular length	2.66097	2.53549
+ coronoidal height	0.41220	0.47870

These weights are used as multipliers for the raw measurements to get a discriminant score. The mean discriminant

Table 2

GROUP WITH LARGEST PROBABILITY		SQUARE OF DISTANCE FROM AND POSTERIOR PROBABILITY FOR GROUP			
GROUP ROCK CASE		ROCK		NOROCK	
1	NOROCK	7.816	0.296,	6.088	0.704,
2	ROCK	10.563	0.759,	12.855	0.241,
3	ROCK	6.558	0.593,	7.314	0.407,
4	NOROCK	5.739	0.429,	5.168	0.571,
5	ROCK	5.088	0.582,	5.752	0.418,
6	ROCK	16,610	0.701,	18.312	0.299,
7	NOROCK	11.182	0.296,	9.448	0.704,
8	ROCK	8.540	0.829,	11.691	0.171,
9	ROCK	5.340	0.752,	7.599	0.248,
10	ROCK	15.619	0.679,	17,114	0.321,
11	ROCK	3.680	0.538,	3.985	0.462,
12	ROCK	8.014	0.684,	9.559	0.316,
13	NOROCK	2.847	0.424,	2.233	0.576,
14	NOROCK	14.006	0.235,	11.642	0.765,
15	ROCK	7.193	0.610,	8.086	0.390,
16	ROCK	7.788	0.753,	10.021	0.247,
17	NOROCK	12.287	0.237,	9.951	0.763,
18	NOROCK	11.262	0.139,	7.620	0.861,
19	NOROCK	12.038	0.361,	10.893	0.639,
20	ROCK	6.594	0.576,	7.209	0.424,
21	ROCK	11.156	0.568,	11.704	0.432,
22	ROCK	17.406	0.741,	19.510	0.259,
23	ROCK	6.511	0.732,	8.525	0.268,
24	ROCK	3.787	0.748,	5.966	0.252,
25	ROCK	9.309	0.891,	13.516	0.109,
26	NOROCK	13.810	0.301,	12.127	0.699.
27	ROCK	6.842	0.834,	10.072	0.166,
28	NOROCK	13.311	0.410,	12,582	0.590,
29	ROCK	4.066	0.635,	6.172	0.365,
30	ROCK	4.066	0.630,	5.134	0.370,
31	ROCK	7.711	0.636,	8.826	0.364,
32	NOROCK	3.965	0.424,	3.355	0.576,
33	ROCK	3.299	0.817,	6.287	0.183,
34	ROCK	19.788	0.934,	25.084	0.066,
35	ROCK	2.170	0.773,	4.626	0.227,
36	ROCK	10.715	0.742,	12.827	0.258,
37	ROCK	10.118	0.542,	10.454	0.458,
38	ROCK	6.960	0.857,	10.545	0.143,
39	NOROCK	12.420	0.303,	10.757	0.697,
40	ROCK	8.093	0.519,	8.173	0.490,
41	ROCK	9.009	0.875,	12.906	0.125,
42	ROCK	3.741	0.686,	5.300	0.314,
43	ROCK	9.987	0.907,	14.531	0.093,
44	NOROCK	13.143	0.301,	11.459	0.699,
45	ROCK	3.698	0.675,	5.159	0.325,

Table 2 (con't)

46	ROCK	17,501	0.897,	21.839	0.103,
47	ROCK	8.659	0.674,	10.107	0.326,
48	NOROCK	12.821	0.436,	12,307	0.564,
49	ROCK	21.087	0.887,	25.207	0.113,
50	ROCK	3.863	0.646,	5.063	0.354,
51	ROCK	8.912	0.657,	10.214	0.343,
52	ROCK	9.836	0.601,	10.657	0.399,
53	NOROCK	9.826	0.432,	9.275	0.568,
54	ROCK	8.354	0.707,	10.118	0.293,
55	ROCK	5.383	0.639,	6.523	0.361,
56	ROCK	5.406	0.530,	5.650	0.470,
57	ROCK	10.240	0.624,	11.250	0.376,
58	NOROCK	5.978	0.321,	4.478	0.679,
59	NOROCK	8.208	0.453,	7.831	0.547,
60	ROCK	10.527	0.800,	13.301	0.200,
61	ROCK	5.509	0.794,	8.205	0.206,
62	ROCK	17.319	0.868,	21.090	0.132,
63	NOROCK	8.992	0.324,	7.525	0.676,
64	ROCK	4.926	0.642,	6.098	0.358,
65	ROCK	10.543	0.582,	11.196	0.418,
66	ROCK	6.942	0.649,	8.169	0.351,
67	ROCK	7.957	0.926,	12.996	0.075,
68	ROCK	8.118	0.830,	11.291	0.170,
69	NOROCK	7.511	0.393,	6.640	0.607,
70	ROCK	9.304	0.874,	13.176	0.126,
71	NOROCK	12.795	0.287,	10.973	0.713,
72	ROCK	5.493	0.613,	6.415	0.387,
73	ROCK	123.389	0.966,	130.100	0.034,
74	ROCK	12.564	0.784,	15,139	0.216,
75	ROCK	8.672	0.872,	12,504	0.128,
76	ROCK	6.895	0.890,	11.067	0.110,
77	ROCK	9.586	0.893,	13.825	0.107,
78	NOROCK	8.309	0.480,	8.150	0.520,
79	NOROCK	7.324	0.341,	6.005	0.659,
80	ROCK	10.162	0.873,	14.022	0.127,
81	ROCK	5.956	0.708,	7.723	0.292,
82	NOROCK	12.847	0.464,	12.560	0.536,
83	ROCK	11.374	0.866,	15.102	0.134,
84	ROCK	4.137	0.874,	8.011	0.126,
85	ROCK	11.705	0.696,	13.359	0.304,
86	ROCK	7.583	0.546,	7.945	0.454,
87	ROCK	5.531	0.611,	6.436	0.389,
88	ROCK	9.099	0.823,	12.179	0.177,
89	ROCK	9.211	0.779,	11.732	0.221,
90	ROCK	10.452	0.537,	10.749	0.463,
91	ROCK	14.207	0.518,	14.351	0.482,
92	ROCK	6.420	0.724,	8.348	0.276,
93	ROCK	8.183	0.541,	8.510	0.459,
94	ROCK	5.847	0.908,	10.416	0.092,
95	ROCK	5.116	0.718,	6.985	0.282,

Table 2 (con't)

96	ROCK	0.322	0.626,	1.352	0.374,
97	ROCK	13.729	0.765,	16.086	0.235,
98	NOROCK	10.508	0.285,	8.671	0.715,
99	ROCK	6.066	0.620,	7.046	0.380,
100	NOROCK	17.951	0.048,	11.966	0.952,
101	ROCK	14.392	0.504,	14.421	0.496,
102	ROCK	3.014	0.517,	3.152	0.483,
103	ROCK	11.944	0.956,	18.109	0.044,
104	ROCK	7.052	0.668,	8.447	0.332,
105	ROCK	9.750	0.602,	10.581	0.398,
106	ROCK	14.300	0.650,	15.541	0.350,
107	ROCK	7.185	0.503,	7.207	0.497,
108	ROCK	3.915	0.623,	4.921	0.377,
109	ROCK	21.655	0.659,	22.969	0.341,
110	ROCK	6.242	0.837,	9.516	0.163,
111	NOROCK	7.615	0.445,	7.171	0.555,
112	ROCK	7.040	0.750,	9.238	0.250,
113	ROCK	4.780	0.608,	5.544	0.392,
114	ROCK	6.417	0.518,	6.559	0.482,
115	ROCK	9.459	0.705,	11.206	0.295,
116	NOROCK	6.221	0.294,	4.474	0.706,
117	NOROCK	5.026	0.326,	3.577	0.674,
118	ROCK	4.177	0.706,	5.931	0.294,
119	NOROCK	9.492	0.365,	8.386	0.635,
120	NOROCK	15.388	0.228,	12,948	0.772,
121	NOROCK	5.546	0.486,	5.436	0.514,
122	ROCK	12.138	0.888,	16.270	0.112,
123	ROCK	6.213	0.827,	9.339	0.173,
124	ROCK	11.993	0.963,	18.519	0.037,
125	ROCK	2.497	0.755,	4.749	0.245,
126	ROCK	10.354	0.822,	13.414	0.178,
127	ROCK	8.215	0.859,	11.823	0.141,

1	NOROCK	4.913	0.474,	4.703	0.526,
2	ROCK	11.474	0.803,	14.288	0.197,
3	NOROCK	7.894	0.392,	7.014	0.608,
4	NOROCK	26.155	0.023,	18.619	0.977,
5	NOROCK	12.340	0.294,	10.590	0.706,
6	NOROCK	13.979	0.095,	9.471	0.905,
7	NOROCK	17.960	0.227,	15.507	0.773,
8	NOROCK	17.335	0.442,	16.871	0.558,
9	ROCK	4.827	0.599,	5.628	0.401,
10	NOROCK	17.540	0.198,	14.736	0.802,
11	NOROCK	26.800	0.170,	23.633	0.830,
12	NOROCK	28.191	0.099,	23.784	0.901,
13	ROCK	9.812	0.632,	10.896	0.368,
14	NOROCK	9.456	0.369,	8.382	0.631,
15	NOROCK	8.192	0.220,	5.658	0.780,

Table 2 (con't)

16	NOROCK	10.884	0.142,	7.279	0.858,
17	NOROCK	15.872	0.034,	9.185	0.966,
18	NOROCK	9.540	0.159,	6.214	0.841,
19	NOROCK	27.366	0.959,	21.816	0.941,
20	ROCK	2.568	0.855,	6.109	0.145,
21	ROCK	6.162	0.540,	6.483	0.460,
22	NOROCK	19.958	0.092,	15.381	0.908,
23	ROCK	6.305	0.841,	9.632	0.159,
24	NOROCK	5.783	0.415,	5.095	0.585,
25	NOROCK	4.927	0.345,	3.646	0.655,
26	NOROCK	13.322	0.403,	12.537	0.597,
27	ROCK	10.937	0.716,	12.789	0.284,
28	ROCK	6.646	0.938,	12.076	0.062,
29	NOROCK	3.815	0.251,	1.629	0.749,
30	NOROCK	12.810	0.130,	9.014	0.870,
31	ROCK	2.957	0.749,	5.148	0.251,
32	ROCK	13.381	0.595,	14.150	0.405,
33	ROCK	9.303	0.528,	9.525	0.472,
34	NOROCK	9.129	0.407,	8.377	0.593,
35	NOROCK	6.946	0.443,	6.488	0.557,
36	NOROCK	6.103	0.339,	4.771	0.661,
37	NOROCK	4.363	0.437,	3.859	0.563,
38	NOROCK	12.558	0.230,	10.143	0.770,
39	ROCK	5.213	0.532,	5.470	0.468,
40	NOROCK	7.458	0.318,	5.927	0.682,
41	NOROCK	12.230	0.359,	11.072	0.641,
42	NOROCK	8.809	0.386,	7.880	0.614,
43	NOROCK	10.286	0.148,	6.787	0.852,
44	NOROCK	9.150	0.232,	6.754	0.768,
45	NOROCK	28.546	0.244,	26.288	0.756,
46	NOROCK	6.747	0.461,	6.431	0.539,

NUMBER OF CASES CLASSIFIED INTO GROUP

GROUP	ROCK	NOROCK
ROCK	96	31
NOROCK	12	34

score for the group was:

	N	$\overline{Y}$
Rocker	127	-288.18701
Non-Rocker	46	-283.76831

It is important to note that the value for $\overline{Y}$ (or constant) must be doubled in order to coincide with the actual scores of the individuals. Reference to the equation for the constant (C_{ko}) stated by Dixon (1970; 214) gives it as:

$$C_{ko} = -\tfrac{1}{2}\sum_{i=1}^{r} C_{ki}\overline{X}_{ki}$$

Where: i = the range of variables
k = the number of cases

Thus, since $-\frac{1}{2} \times 2 = -1$, the constant must be doubled or, vice versa, the actual individual score may be divided by $\frac{1}{2}$. But since the Square of Mahalanobis distance is computed by the difference in the mean values of each character for each group, it would be easier to double the constant.

The mid-point between the two constants is called the sectioning point. In this case, the value is:

$$-288.18701 + -283.76831 = -571.95532$$

Notice that division of the sum is not necessary since the figure must be doubled in order to compare with each individual's value.

Hence, this value theoretically is the determination (or sectioning) point between each group. An individual's location relative to this point determines his respective group membership.

Generalized distance (D_2) is computed by the means of the group against the particular individual in concern. The description of D_2 calculation will not be attempted in this paper due to its length and complexity. Reference may be found in any number of studies, such as those by Rao, Howells, and Rightmire, to name a few. But the importance of the D_2 is that it measures the distance between two groups (or as in this case, the individual against the Rocker and Non-Rocker groups) separately. Hence, the higher the D_2 value, the greater the distance the individual is from that particular group. And, vice versa, the smaller the D_2, the closer he is to the group.

Table 2 shows the square of the distance and the probability of occurrence within the group. Take, for example, Case 1 of the Rocker group who was initially misassigned and, according to the calculated discriminant function, was re-classified to the Non-Rocker group because the individual's distance was smaller when calculated against that group than it was for the Rocker group (i.e. 7.816 vs. 6.088). The probability of this specimen belonging to the Non-Rocker group also exceeds his probability of membership into the Rocker group (i.e. 0.707 vs. 0.290). This was expected since the posterior probability correlates with D_2. Also, the greater the difference between the two D_2 values of each group for the individual, the greater the distance between his two posterior probabilities with the smaller D_2 value having the greater probability value of the two.

Although the aim of the discriminant function is absolute segregation, one cannot expect perfect results when the discriminant is testing the same cases from which it was computed.

The results for this Rocker vs. Non-Rocker grouping are:

24.4%, or 31 of 127, Rockers misassigned
38.4%, or 12 of 46, Non-Rockers misassigned

Correct classification for the discrimination was 130 mandibles out of 173, or 75.2%.

SEX DISCRIMINATION

Sex discrimination was carried out among the Rocker group only. The total number of individuals introduced into this calculation was 127, consisting of 48 males and 79 females.

The following weights of discrimination resulted:

Table 3

Function:	Male	Female
Y = condylar breadth	2.76536	2.69315
+ m_2p_1 chord	7.13350	7.09789
- condylar length	4.37561	4.47088
- corpus height (p_1p_2)	3.53146	3.81721
- distance between foramina	0.21240	0.23820
+ gonial breadth	1.47420	1.38735
+ rameal length	1.52681	1.44590
+ mandibular length	4.18276	4.09043
- coronoidal height	1.19445	1.12217
+ condylar-coronial angle	3.60188	3.40371

The mean discriminant score for the group was:

	N	$\bar{Y}$
Male	48	-620.14185
Female	79	-565.00635

Table 4 gives the square of the distances and posterior probabilities for sex determination.

Table 4

GROUP. MALE CASE	GROUP WITH LARGEST PROBABILITY	SQUARE OF DISTANCE FROM AND POSTERIOR PROBABILITY FOR GROUP: MALE		FEMALE	
1	MALE	7.504	0.557,	7.964	0.443,
2	MALE	9.575	0.994,	19.757	0.006,
3	MALE	9.036	0.988,	17.887	0.012,
4	MALE	6.140	0.832,	9.342	0.168,
5	MALE	6.204	0.759,	8.494	0.241,
6	MALE	18.859	0.957,	25.086	0.043,
7	FEMALE	17.854	0.328,	16.417	0.672,
8	MALE	8.335	0.837,	11.605	0.163,
9	MALE	10.245	0.937,	15.649	0.063,
10	FEMALE	17.130	0.018,	9.164	0.982,
11	MALE	8.815	0.982,	16.833	0.018,
12	MALE	13.829	9.648,	15.046	0.352,
13	FEMALE	9.045	0.279,	7.146	0.721,
14	FEMALE	9.669	0.495,	9.629	0.505,
15	MALE	5.558	0.529,	5.789	0.471,
16	MALE	7.032	0.982,	15.086	0.018,
17	MALE	5.458	0.594,	6.222	0.406,
18	MALE	19.123	0.999,	33.170	0.001,
19	FEMALE	4.269	0.492,	4.206	0.508,
20	MALE	6.589	0.908,	11.167	0.092,
21	FEMALE	15.484	0.028,	8.403	0.972,
22	MALE	8.268	0.811,	11.184	0.189,
23	MALE	2.492	0.953,	8.493	0.047,
24	MALE	11.270	0.554,	11.702	0.446,
25	MALE	9.056	0.920,	13.945	0.080,
26	MALE	21.259	0.992,	30.883	0.008,
27	FEMALE	5.280	0.232,	2.890	0.768,
28	MALE	7.955	0.988,	16,717	0.012,
29	MALE	9.271	0.971,	16.271	0.029,
30	MALE	7.747	0.905,	12,250	0.095,
31	MALE	2.000	0.831,	5.186	0.169,
32	MALE	17.411	0.638,	18.545	0.362,
33	MALE	10.411	0.889,	14.568	0.111,
34	MALE	10.210	0.960,	16.549	0.040,
35	MALE	14.357	0.830,	17.525	0.170,
36	MALE	6.414	0.773,	8.862	0.227,
37	MALE	5.943	0.935,	11.284	0.065,
38	MALE	93.804	0.936,	99.167	0.064,
39	MALE	10.354	0.974,	17.605	0.026,
40	MALE	7.683	0.981,	15.545	0.019,
41	MALE	9.273	0.997,	20.808	0.003,
42	MALE	11.946	0.998,	24.136	0.002,
43	MALE	4.154	0.648,	5.372	0.352,
44	FEMALE	12.239	0.349,	10.991	0.651,

Table 4 (co: 't)

45	MALE	6.592	0.943,	12.204	0.057,
46	MALE	10.601	0.501,	10.612	0.499,
47	MALE	7.272	0.855,	10.818	0.145,
48	FEMALE	11.373	0.303,	9.709	0.697,
1	FEMALE	10.257	0.189,	7.345	0.811,
2	FEMALE	6.889	0.088,	2.208	0.912,
3	FEMALE	10.934	0.046,	4.888	0.954,
4	FEMALE	22.836	0.123,	18.899	0.877,
5	FEMALE	16.125	0.043,	9.918	0.957,
6	FEMALE	12.488	0.417,	11.818	0.583,
7	FEMALE	11.725	0.024,	4.330	0.976,
8	FEMALE	10.505	0.075,	5.491	0.925,
9	FEMALE	9.355	0.232,	6.959	0.768,
10	FEMALE	8.800	0.162,	5.514	0.838,
11	FEMALE	13.869	0.260,	11.772	0.740,
12	FEMALE	20.889	0.343,	19.591	0.657,
13	FEMALE	18.300	0.240,	15.993	0.760,
14	FEMALE	6.876	0.362,	5.742	0.638,
15	FEMALE	15.434	0.130,	11.634	0.870,
16	FEMALE	8.090	0.117,	4.049	0.883,
17	FEMALE	9.054	0.090,	4.438	0.910,
18	FEMALE	17.246	0.191,	14.360	0.809,
19	FEMALE	16.600	0.004,	5.407	0.996,
20	FEMALE	14.292	0.095,	9.788	0.905,
21	FEMALE	8.748	0.253,	6.579	0.747,
22	FEMALE	9.689	0.108,	5.459	0.892,
23	MALE	8.108	0.574,	8.703	0.426,
24	FEMALE	13.977	0.242,	11.670	0.758,
25	FEMALE	6.909	0.396,	6.067	0.604,
26	FEMALE	9.617	0.306,	7.983	0.694,
27	FEMALE	14.885	0.035,	8.277	0.965,
28	FEMALE	14.009	0.473,	13.790	0.527,
29	FEMALE	10.293	0.080,	5.399	0.920,
30	FEMALE	6.978	0.214,	4.376	0.786,
31	FEMALE	9.549	0.109,	5.338	0.891,
32	FEMALE	5.115	0.197,	2.298	0.803,
33	FEMALE	15.137	0.318,	13.614	0.682,
34	MALE	9.356	0.910,	13.977	0.090,
35	FEMALE	11.787	0.090,	7.168	0.910,
36	MALE	19.686	0.750,	21.882	0.250,
37	FEMALE	7.925	0.302,	6.249	0.698,
38	FEMALE	11.000	0.061	5.543	0.939,
39	MALE	3.899	0.643,	5.078	0.357,
40	FEMALE	9.553	0.073,	4.479	0.927,
41	FEMALE	15.451	0.071,	10.295	0.929,
42	FEMALE	9.490	0.203,	6.755	0.797,
43	FEMALE	12.639	0.174,	9.520	0.826,

Table 4 (con't)

44	FEMALE	9.668	0.046,	3.606	0.954,
45	FEMALE	15.849	0.098,	11.414	0.902,
46	FEMALE	22.637	0.091,	18.045	0.909,
47	FEMALE	13.922	0.016,	5.733	0.984,
48	FEMALE	14.639	0.031,	7.766	0.969,
49	FEMALE	5.248	0.263,	3,186	0.737,
50	FEMALE	9.473	0.103,	5.147	0.897,
51	FEMALE	9.844	0.050,	3.944	0.950,
52	FEMALE	15.210	0.110,	11.037	0.890,
53	FEMALE	13.236	0.213,	10.619	0.787,
54	MALE	6.724	0.662,	8.067	0.338,
55	FEMALE	19.625	0.070,	14.442	0.930,
56	FEMALE	10.113	0.040,	3.769	0.960,
57	FEMALE	13.615	0.221,	11.096	0.779,
58	FEMALE	8.511	0.451,	8.118	0.549,
59	FEMALE	23.898	0.013,	15.290	0.987,
60	FEMALE	21.570	0.067,	16.288	0.933,
61	FEMALE	12.636	0.032,	5.786	0.968,
62	FEMALE	18.329	0.007,	8.553	0.993,
63	FEMALE	11.466	0.391,	10.579	0.609,
64	FEMALE	14.120	0.015,	5.760	0.985,
65	FEMALE	19.032	0.011,	9.967	0.989,
66	FEMALE	14.642	0.018,	6.683	0.982,
67	FEMALE	14.803	0.060,	9.311	0.940,
68	FEMALE	7.468	0.172,	4.318	0.828,
69	FEMALE	10.267	0.241,	7.977	0.759,
70	FEMALE	10.122	0.237,	7.784	0.763,
71	MALE	10.051	0.936,	15.402	0.064,
72	FEMALE	11.415	0.201,	8.654	0.799,
73	MALE	9.920	0.657,	11.224	0.343,
74	FEMALE	16.939	0.069,	11.783	0.931,
75	FEMALE	8.017	0.156,	4.641	0.844,
76	FEMALE	14.252	0.033,	7.474	0.967,
77	FEMALE	26.899	0.001,	13.610	0.999,
78	MALE	12.521	0.913,	17.235	0.087,
79	FEMALE	10.219	0.052,	4.400	0.948,

NUMBER OF CASES CLASSIFIED INTO GROUP

GROUP	MALE	FEMALE
MALE	39	9
FEMALE	8	71

The results of this function was:

18.8%, or 9 of 46, males misassigned
10.1%, or 8 of 79, females misassigned

Correct classification for Sex (among rocker jaws only) was 110 out of 127, or 85.9%.

FOUR GROUP DISCRIMINATION

Four group discrimination (Rocker Male vs. Rocker Female vs. Non-Rocker Male vs. Non-Rocker Female Matrix) treats all four groups at the same time, thereby avoiding the hierarchical arrangement of deciding one group from one discriminant, which is directly resultant from the first discriminant. For example, if the first discriminant is sex, the second discriminant would be sex-limited (i.e. being calculated from the first grouping).

Table 5 (following page) gives the discriminant functions obtained for the groups. The mean discriminant scores for each group are:

	N	$\bar{Y}$
Rocker Males	48	-619.52393
Rocker Females	79	-565.63013
Non-Rocker Males	29	-579.18018
Non-Rocker Females	17	-589.69287

The results of classification for the four groups are:

Rocker Males(48):
Misassigned in 15 cases (31.3%), 5 as Rocker Females, 5 as Non-Rocker Males, and 5 as Non-Rocker Females.

Rocker Females (79):
Misassigned in 25 cases (31.6%), 5 as Rocker Males, 10 as Non-Rocker Males, and 10 as Non-Rocker Females.

Table 5

Four Group Discrimination

Function:	Rocker Male	Rocker Female	Male	Female
Y = condylar breadth	3.03070	2.92134	2.83982	2.94300
+ rameal breadth	2.69169	2.64106	2.89894	2.70693
+ m_2p_1 chord	7.81438	7.71417	7.75550	7.57047
+ corpus height (m_1m_2)	4.64614	4.42319	3.92178	4.33414
- corpus height (p_1p_2)	6.78784	6.85516	6.30111	6.43692
+ gonial breadth	1.12149	1.04252	1.08990	1.30942
- corpus length	2.23945	2.16267	2.13101	2.29399
+ mandibular length	4.52049	4.37819	4.29441	4.34956
- coronoidal height	1.74356	1.66463	1.60499	1.76407
+ condylar-coronial angle	3.75767	3.54963	3.66860	3.63393

Table 6

GROUP WITH LARGEST PROBABILITY		SQUARE OF DISTANCE FROM AND POSTERIOR PROBABILITY FOR GROUP			
GROUP RMALE CASE		RMALE	RFEMAL	MALE	FEMALE
1	MALE	10.988 0.125,	10.958 0.127,	7.702 0.648,	11.442 0.100,
2	RMALE	7.626 0.924,	15.950 0.014,	15.145 0.022,	13.891 0.040,
3	RMALE	11.302 0.543,	18.525 0.015,	13.538 0.177,	12.733 0.265,
4	RMALE	2.984 0.593,	6.940 0.082,	6.925 0.083,	4.773 0.242,
5	RMALE	3.330 0.572,	5.099 0.236,	7.979 0.056,	6.194 0.136,
6	RMALE	16.910 0.956,	24.516 0.021,	25.938 0.010,	25.602 0.012,
7	FEMALE	11.458 0.067,	8.387 0.310,	11.177 0.077,	7.254 0.546,
8	RMALE	8.618 0.499,	11.558 0.115,	10.372 0.208,	10.679 0.178,
9	RMALE	11.124 0.473,	15.436 0.055,	14.015 0.112,	11.670 0.360,
10	RFEMAL	15.153 0.019,	8.062 0.665,	10.393 0.207,	11.676 0.109,
11	RMALE	7.920 0.486,	14.568 0.018,	11.993 0.063,	8.152 0.433,
12	RMALE	8.695 0.393,	10.371 0.170,	10.446 0.164,	9.418 0.274,
13	MALE	7.771 0.130,	6.514 0.244,	5.524 0.400,	6.670 0.226,
14	RMALE	11.417 0.453,	11.807 0.373,	16.833 0.030,	13.722 0.143,
15	RFEMAL	7.500 0.301,	6.998 0.387,	7.988 0.236,	10.249 0.076,
16	RMALE	5.083 0.721,	12.856 0.015,	12.520 0.018,	7.227 0.247,
17	FEMALE	4.866 0.252,	4.484 0.305,	6.362 0.119,	4.359 0.324,
18	RMALE	17.977 0.926,	31.164 0.001,	28.641 0.004,	23.183 0.069,
19	RMALE	3.690 0.537,	4.609 0.339,	8.662 0.045,	7.524 0.079,
20	RMALE	2.855 0.510,	6.569 0.080,	4.330 0.244,	5.101 0.166,
21	RFEMAL	16.028 0.024,	9.969 0.502,	11.278 0.261,	11.682 0.213,
22	RMALE	8.146 0.508,	10.846 0.132,	13.674 0.032,	9.020 0.328,
23	RMALE	5.667 0.781,	10.602 0.066,	11.128 0.051,	9.732 0.102,
24	FEMALE	13.416 0.202,	12.909 0.261,	13.277 0.217,	12.498 0.320,
25	RMALE	9.645 0.642,	13.781 0.081,	13.592 0.089,	12.103 0.188,
26	RMALE	47.868 0.815,	57.123 0.008,	54.436 0.031,	51.303 0.146,
27	RFEMAL	5.690 0.160,	3.278 0.534,	4.965 0.230,	7.176 0.076,

Table 6 (con't)

28	RMALE	9.803 0.891,	18.654 0.011,	17.718 0.017,	14.597 0.081,
29	RMALE	5.327 0.800,	12.588 0.021,	10.537 0.059,	9.124 0.120,
30	MALE	10.847 0.278,	14.400 0.047,	9.636 0.509,	11.865 0.167,
31	RMALE	2.753 0.556,	5.314 0.155,	6.502 0.085,	4.764 0.204,
32	RFEMAL	12.163 0.318,	12.017 0.342,	17.729 0.020,	12.141 0.321,
33	RMALE	8.379 0.425,	10.976 0.116,	12.910 0.044,	8.425 0.415,
34	FEMALE	8.807 0.398,	13.786 0.033,	11.128 0.125,	8.587 0.444,
35	RMALE	17.780 0.751,	21.207 0.135,	22.200 0.082,	24.167 0.031,
36	MALE	5.733 0.188,	6.675 0.118,	4.037 0.440,	5.130 0.254,
37	RMALE	7.618 0.640,	13.627 0.032,	11.756 0.081,	9.514 0.248,
38	RMALE	10.264 0.675,	12.837 0.186,	15.212 0.057,	14.498 0.081,
39	RMALE	12.253 0.653,	19.132 0.021,	20.722 0.009,	13.701 0.317,
40	RMALE	11.092 0.827,	20.094 0.009,	22.613 0.003,	14.358 0.162,
41	RMALE	9.000 0.950,	19.657 0.005,	17.734 0.012,	15.680 0.034,
42	RMALE	12.287 0.923,	22.999 0.004,	18.002 0.053,	19.942 0.020,
43	RMALE	2.886 0.321,	3.834 0.200,	3.597 0.225,	3.357 0.254,
44	RMALE	10.292 0.607,	11.407 0.347,	17.978 0.013,	16.108 0.033,
45	RMALE	5.229 0.741,	9.856 0.073,	8.695 0.131,	10.457 0.054,
46	RMALE	10.365 0.499,	11.977 0.223,	14.162 0.075,	12.169 0.203,
47	FEMALE	6.314 0.240,	8.062 0.100,	5.909 0.264,	5.480 0.365,
48	MALE	8.472 0.171,	7.442 0.285,	6.651 0.424,	9.174 0.120,

GROUP
RFEMAL
CASE

1	MALE	9.048 0.140,	7.242 0.346,	6.674 0.460,	10.955 0.054,
2	MALE	10.692 0.026,	5.564 0.343,	4.525 0.577,	9.262 0.054,
3	RFEMAL	10.844 0.044,	5.550 0.616,	7.150 0.277,	10.073 0.064,
4	RFEMAL	24.073 0.081,	19.776 0.694,	22.529 0.175,	25.045 0.050,
5	MALE	18.543 0.018,	13.229 0.263,	11.345 0.675,	16.853 0.043,
6	MALE	12.902 0.031,	11.850 0.052,	6.161 0.888,	12.919 0.030,

Table 6 (con't)

7	MALE	20.238	0.008,	12.524	0.371,	11.551	0.603,	18.474	0.019,
8	RFEMAL	8.508	0.067,	4.362	0.532,	7.045	0.139,	5.773	0.262,
9	RFEMAL	10.869	0.127,	8.083	0.512,	9.219	0.290,	12.038	0.071,
10	FEMALE	5.823	0.095,	3.796	0.263,	4.637	0.172,	2.633	0.470,
11	RFEMAL	11.596	0.221,	9.880	0.521,	11.434	0.240,	16.606	0.018,
12	RFEMAL	11.579	0.171,	8.734	0.708,	12.852	0.090,	14.989	0.031,
13	RFEMAL	16.961	0.237,	15.227	0.564,	17.362	0.194,	24.564	0.005,
14	FEMALE	7.777	0.187,	6.675	0.324,	9.838	0.067,	6.141	0.423,
15	RFEMAL	18.673	0.132,	15.090	0.789,	21.184	0.037,	20.955	0.042,
16	RFEMAL	4.944	0.174,	2.783	0.513,	5.388	0.140,	4.958	0.173,
17	RFEMAL	7.761	0.046,	3.168	0.454,	3.338	0.417,	6.562	0.083,
18	RFEMAL	12.363	0.129,	9.680	0.495,	12.334	0.131,	11.085	0.245,
19	RFEMAL	18.777	0.005,	8.429	0.835,	12.204	0.126,	14.854	0.034,
20	RFEMAL	14.036	0.108,	10.004	0.809,	16.239	0.036,	15.656	0.048,
21	RFEMAL	12.349	0.155,	9.741	0.572,	16.247	0.022,	11.391	0.251,
22	RFEMAL	9.040	0.043,	4.284	0.465,	4.548	0.408,	7.716	0.084,
23	FEMALE	8.851	0.333,	10.547	0.142,	15.229	0.014,	7.992	0.511,
24	MALE	16.838	0.020,	12.962	0.136,	9.379	0.819,	16.335	0.025,
25	RFEMAL	4.329	0.262,	4.001	0.308,	4.438	0.248,	5.056	0.182,
26	FEMALE	8.777	0.116,	7.739	0.195,	11.439	0.031,	5.312	0.658,
27	RFEMAL	21.063	0.012,	13.314	0.567,	15.522	0.188,	15.091	0.233,
28	RMALE	12.651	0.474,	13.155	0.368,	15.304	0.126,	18.075	0.031,
29	RFEMAL	10.149	0.087,	5.736	0.790,	10.240	0.083,	11.735	0.039,
30	RFEMAL	7.425	0.228,	5.560	0.580,	11.818	0.025,	8.063	0.166,
31	RFEMAL	6.750	0.147,	4.119	0.547,	6.656	0.154,	6.684	0.152,
32	RFEMAL	4.361	0.167,	2.245	0.480,	5.013	0.120,	3.696	0.232,
33	RFEMAL	13.283	0.193,	11.551	0.458,	13.462	0.176,	13.492	0.174,
34	MALE	13.942	0.240,	16.470	0.068,	12.628	0.463,	14.031	0.229,
35	FEMALE	8.733	0.079,	5.367	0.425,	9.230	0.062,	5.325	0.434,
36	FEMALE	19.850	0.023,	19.894	0.022,	13.842	0.457,	13.670	0.498,
37	RFEMAL	7.342	0.336,	6.747	0.453,	9.588	0.109,	9.733	0.102,
38	RFEMAL	11.044	0.039,	5.635	0.590,	9.138	0.102,	7.208	0.269,
39	MALE	8.213	0.352,	9.459	0.189,	8.192	0.356,	10.650	0.104,

Table 6 (con't)

40	RFEMAL	10.522	0.064,	6.820	0.410,	7.167	0.344,	8.447	0.182,
41	RFEMAL	11.604	0.144,	8.498	0.681,	13.714	0.050,	11.894	0.125,
42	RFEMAL	11.484	0.122,	8.070	0.673,	12.278	0.082,	11.461	0.123,
43	RFEMAL	14.709	0.264,	13.011	0.617,	22.562	0.005,	16.381	0.114,
44	RFEMAL	8.412	0.060,	3.413	0.736,	6.305	0.173,	9.786	0.030,
45	RFEMAL	14.091	0.166,	11.171	0.714,	15.561	0.079,	16.875	0.041,
46	RFEMAL	14.253	0.061,	9.722	0.592,	11.446	0.250,	13.333	0.097,
47	RFEMAL	12.702	0.018,	5.573	0.653,	9.838	0.077,	7.487	0.251,
48	RFEMAL	11.272	0.023,	5.037	0.526,	5.424	0.433,	11.771	0.018,
49	MALE	4.749	0.121,	2.848	0.313,	1.878	0.508,	6.234	0.058,
50	RFEMAL	9.861	0.119,	6.528	0.630,	10.182	0.101,	9.408	0.149,
51	RFEMAL	7.869	0.054,	2.850	0.661,	7.664	0.060,	5.000	0.226,
52	RFEMAL	15.667	0.111,	11.805	0.767,	16.887	0.060,	16.859	0.061,
53	FEMALE	14.244	0.045,	10.521	0.287,	10.406	0.304,	10.050	0.364,
54	RMALE	6.575	0.501,	8.063	0.238,	11.545	0.042,	8.231	0.219,
55	FEMALE	15.292	0.026,	11.016	0.224,	10.906	0.237,	9.358	0.513,
56	RFEMAL	8.438	0.026,	2.877	0.734,	6.495	0.120,	6.847	0.101,
57	RFEMAL	11.542	0.172,	9.223	0.549,	11.351	0.190,	12.868	0.089,
58	RMALE	6.558	0.569,	8.107	0.262,	11.741	0.043,	9.570	0.126,
59	RFEMAL	20.409	0.016,	12.408	0.888,	17.221	0.080,	20.528	0.015,
60	RFEMAL	16.459	0.057,	11.799	0.590,	17.650	0.032,	13.020	0.321,
61	MALE	13.549	0.024,	8.069	0.375,	7.467	0.507,	10.849	0.093,
62	RFEMAL	17.006	0.006,	7.406	0.779,	10.786	0.144,	12.187	0.071,
63	RFEMAL	11.403	0.118,	8.639	0.470,	9.147	0.364,	13.217	0.048,
64	RFEMAL	17.987	0.013,	9.531	0.916,	16.663	0.026,	15.555	0.045,
65	RFEMAL	16.336	0.021,	8.705	0.933,	18.151	0.008,	15.114	0.038,
66	RFEMAL	16.152	0.010,	7.709	0.651,	9.149	0.317,	14.388	0.023,
67	FEMALE	11.845	0.048,	7.462	0.432,	12.503	0.035,	7.228	0.485,
68	RFEMAL	11.061	0.061,	7.071	0.445,	7.117	0.435,	11.112	0.059,
69	RFEMAL	11.397	0.237,	9.961	0.485,	14.852	0.042,	11.401	0.236,
70	RFEMAL	9.984	0.158,	7.198	0.636,	11.412	0.077,	10.387	0.129,
71	RMALE	6.833	0.488,	12.265	0.032,	12.166	0.021,	6.952	0.459,

Table 6 (con't)

72	RFEMAL	15.256	0.050,	34.023	0.004,	23.179	0.883,	27.895	0.084,
73	RMALE	11.968	0.569,	15.061	0.121,	15.441	0.100,	13.970	0.209,
74	RFEMAL	16.520	0.187,	14.881	0.425,	17.688	0.104,	15.686	0.284,
75	RFEMAL	11.603	0.067,	7.481	0.526,	8.713	0.284,	10.385	0.123,
76	RFEMAL	11.346	0.036,	5.506	0.659,	7.440	0.251,	10.500	0.054,
77	RFEMAL	19.326	0.003,	8.765	0.654,	10.206	0.318,	15.333	0.025,
78	FEMALE	8.657	0.329,	12.842	0.041,	10.687	0.119,	7.771	0.512,
79	RFEMAL	11.999	0.086,	7.579	0.783,	11.806	0.095,	13.713	0.036,

GROUP
MALE
CASE

1	MALE	29.993	0.029,	34.023	0.004,	23.179	0.883,	27.895	0.084,
2	MALE	43.058	0.053,	41.824	0.098,	37.829	0.726,	41.390	0.122,
3	RFEMAL	21.256	0.126,	18.264	0.562,	20.280	0.205,	21.572	0.107,
4	MALE	11.844	0.080,	10.958	0.125,	7.597	0.672,	11.010	0.122,
5	RFEMAL	8.133	0.033,	1.794	0.790,	5.604	0.118,	6.994	0.059,
6	RFEMAL	21.614	0.011,	13.055	0.824,	16.625	0.138,	19.951	0.026,
7	MALE	12.246	0.083,	9.767	0.288,	8.290	0.603,	14.567	0.026,
8	RMALE	13.368	0.455,	14.194	0.301,	15.122	0.189,	17.641	0.054,
9	RMALE	5.972	0.513,	10.645	0.050,	6.603	0.374,	10.141	0.064,
10	MALE	9.729	0.282,	12.052	0.088,	9.432	0.327,	9.583	0.303,
11	RFEMAL	15.709	0.012,	8.243	0.516,	10.769	0.146,	9.159	0.326,
12	MALE	13.922	0.089,	16.292	0.027,	10.484	0.496,	10.978	0.388,
13	MALE	13.579	0.022,	8.934	0.225,	6.590	0.727,	13.227	0.026,
14	RMALE	5.851	0.454,	8.970	0.095,	10.259	0.050,	6.104	0.400,
15	MALE	18.885	0.138,	21.490	0.037,	15.436	0.773,	20.822	0.052,
16	FEMALE	12.299	0.034,	7.845	0.320,	9.964	0.111,	6.815	0.535,
17	MALE	8.712	0.037,	4.855	0.255,	3.017	0.640,	7.497	0.068,
18	MALE	28.730	0.044,	29.876	0.025,	22.667	0.910,	30.124	0.022,
19	MALE	31.347	0.042,	33.283	0.016,	25.194	0.914,	32.164	0.028,

Table 6 (con't)

20	RFEMAL	5.346	0.098,	2.563	0.393,	2.865	0.338,	4.212	0.172,
21	RMALE	7.972	0.348,	8.447	0.274,	8.031	0.338,	12.293	0.040,
22	MALE	19.720	0.015,	17.726	0.041,	11.438	0.941,	22.846	0.003,
23	FEMALE	8.900	0.131,	9.929	0.078,	8.277	0.179,	5.818	0.612,
24	MALE	11.148	0.108,	9.054	0.306,	7.884	0.550,	13.324	0.036,
25	MALE	4.204	0.197,	5.063	0.128,	2.153	0.549,	5.085	0.127,
26	FEMALE	12.774	0.027,	11.660	0.047,	8.534	0.226,	6.280	0.699,
27	MALE	15.860	0.057,	19.814	0.008,	11.038	0.634,	12.529	0.301,
28	RFEMAL	19.242	0.057,	12.191	0.473,	12.382	0.430,	15.663	0.083,
29	MALE	21.689	0.048,	18.812	0.200,	17.200	0.449,	17.981	0.304,

GROUP
FEMALE
CASE

1	FEMALE	12.544	0.097,	15.735	0.020,	12.763	0.087,	8.336	0.796,
2	FEMALE	25.615	0.055,	31.454	0.003,	25.972	0.046,	20.027	0.896,
3	RMALE	2.737	0.467,	3.245	0.363,	6.001	0.091,	6.307	0.078,
4	FEMALE	15.903	0.018,	10.076	0.338,	12.487	0.101,	9.125	0.543,
5	FEMALE	14.620	0.054,	10.746	0.374,	14.167	0.068,	10.149	0.504,
6	MALE	15.541	0.025,	12.181	0.136,	9.014	0.662,	11.655	0.177,
7	MALE	14.943	0.014,	9.945	0.174,	6.993	0.760,	12.356	0.052,
8	FEMALE	15.886	0.097,	17.763	0.038,	14.142	0.233,	12.143	0.632,
9	RMALE	9.403	0.857,	16.238	0.028,	17.812	0.013,	13.659	0.102,
10	FEMALE	5.333	0.221,	5.756	0.179,	5.956	0.162,	3.973	0.437,
11	FEMALE	2.423	0.352,	4.808	0.107,	3.853	0.172,	2.329	0.369,
12	FEMALE	24.319	0.018,	27.540	0.004,	29.359	0.001,	16.369	0.977,
13	RMALE	9.708	0.678,	18.118	0.010,	16.326	0.025,	11.431	0.287,
14	RMALE	9.938	0.389,	11.234	0.204,	11.611	0.169,	10.920	0.238,
15	RFEMAL	10.227	0.167,	7.301	0.719,	15.193	0.014,	11.245	0.100,
16	FEMALE	7.644	0.158,	7.276	0.189,	8.874	0.085,	5.080	0.568,
17	FEMALE	4.868	0.124,	4.879	0.123,	3.103	0.299,	2.263	0.455,

Table 6 (con't)

GROUP	NUMBER OF CASES CLASSIFIED INTO GROUP RMALE	RFEMAL	MALE	FEMALE
RMALE	33	5	5	5
RFEMAL	5	54	10	10
MALE	4	6	16	3
FEMALE	4	1	2	10

RMALE = Rocker Male
RFEMAL = Rocker Female
MALE = Non-Rocker Male
FEMALE = Non-Rocker Female

Non-Rocker Females (29):
Misassigned in 13 cases (44.8%), 4 as Rocker Males, 6 as Rocker Females, and 3 as Non-Rocker Females.

Non-Rocker Females (17):
Misassigned in 7 cases (41.2%), 4 as Rocker Males, 1 as Rocker Females, and 2 as Non-Rocker Males.

The four group discriminant thus correctly classified 113 mandibles out of 173, or 65.3%.

INTERPRETATION OF THE DATA

Before attempting the interpretation of the data, further discussion concerning the normality of the sample size and its associated characteristics is necessary to promote a better understanding of the results.

As stated previously, it was assumed that the sample studied was a normal class population. This means that the distribution of the individuals of the population were distributed on a bell shaped curve (more or less) with the majority of them near the means of the population, thereby forming the apex of the bell (see figure IV). In theory, especially when studying representative sample populations, the peripheral limits (i.e. range of variation) of the curve extends into infinity. The parameters in this case, though, are finite since the number of individuals are known. The working population numbers 173 individuals, forming one bell-shaped curve as in figure IV. But by dividing the population into two groups, such as Rocker and Non-Rocker, obviously will result in two curves instead of the original one since each group has its own mean (C_{KO} or constant). Although the parameters of the original curve will not change, there will be overlap among the two new curves (see figure V). Absolute discrimination will result in no overlap (i.e. two separate curves within the original parameters (see figure VI) but this is highly unlikely and overlap is inevitable, especially when working with metrical measurements on pop-

FIGURE IV
Bell-Shaped Curve

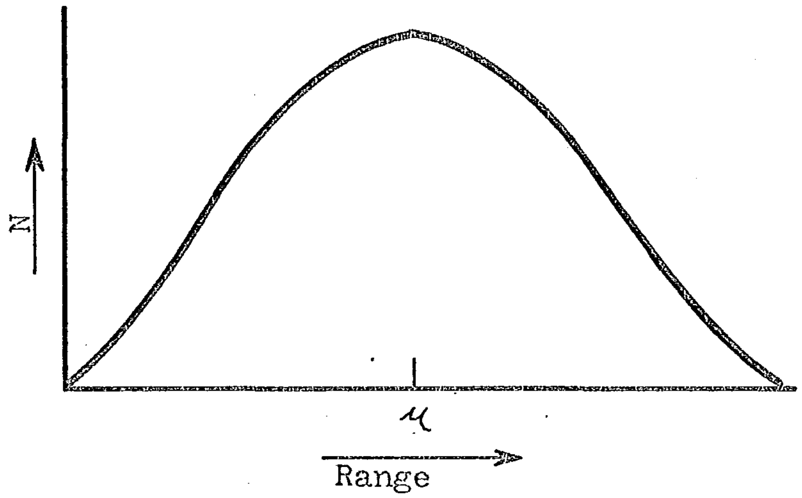


FIGURE V
Overlap between two groups of a single population

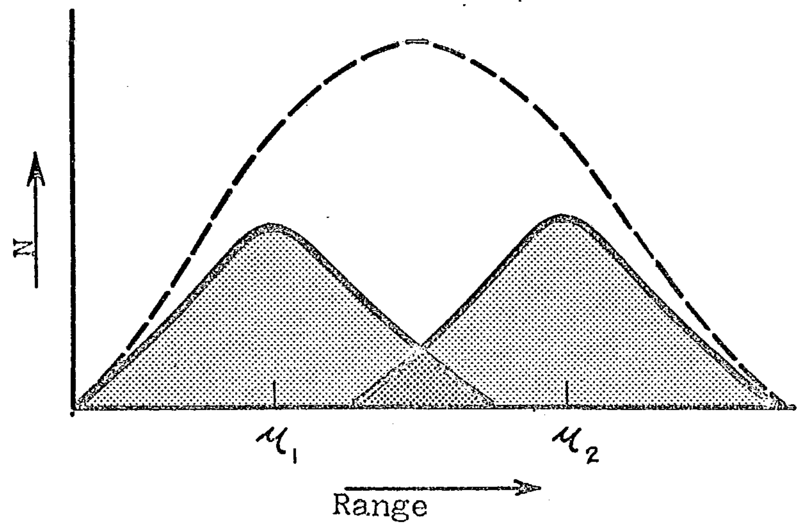


FIGURE VI
No overlap between two groups of a single population

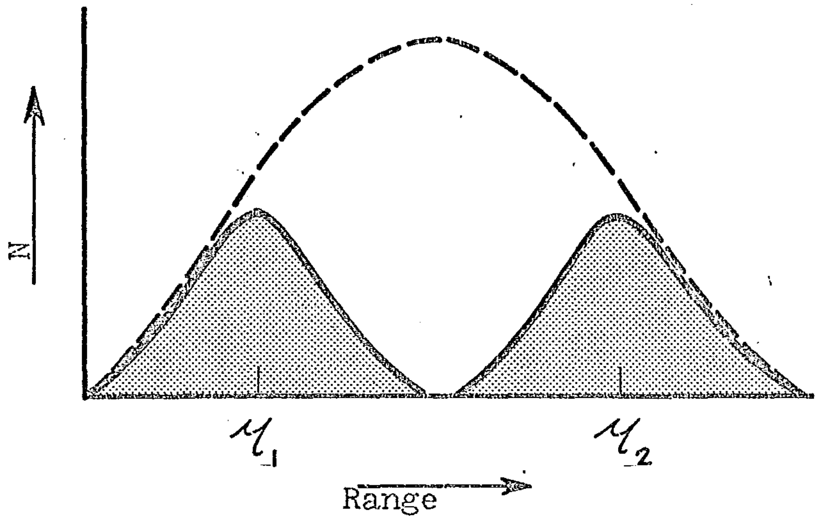
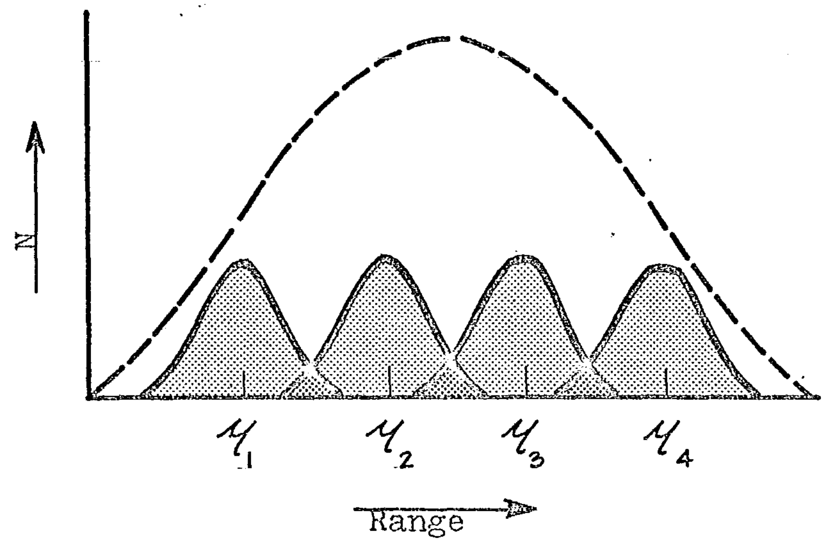


FIGURE VII
Four group overlap



ulations. Also, the data of this study show that many individuals' posterior probabilities of group membership are borderline (i.e. $\sim$0.500). These individuals may be theoretically classified as intermediates and, schematically, are within the overlap section of the two curves.

In a four group discrimination, more extensive overlap is expected and would appear as figure VII.

Since the differences between the discriminant constants are good, though not thorough, reflectors of general overlap, it appears that the results of the three groupings have a significant degree of overlap. This is further documented by a reading of the posterior probabilities for each group (see Tables 2, 4 and 6).

The point intended here is that, considering the characteristics of the normal distribution and the data of the study, overlapping of the population groups is expected. This is based mainly on two facts: 1) the weights of discrimination were not selected as thoroughly as they should have (due to time and money), and 2) absolute results are almost impossible when the discriminant function is testing the cases from which it was calculated from.

Another point is the fact that the 95% level of significance is quite harsh, especially when the point of the study, the hope of establishing correlates for Rocker jaw discrimination, is based on data from overlapping populations.

As Trevor and Mulhall state:

> "...The pre-assigned probability level, the significance level of the test, is necessarily arbitrary; commonly used levels are 0.05 and 0.01 but there is nothing sacrosanct about these values. It is convenient to express the significance level as a percentage and to speak, for example, of 'the 5 percent level of significance'. This reasoning can of course lead to an improper rejection of the hypothesis, owing to a 'significantly large' deviation from expectation by a sample characteristic being simply the result of the occurrence of an improbable event. The significance level of a test is in fact a measure of the risk of falsely rejecting the hypothesis being tested...." (1962;40)

Thus, the significance levels are good indicators but due to their arbitrary origin, are not the ultimate indicators.

The basis of classification for the program was based on the square of distance and the posterior probabilities. The latter's classification was based on the fact that any individual whose posterior probability was greater than 50% entitled him classification to that respective group. Theoretically, an individual may have a posterior probability of 100% for one group and 0% for the other group(s) but this is very highly unlikely due to the relative nature of the variables and the normal distribution. A case in point is #42 of the male cases of the Male/Female groupings (see Table 4). The fact that this individual has a 99.8% (0.998 as seen in the table) probability means that he is very near the outer parameter (i.e. near the extreme end of the bell curve where the individuals' constant values exceed -620.14185). He has a great probability of being a male, according to the calculation, but there still exists a small probability (0.2% or 0.002) of being a female because his measurements show his relation to the female group to that degree (i.e. 0.2%). Again this shows the relativity of the variables and also the nature of the type of study this field of anthropology is obligated to use. Complete discrimination is possible but a great amount of "fixing" and "remodeling" must be utilized by the researcher.

F-RATIO

The discriminant function wieghts are selected from the F-ratios which are univariate values. Each F-ratio is a reflection of that characteristic's discrimination between the groups. But these values only measure each characteristic singly, in other words, it does not calculate all the characteristics' values toward group discrimination.

In such a comparison the relations among the various measurements used, both with regard to correlation and to the direction of difference, do not appear - i.e. the essential morphology, or total shape difference, is not apprehended even though the information is present in the measurements. This of course is what multivariate analysis does, here in the form of discriminant functions. (Howells: 1966; 21)

The program computes pooled within-groups and total sample cross-product matrices using all the data and selects the character giving the highest F-ratio as the first and "best" measurement; other characters are then added in stepwise fashion. At each step the variables are divided into two disjoint sets ("included" and "remaining"), and the two cross-product matrices are partioned to permit independent analysis of the dispersion of those remaining. The variable entered is that which gives the highest F-value computed after removal of the effects of those already selected. (Rightmire: 1970; 180)

In sum, since the F-ratio cannot be utilized for total discrimination due to its univariate origin, the program recomputes the remaining variables after the highest F-value was removed. Also due to its univariate origin is the fact that, singly, an F-value may be very significant (i.e. have a large value relative to the others) but when placed in the final discriminant function, its value may decrease. This is reflected by examination of the discriminant coefficients. A case in point is variable #2 (rameal breadth) in the Rocker discrimination whose F-value was the first to be selected out (see Table 2) and, after the first step, had a calculated discriminant coefficient of 5.20014. But after selection of all the variables concluded, the value of its coefficient decreased to 1.07647 (as seen in Table 1).

The reverse of this process may also occur. Examination of the condylar breadth in the same discrimination program shows that this variable had increased its dicriminant coefficient value. Originally with an F-value of 0.0029 (see Table 8) it was not selected out until the sixth step (i.e. it was the sixth variable selected out). Its initial discriminant weight was 2.01854, after the sixth step. But the final discriminant function (see Table 1) shows its final value to be the largest in the function, that is, 3.11306.

Thus, variables initially may either have significant or non-significant F-values. But only after the final discrimination function is computed does the "true" value of its discriminatory powers show itself. Of course, this is also relative to the other variables in the final function.

DISCUSSION

ROCKER DISCRIMINANT

Table 7 shows the initial and final F-values (i.e. value during selection out) for the selected variables.

Table 7

Rocker/Non-Rocker Discriminant

Step #	Variable	Initial 'F'	Final 'F'
1	2. Rameal breadth (rb')	5.2002	5.2002
2	6. Corpus height (m_1m_2)	2.6477	6.3917
3	7. Corpus height (p_1p_2)	0.3748	8.3635
4	14. Mandibular length (ml)	1.9853	7.2899
5	10. Gonial breadth (gogo)	5.1022	3.8275
6	1. Condylar breadth (w_1)	0.0029	3.7321
7	15. Coronoidal height (crh)	1.8730	1.0861
8	13. Rameal length (rl)	0.7978	1.1657
9	4. Condylar length (cyl)	0.1939	1.2407
10	8. Distance between foramina (zz)	0.4719	0.4491

By correlating these values, it is found that, initially, variables #2, #10, and #6 are good individual discriminators of Rocker/Non-Rocker groups. But as the higher values are removed, there is a change in their values. For example, variable #6 increased its F-value from 2.6477 to 6.3917 after variable #2 was removed. Final values then show that variables #2, #6, #7, and #14 are relatively good discriminants individually. But correlation with Table 1 which shows their discriminant weights, show that the "best" variables for Rocker discrimination are those with the largest values. But the discrimination does not end here. Since there are two discriminant functions computed, the best discriminators for Rocker/Non-Rocker separation would be those coefficients with the greatest degree of difference between its two values. Thus, in the sphere of the ten variables listed in Table 1, variables #6 and #7 show the greatest degree of difference within the final group. Since the degree of separation is a reflection of the different values of the coefficient for each group, the exact amount of difference for significance is arbitrary. In essence, a variable (i.e. coefficient) with the greatest change in values has a greater effect on the individual's ultimate scores because it further enhances the degree of separation among the individual's two computed constants (i.e. the product of the coefficients times the individual's measurements).

Thus, variables #6 and #7 have the greatest effect on the individual's final score. Since this discriminant function measures separation between Rocker/Non-Rocker, it is important to note that variables #6 and #7 are the heights of the corpus at m_1m_2 and p_1p2, respectively. These areas are critical in the visual determination of the rocker jaw.

What these two functions reflect is that although there are variables with significant coefficients which contribute greatly to the final score, the fact that there exists two functions, instead of one made up of the means of the coefficients, shows that the degree of difference is highly important for the purposes of analysis.

In sum, variables with the higher values obviously add more to the discriminant score. But a variable is expressed to a greater degree in their respective functions when its two coefficients have a relatively significant difference, thus enabling better discrimination in the final function.

SEX DISCRIMINANT

Discrimination was carried out only for the rocker jaws. Table 8 shows the initial and final F-values for the selected variables.

Table 8

<u>Sex Discriminant</u>

Step #	Variable	Initial "F"	Final "F"
1	10. Gonial breadth (gogo)	52.4978	52.4978
2	7. Corpus height (p_1p_2)	42.9098	15.3196
3	16. Condylar-coronial angle (R∠)	18.1538	12.6873
4	1. Condylar breadth (w_1)	46.6801	3.4341
5	14. Mandibular length (ml)	33.6428	2.5504
6	13. Rameal length (rl)	29.8124	0.8567
7	15. Coronoidal height (crh)	27.3757	0.9578
8	8. Distance between foramina (zz)	10.7294	0.2166
9	4. Condylar length (cyl)	33.2226	0.1738
10	3. m_2p_1 chord	3.0063	0.0601

Correlation of these values with Table 3 shows that variables #10, #7, and #16 are good individual discriminatiors, their powers of discrimination are relatively small in the final function.

Variable #3 (m_2p_1 chord) was the tenth, and last, variable to be selected out. Although its final F-value was the smallest of the ten, its powers of discrimination in the final function was the largest. Thus, in context with and relative to the other selected variables, the"best" discriminators of sex for the sample were variable #3 and #14.

In my opinion, the difference between the coefficients were not significant compared to the Rocker/Non-Rocker discriminant. As expected, the females' weights and measurements were, on the whole, smaller than the males. This is just a reflection of sexual dimorphism.

The range between the constants is quite large compared to the previous group. Again this would be expected (i.e. sexual dimorphism) since the previous discriminant was not divided by sex.

The high values of the weights of variables #3 and #14, m_2p_1 chord and mandibular length, implies that the length of the mandible is a good sex discriminant. Measurement m_2p_1 is a partial measure of mandibular length, and thus is closely associated with it.

FOUR GROUP DISCRIMINANT

The initial and final F-values for the four group discriminant are listed in Table 9.

Table 9

Four Group Discriminant

Step #	Variable	Initial "F"	Final "F"
1	10. Gonial breadth (gogo)	17.2821	17.2821
2	6. Corpus height (m_1m_2)	12.4875	7.3845
3	16. Condylar-coronial angle (R∠)	8.9923	7.4813
4	7. Corpus height (p_1p_2)	14.2636	3.5539
5	14. Mandibular length (ml)	12.7845	3.7191
6	2. Rameal breadth (rb')	6.5438	3.6654
7	1. Condylar breadth (w_1)	15.0190	2.8158
8	15. Coronoidal height (crh)	8.8760	1.8913
9	12. Corpus length (cpl)	8.4915	0.9985
10	3. m_2p_1 chord	17.2821	0.8639

Correlation with Table 5 shows that, as in the Rocker discriminant, variables #6 and #7 have the greatest range of values as coefficients. Variables #3, #6, and #14 have the greatest discriminant weights and, therefore, add greatly to discrimination among the four groups.

This discriminant only re-iterated the fact that variables #3 and #14, as in the Sex discriminant, remained good discriminators despite the increased number of groups. Also variables #6 and #7 retained their divergence, as was first noted in the Rocker discriminant.

The focus of this study was an attempt to produce a valid discriminant function, which would be able to separate Rocker jaws from normal jaws, based only on metrical characteristics. If there existed any correlating metrical characteristics, it was also the aim to determine them.

The discriminant functions of the Four group discriminant showed that correct classification of Rocker males was 68.7% (33 of 46) and, in Rocker females, 68.4% (54 of 79).

The best discriminators of the Rocker jaw are the corpus heights which are necessarily the best discriminators for visual classification.

Though the corpus heights (m_1m_2 and p_1p_2) showed to be the best discriminators of Rocker and Non-Rocker individuals, note should be taken that their discriminatory powers were large within the context of the other variables they were selected out with. Analysis of their initial and final F-values, and their discriminant weights show that they are fairly good discriminators when taken individually but their powers increase when included within the final discriminant function.

Discriminatory powers, in this case, were not necessarily based on high coefficient values but in the degree of difference exhibited by their coefficients for their respective groups.

Gonial eversion was evident in 32.4% of the sample, 18.6% of this total were Rocker jaw individuals. Rocker jaw individuals without gonial eversion consisted of 59.0% of the sample. Though these figures tend to imply that no correlation exists between this trait and Rocker jaw, I would hesitate to give a definite statement until more definitive methods of analysis are carried out.

The other non-metrical characteristics measured showed no hint of correlation with the Rocker jaw frequency (i.e. percentage frequencies were not compatible). Also, no specimens with torus mandibularis were evident in the sample.

In summary, it appears that, by this study, the Rocker jaw's only characteristic is its deviation in the corpus height. Although other variables lend their weight to the discrimination process, their weights, when compared among the three discriminant programs recorded, remained relatively the same. These weights, in my opinion, would be constant in all cases and combinations of variables.

Although the results of this study are not quite spectacular, the value of it lies in the method and procedure of discriminant analysis. This type of analysis offers a great deal to the researcher because it eliminates much subjectivity, considering that the researcher is aware of its limitations, by its analytical nature.

Comparatively speaking, rocker jaws are present in other non-Hawaiian populations. Evidence of this are the studies by Oschinsky (1964), Murrill (1968), and Pietrusewsky (1969).

Oschinsky's study gives the frequencies of rocker jaw among the Eskimo (4.0%) and Indians (20.0%) out of sample sizes of 17 and 20, respectively. The fact that these sample sizes are very small when compared to this study's sample of 173 does not lend much reason to a valid comparison of rocker jaw frequencies between the Eskimo, Indian and Hawaiian. But it should be noted that the diets of these three peoples vary considerably. The Eskimos, on one extreme, chewed considerably and on much tougher items (i.e. leather) than did the Hawaiians, the other extreme, whose diet did not cause tooth attrition to be as severe as that of the Eskimo. The possibility that the rocker jaw is not a functional development is inferred.

Murrill's study of skeletal remains of Easter Island gives the frequency of rocker jaw as 35.3% among a sample of 17 individuals. Again this sample size is very small when compared to this study's. But it should also be noted that the diet of the Easter Islanders was typically Polynesian as described by Murrill (1968;59-60). It would appear that a more favorable complementation of rocker jaw frequencies might occur if a larger sample size were possible. But as in the first comparison, this is only inferred by the existing data.

Pietrusewsky's study of 99 Tongan individuals gives the frequency of rocker jaw as 76.4%. The Tongans, and the Easter Islanders, are considered Polyneasians by physical type and the frequencies among these three groups only enhance the fact that the rocker jaw is very prevalent in Polynesia.

It would not appear that diet and chewing habits lend to the development of rocker jaw among the prehistoric populations mentioned above. It does appear that this is a genetic trait which may or may not have had any selective advantage.

The rocker jaw, being heavier and with larger muscles, may have been socially advantageous in making the individual Eskimo female a more competent chewer and biter, especially in the selection of wives.

On the other hand, there appears to be no selective social advantages of rocker jaws among the Polynesians. Figurines and wooden images attest to the fact that this trait was noticed by the Polynesians (Snow: in press).

The sporadic occurrence of this characteristic among individuals of other racial ancestries not mentioned lend to the hypothesis that the rocker jaw is a purely genetic trait and that Polynesians may have exhibited an almost perfect isolation of it.

SUMMARY

The results of multivariate analysis suggest that the best discriminators of rocker jaw are variables #6 and #7, the heights of the corpus at m_1m_2 and p_1p_2. These measurements are also the best visual discriminators due to the fact that they consist of the critical area of observation for rocker jaw (i.e. the lower border of the corpus). Also, there was no significant evidence of any other mandibular characteristic related to the rocker jaw.

The best indicators of sex are variables #3 and #14, m_2p_1 chord and mandibular length, respectively. These two measurements reflect the most significant difference between the male and female Mokapuan samples. As with other Polynesian populations, the male is more robust and larger while the female has finer features.

Distribution of the trait within the sample demonstrates that it is not sex-limited and that it is first evident during adolescence. Since it occurs in both sexes it is not a secondary sexual characteristic and it is probable that its development is under the influence of the pituitary growth hormones.

In the absence of evidence to the contrary, it appears to be a genetic trait. This conclusion is based largely on negative evidence: a) it does not appear to be pathological, b) it does not appear to be associated with environmental influences such as nutrition, head deformation or mode of life,

c) the occurrence of the trait sporadically in populations living under a wide variety of conditions throughout the world.

The trait appears to have no functional role and accordingly environmental selection is unlikely to act directly upon it.

Gentic drift, as opposed to functional adaptation, is the most probable reason for the high frequency of the rocker jaw among the Polynesians of this sample. Although the frequency of the trait compares favorably with that of Tonga and of Easter Island, uncertainty of dating makes exact comparison impossible. Inferences as to migration and diffusion cannot be made until more precise dating of samples is available.

In concluding, it must be re-iterated that interpretation of the results is limited by uncertainty in dating the sample and its possible heterogeneity arising from the nature of the excavation of the material. Statistically, the results are qualified by the relatively small sample size and the fact that the variales were selected beforehand.

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APPENDIX

ROCKER vs. NON-ROCKER MEANS

Variable	Group ROCK	NOROCK	Grand Means
1	122.92494	122.98650	122.94131
2	34.92264	36.10208	35.23624
3	29.27943	29.00209	29.20567
4	21.21565	21.36731	21.25598
5	30.04716	30.74123	30.23170
6	28.60069	27.81297	28.39122
7	29.72202	30.10861	29.87619
8	49.87115	49.33907	49.72964
9	96.15033	96.39334	96.21495
10	97.44386	99.75195	98.05757
11	122.56480	120.98633	122.14508
12	76.96530	77.32600	77.06120
13	60.52844	59.67601	60.30177
14	105.90868	104.38672	105.50398
15	61.99846	63.38033	62.36588
16	72.09196	74.42816	72.71315

Standard Deviations

Variable	Group ROCK	NOROCK
1	6.42392	6.96361
2	2.91943	3.23460
3	1.94503	2.44234
4	1.82678	2.42384
5	4.37395	2.84911
6	2.81758	2.80066
7	2.98573	3.05908
8	5.08901	2.11338
9	5.79684	5.88423
10	5.42769	7.17595
11	6.26630	6.42019
12	5.05543	5.50411
13	5.16537	6.49441
14	6.40285	5.90933
15	5.58667	6.58976
16	6.49423	6.26348

MALE vs. FEMALE MEANS

Variable	Group MALE	FEMALE	Grand Means
1	127.20581	120.32451	122.92531
2	36.08115	34.21889	34.92273
3	29.66034	29.04800	29.27943
4	22.28534	20.56573	21.21567
5	32.20827	28.73410	30.04716
6	30.24367	27.60243	28.60069
7	31.72076	28.62016	29.79204
8	51.69992	48.76067	49.87155
9	99.59351	94.05898	96.15077
10	101.21631	95.15244	97.44429
11	121.76797	123.04953	122.56517
12	79.71033	75.29829	76.96582
13	63.42493	58.76933	60.52890
14	109.67676	103.61966	105.90895
15	65.02490	60.16045	61.99898
16	75.04784	70.29697	72.09254

Standard Deviations

Variable	Group MALE	FEMALE
1	6.47962	4.82077
2	~~2.96969~~	~~2.66955~~
3	1.80550	2.00087
4	1.55768	1.67239
5	3.60329	4.29661
6	2.95101	2.21503
7	2.97299	2.32264
8	7.38339	2.38324
9	5.83593	4.69435
10	4.44995	4.64575
11	5.81553	6.51304
12	5.11106	4.25367
13	5.52640	4.04786
14	5.54396	5.80183
15	6.41519	4.06952
16	5.83568	6.24272

FOUR GROUP MEANS

Variable	Group RMALE	RFEMAL	MALE	FEMALE	Grand Means
1	127.20581	120.32451	121.65164	125.26462	122.94165
2	36.08115	34.21889	36.54131	35.35287	35.23628
3	29.66034	29.04800	29.14130	28.76465	29.20567
4	22.28534	20.56573	21.03096	21.94113	21.25600
5	32.20827	28.73410	30.43095	31.27054	30.23170
6	30.24367	27.60243	27.30684	28.67642	28.39122
7	31.72076	28.62016	29.57581	31.01758	29.87619
8	51.69992	48.76067	49.26199	49.47054	49.72993
9	99.59351	94.05898	96.03439	97.00583	96.21527
10	101.21631	95.15244	98.23784	102.33521	98.05789
11	121.76797	123.04953	120.04129	122.59990	122.14548
12	79.71033	75.29829	77.76888	76.57051	77.06157
13	63.42493	58.76933	59.26544	60.37640	60.30211
14	109.67676	103.61966	103.33440	106.18228	105.50421
15	65.02490	60.16045	64.08612	62.17639	62.36626
16	75.04784	70.29697	75.77232	72.13522	72.71355

Standard Deviations

Variable	RMALE	RFEMAL	MALE	FEMALE
1	6.47962	4.82077	7.11470	6.24981
2	2.96969	2.66955	3.65067	2.27104
3	1.80550	2.00087	2.97914	1.07233
4	1.55768	1.67239	2.61057	2.01062
5	3.60329	4.29661	3.12170	2.30319
6	2.95101	2.21503	3.04313	2.14434
7	2.97299	2.32264	3.36840	2.25201
8	7.38339	2.38324	2.26470	1.88605
9	5.83593	4.69435	6.24724	5.33388
10	4.44995	4.64575	6.62071	7.54143
11	5.81553	6.51304	6.63058	5.88225
12	5.11106	4.25367	5.84074	4.95425
13	5.52640	4.04786	7.58562	4.13529
14	5.54396	5.80183	5.74874	5.91164
15	6.41519	4.06962	7.47241	4.68794
16	5.83568	6.24272	6.59744	5.03053