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SYMMETRY ANALYSIS OF *INCISURA ISCHIADICA MAJOR* IN SEXING THE HUMAN PELVIS

ABSTRACT: The shape analysis of incisura ischiadica major *(greater sciatic notch) on 97 male* os coxae *and 98 female* os coxae *was performed in order to assess their sexual shape differences. The material, from 19th and 20th centuries, came from Czech and German collections of the Institutes of Anatomy in Prague and Brno.*

The outline of each incisura *between the* spina ischiadica *and the* spina iliaca posterior-inferior *up until the extremity of the* facies auricularis *was described in terms of asymmetry confronting the inferior and the superior ramus.*

The outlines were standardized for position and normalized at the same dimensions to eliminate size differences.

The analysis was carried out by means of the S.A.M. (Shape Analytical Morphometry) software-system (developed by Research Consortium DIGAMMA, Bari – Italy).

The used analytic procedure involves the construction of a complex in which two profiles (in our case the superior and the inferior ramus of the sciatic notch) are facing each other as in a mirror image separated by a straight segment. This bifrontal figure explains the name of the procedure: "Janus". On the complex, a parabolic interpolation giving a vectorial description of the symmetries in term of allometric and isometric differences between the two rami *of the* incisura *was performed. In addition, the comparison of each profile with a straight line in order to obtain internal allometry and isometry evaluation was also performed. Both metric and analytic data were used in multivariate discriminant analysis; after using a combination of analytic variables obtained from "double" and "single" comparisons, 92% of all cases proved to be correctly classified.*

KEY WORDS: Sex determination – Pelvic bone – Shape analysis – Incisura ischiadica major

INTRODUCTION

Usually, precise morphological and metric boundaries between the male and female sexually differentiating characters of the skeleton, are not precisely definable. This is true for pelvic bones too, despite the fact that they are the most sexually differentiated bones of the skeleton. The bony pelvis, in fact, appears as a complicated, hierarchically integrated system and simultaneously as an intersection point of various factors (mainly locomotion and reproduction) determining their sexual dimorphism.

The single pelvic bone (*os coxae*) can be divided into two evolutionary, functional and causally relatively independent sub-systems, namely the ischiopubic segment and the sacroiliac segment.

The sacroiliac segment reflects well the sexually differentiated process of hominization – adaptation to the verticalization of the body and bipedal locomotion.

The ischiopubic segment reflects mainly the phylogenetic adaptation of the female small pelvis to the mechanical conditions of parturition with a relatively large foetus.

The sexually differentiating morphological characters of the pelvis as a whole, if used to set discriminant function, yield up to 100% of correct sex identification in a known series (Novotný 1986). The discriminant functions

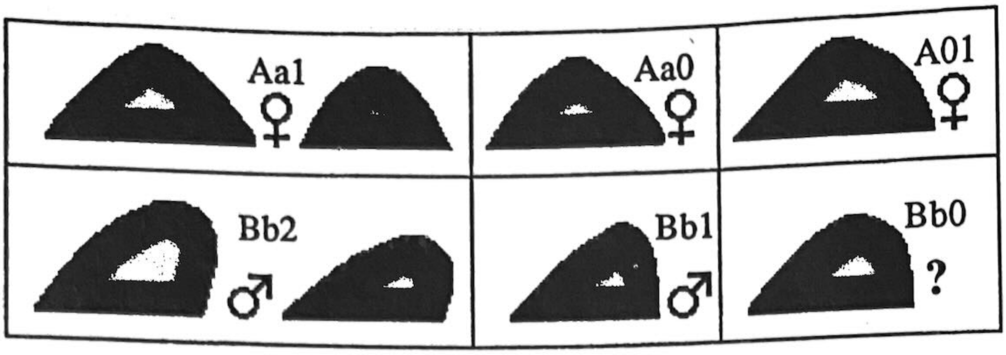


FIGURE 1. Samples of *incisura ischiadica major* profiles classified according to the "logical analysis of an idealized shape" criterion (Novotný 1980). The cases scored **Aa1** correspond to a female morphology characterized by equally long arms symmetrically diverging and with the superior segment without recursive trend; on the contrary, the cases scored **Bb2** correspond to male *incisurae* having the superior segment of the *incisura* shorter, the rami diverge asymmetrically and the superior segment presents recursivenes. The case **Bb1** pertains to a male morphology, but the superior arm does not present recursivity.

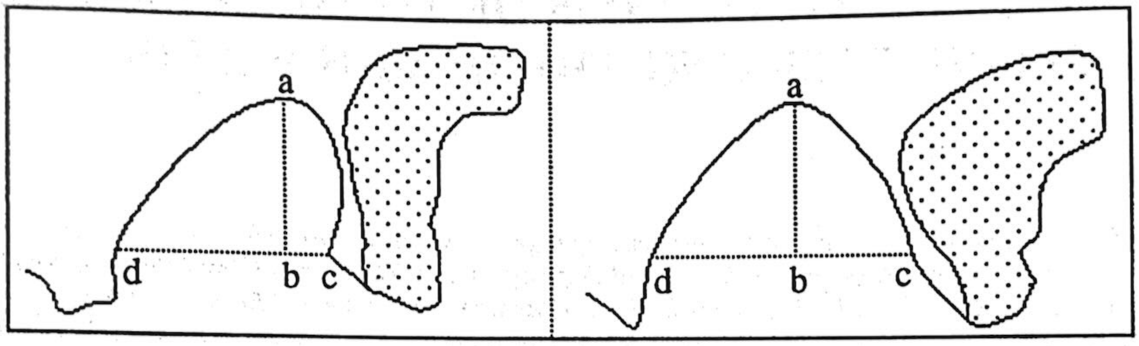


FIGURE 2. A male and a female *incisura* sample: the points used for the positioning (c and d) and the segment adopted for dimensional normalization (a - b) are reported. The examined traits were the superior (a - c) and the inferior (a - d) *rami*.

obtained by using the individual pelvic segments characters are less successful, namely in the sacroiliac segment. The *sulcus preauricularis* alone permits a correct sex determination in 80% of all cases, the shape of the *incisura ischiadica major* in 70%, the lower border of the pelvis (*margo inferior ossis coxae*) in 62%, the "arc composé" in 60% (Novotný 1972).

The above reported results are obtained by metric analysis or by scoring the form of the sex determining characteristics (Ferembach *et al.* 1980).

The scoring methods based on the observer's experience and skilled eyes are not easily standardizable and could suffer from a low level of objectivity; furthermore, despite our visual perception being very effective in shape recognition, we are weak in shape description and sometimes variations of form could escape observation (Pesce Delfino *et al.* 1996). Anyway, attempts to standardize observation can help in defining and understanding different aspects of scoring form. A proposal to standardize observation, in scoring the *incisura ischiadica major* form, was made by Novotný (1981). According to this proposal the shape should be derived and scored from those characteristics of the *incisura* that did not contradict each other: in males the *incisura*, in contrast with the opposite sex, is always narrower, deeper, more closed and the shorter superior arm has a recurvate course; in females the *incisura* on the contrary is wider, shallower, with equally diverging long arms. So that, the *incisura* form, could be identified and defined by the morphoscopic analysis of three main morphological elements: 1) length of the *rami*; 2) symmetry of the *rami*; 3) recursiveness of the superior *ramus*. In Novotný's proposal, each of this aspects of the form is scored by a separate digit; for example, the female traits are classified as follows: if the rami of the *incisura* have the same length, **A** is attributed to the first digit; if the rami diverge in a symmetric way, **a** is attributed to the second digit; if the latero-superior segment does not present recursive trend, the number **1** is attributed to the third digit; following this, a typical female form will be scored **Aa1**. On the contrary the male traits will be classified as follow: if the superior *ramus* of the *incisura* is shorter, **B** is attributed to the first digit; if the *rami* diverge in an asymmetric way, **b** is attributed to the second digit; if the superior *ramus* is characterized by a recursive trend, the number **2** is attributed to the third digit; so that a typical male form will be scored **Bb2**. In case of ambiguous elements the sign **0** (zero) is attributed. In *Figure 1* samples of scored *incisurae* are reported.

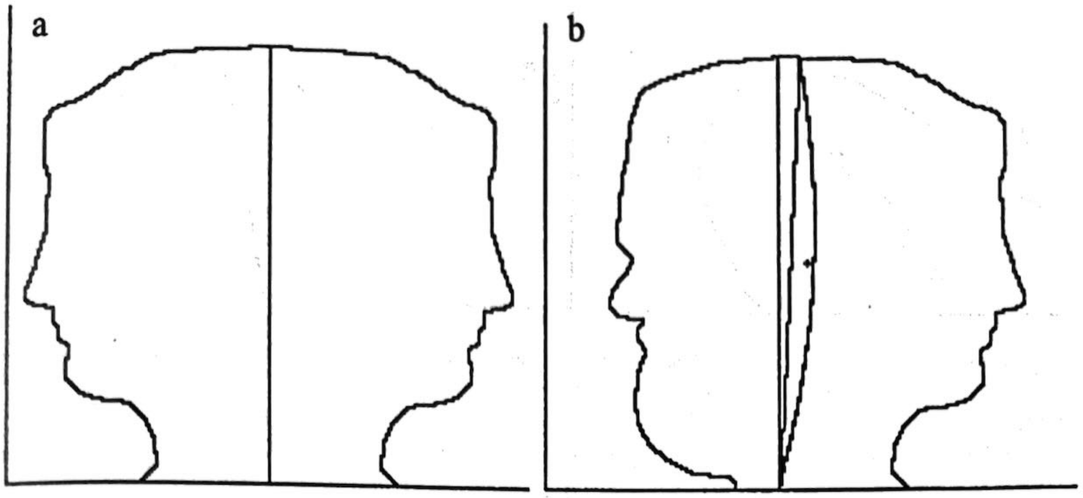


FIGURE 3. "Janus" procedure (parabolic fitting): the profiles are compared facing each other, separated by a straight line segment, as in a mirror image; the symmetry evaluation is performed by interpolating the complessive figure with a second degree equation according to the least squares method. When the symmetry is perfect (i.e. the two compared outlines are the same) the coefficient of the square term of the parabola will be equal to zero and the arc of the parabola flattens to a straight line, corresponding to a symmetry axis (*Figure 3a*); in the other cases, according to the differences between the two curves and consequently according to the coefficient values of the equation, the arc will be more or less convex, shifted and inclined (*Figure 3b*).

The shape variability scored according to this "ideal shape analysis" principles is great indeed, given that only 70% of correct sex attribution is obtained (Novotný 1981).

Considering this, one can ask whether this result corresponds to the actual degree of sexual dimorphism expressed by the sciatic notch or, simply, whether shape variations are only partially described by the adopted observative scoring method. If so, specific solutions for numerical description of the shape, able to reduce the share of subjectivity, could be of help in extracting as much as possible of shape information due to sexual dimorphism.

The method to score the shape of the *incisura* that we have seen above, is based, practically, on the comparison of the two *rami* of the *incisura* in terms of symmetries; this led us to study the same samples of *incisurae*, on which the "ideal shape analysis" had been carried out, by using shape parametric description based on the logic of the S.A.M. (Shape Analytical Morphometry) software system (Pesce Delfino, Ricco 1983); this system, based on analytic geometry morphometric procedures, in fact, provides a section for comparing open curves in terms of symmetry.

MATERIALS AND METHODS

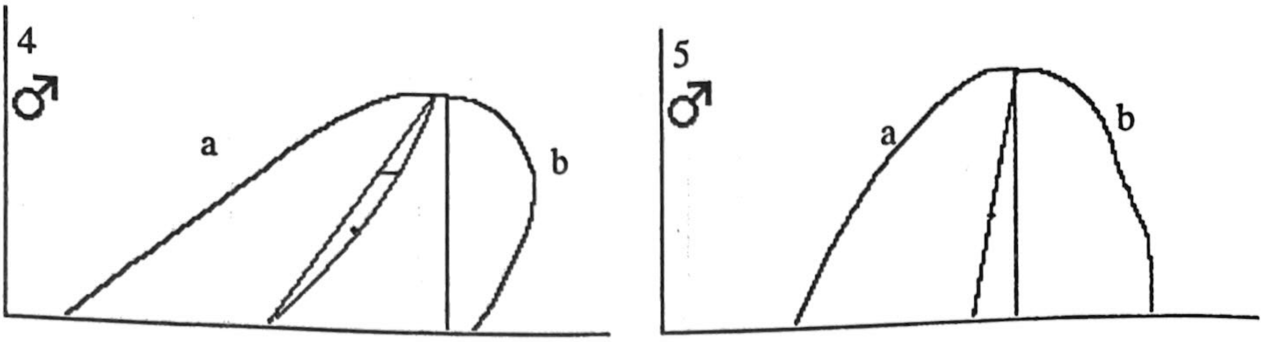
In this work 97 male and 98 female *os coxae* were studied. The material, of known sex, was of Czech and German origin, dated to the last century (about 1880-1980) from the collections of Anatomical Institutes in Prague and Brno.

For each *os coxae* the silhouette of the *incisura ischiadica* was firstly obtained by optical projection and by illuminating the *incisura* by an extended and sufficiently distant light source (*Figure 1*); then the *incisura* was considered in the trait between the root of the *spina ischiadica* (the point where the *spina* deflects from the *incisura*) and the top of *tuberculum musculi piriformis* (points **d**, **c** in *Figure 2*). This reference points were placed in a system of orthogonal Cartesian axis on the same ordinate value; the profiles were dimensionally normalized with an optical scaling attributing the same value of depth to every one (segments **a-b** in *Figure 2*) so as to reduce size influences.

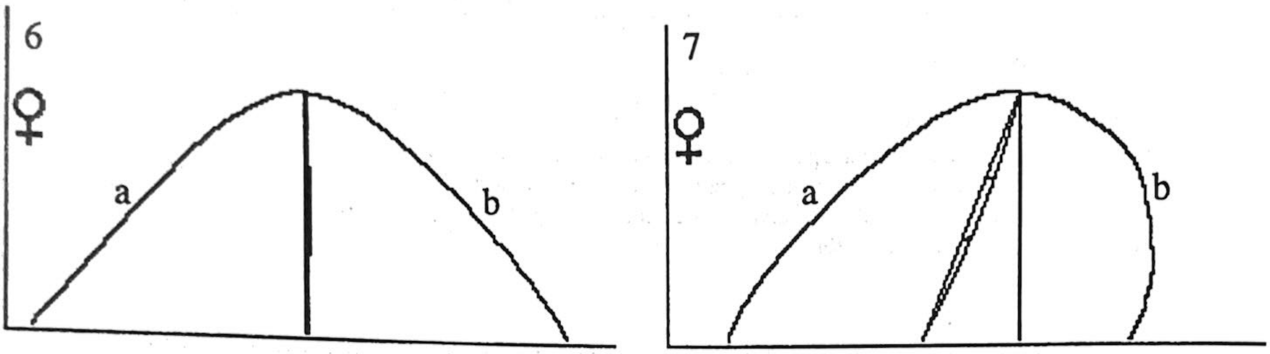
For each *incisura* two separate series of 90 equispaced abscissa values were serially acquired starting from the deepest point of the *incisura* (point **a** in *Figure 2*) up to the two extremities of the outline (points **c** and **d** in *Figure 2*) corresponding to the the superior part and the inferior part (**a-c** and **a-d** traits in *Figure 2*) of the notch.

The acquisition and the analytical data processing were performed by using the S.A.M. system. The system is constituted by an integrated architecture of analytical geometry procedures which allows a description of the shape in two dimensional objects. For this work, the section dedicated to the symmetry analysis was mainly used (Pesce Delfino *et al.* 1990, 1991). This section permits the evaluation of allometric and isometric shape differences of profiles constituted by open curves placed in a standardized position.

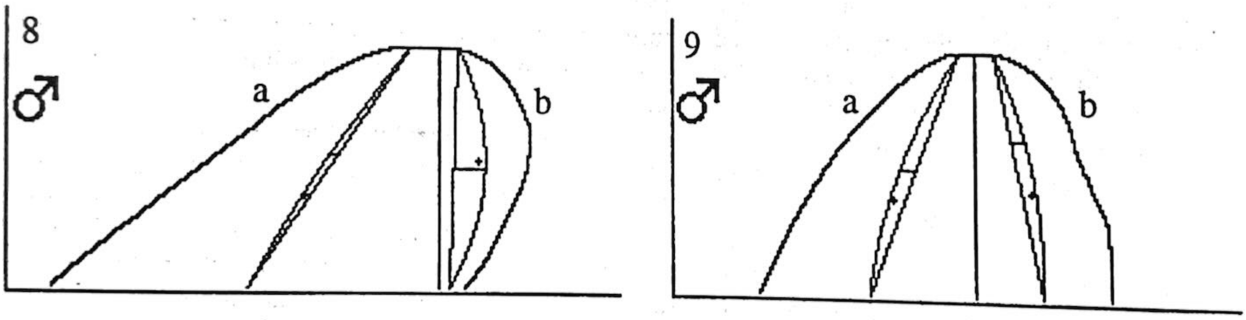
The profiles to compare face each other, separated by a straight line segment, as in a mirror image; for example, in the case of fronto-facial profiles, a two-faced figure will have to be constructed which is formed by the two profiles to be compared (*Figure 3*) as in a bifrontal herma or as in the latin god "Janus". In our case the profiles faced are the two rami of the *incisura* (**a-c** and **a-d** traits in *Figure 2*) placed, practically, in their anatomical condition.



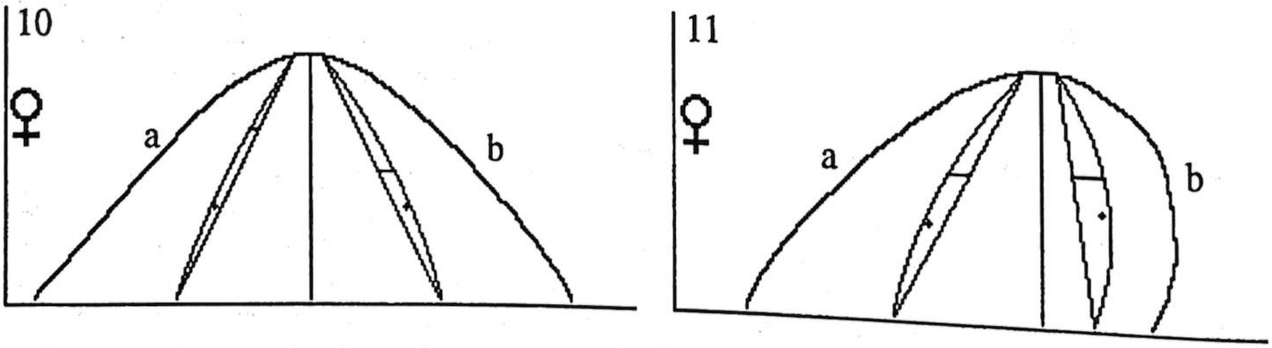
FIGURES 4, 5. Graphic representation of results in the "Janus" procedure applied on two extreme morphologies for the male form. The symmetry analysis is performed comparing the inferior ramus (a) with the superior ramus (b) of the *incisura ischiadica major*. In *Figure 4* a highly asymmetric case both for allometry and isometry with a high degree of chord slope is reported; in *Figure 5* a case characterized by the prevalence of isometric differences with a lesser degree of chord slope and absence of allometries is reported.



FIGURES 6, 7. Graphic representation of results in the "Janus" procedure applied on two extreme morphologies for the female form. The symmetry analysis is performed comparing the inferior ramus (a) with the superior ramus (b) of the *incisura ischiadica major*. In *Figure 6* a symmetric case (allometry, isometry and chord slope are practically absent) is reported; in *Figure 7* a case characterized by a medium degree of allometric and isometric differences is reported.



FIGURES 8, 9. Analysis made by comparing separately the inferior *ramus* (a) and the superior *ramus* (b) to a straight line. In *Figure 8* a case with a high degree of asymmetry both for the inferior ramus (isometries are prevalent) and the superior ramus (allometries are prevalent); in *Figure 9* a case characterized by the presence of allometries and isometries for the two sides.



FIGURES 10, 11. Analysis made by comparing separately the inferior ramus (a) and the superior ramus (b) to a straight line. Samples of the procedure applied on two extreme morphologies for the female form. Both cases are characterized by light allometric differences between the two sides, but for the case in *Figure 11* the allometry is bigger.

TABLE 1. Mean and standard deviation of the metric values (area under the curve, profile length and profile projection on the ordinate axis) obtained by analyzing the *inferior* and the *superior ramus* of the *incisura*. Males: N = 97; Females: N = 98.

	INFERIOR RAMUS			SUPERIOR RAMUS		
	AREA	LENGTH	PROJECTION	AREA	LENGTH	PROJECTION
♂						
MEAN	10952.6	151.8	112.7	7620.8	114.9	38.4
S D	1191.2	15.5	21.3	553.1	4.372	11.5
♀						
MEAN	9837.3	138.1	94.4	8971.2	126.1	67.3
S D	878.4	11.142	17.8	793.1	8.5	14.9

TABLE 2. Mean and standard deviation of the values obtained applying the "Janus" procedure in comparing the *inferior* against the *superior ramus* of the *incisura* and the *superior* and the *inferior ramus* against a straight line. Males N = 97; Females: N = 98.

	INFERIOR RAMUS			SUPERIOR RAMUS		
	SLOPE	ALLOMETRY	ISOMETRY	SLOPE	ALLOMETRY	ISOMETRY
♂						
MEAN	62.1	5.2	38.2	82.0	8.4	18.7
SD	5.0	1.9	4.3	3.6	2.0	4.2
♀						
MEAN	65.6	4.5	34.0	73.7	7.4	27.6
SD	4.6	1.7	3.9	4.1	1.8	4.2

	INFERIOR RAMUS	AGAINST	SUPERIOR RAMUS
♂			
MEAN	68.8	1.1	−19.2
SD	7.1	1.9	6.5
♀			
MEAN	81.0	1.8	−6.6
SD	7.0	1.9	5.7

The symmetry evaluation is performed by interpolating the obtained compressive figure with a second degree equation according to the least squares method.

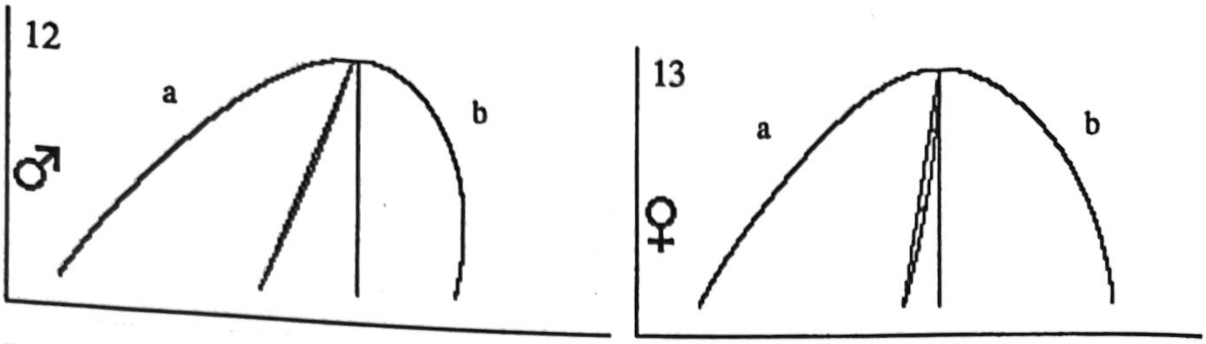
When the symmetry is perfect (i.e. the two compared outlines are the same) the coefficient of the square term of the parabola will be equal to zero and the arc of the parabola flattens to a straight line, corresponding to a symmetry axis (*Figure 3a*); in the other cases, according to the differences between the two curves and consequently according to the coefficient values of the equation, the arc will be more or less convex, shifted and inclined (*Figure 3b*). Because the interpolation minimizes the differences between the compared profile, the areas, on both sides of the parabola arc, will be the same.

In this way, asymmetries resulting from differences between two compared profiles (in our case the superior *ramus* and the inferior *ramus* of the *incisura*) are evaluated depending upon the convexity, shift and inclination of the parabola arc obtained by the equation, on the trend of the two profiles.

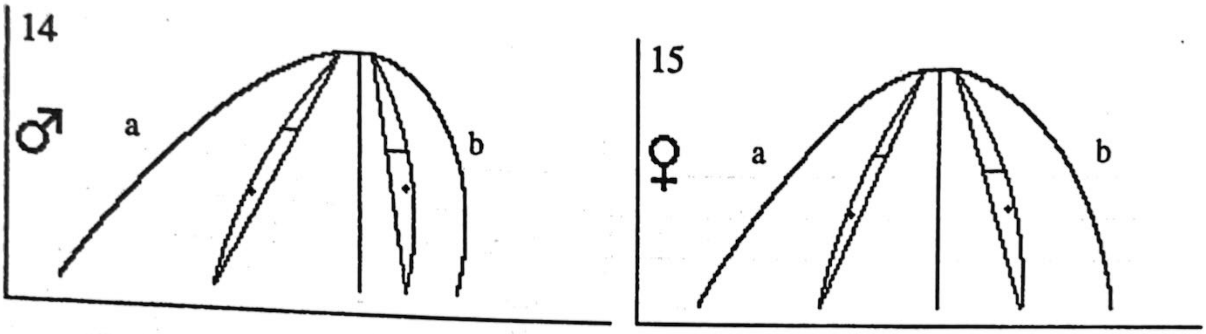
After calculating the parabola, an arc/chord complex is defined using the tract of the parabola (arc) and the straight line segment (chord) joining its extremities.

The convexity rate of the parabola expresses the relative prevalence of that part of the profile towards which such convexity is oriented; in the system, the surface defined by the arc and by its chord is considered as due to allometric differences. The area remaining between the chord and the straight line separating the two components of the figure, originated by the shift and inclination of the arc/chord complex, is considered as due to isometric differences.

Because the parabola equation admits three degrees of freedom, it is possible to give a representation of the found differences like a physical vector with its modulus, direction and versus. The allometric area (in per cent of half of the total area defined by the figures) can be considered as the modulus of the vector; the direction is given by the perpendicular to the chord passing through the maximum convexity of the parabola and the versus of the vector is



FIGURES 12, 13. Symmetry analysis performed comparing the mean inferior *ramus* (a) contra the mean superior *ramus* (b) of the *incisura*.



FIGURES 14, 15. Symmetry analysis performed describing the mean inferior *ramus* (a) and the mean superior *ramus* (b) of the *incisura* with a straight line.

indicated by the side toward which the convexity of the parabola is oriented.

The absolute evaluation on only one profile can also be performed comparing in turn each profile with a straight line.

The analytic variables considered in the analysis were: allometry, isometric differences (both calculated in per cent of half of the total area defined by the figures) and chord inclination.

Beside analytic symmetry evaluators, the same procedure provides traditional morphometric evaluators like: the profiles length, the area under the profiles, the projection on the *abscissa axis* of the *rami*. Some of them (profile length, area under the profile) are not usually present in morphometry of the *incisura*, so they were considered in this analysis.

All the obtained variables were used to perform multivariate discriminant analysis (Wilkinson 1989). Each set of variables was tested in turn trying to find the best linear combination between the minimum number of variates necessary to obtain the minimum percentage of error in discriminating the male and female group, and the maximum distance between the centroids.

RESULTS AND DISCUSSION

Some graphic results of the symmetry analysis performed on dimensionally normalized profiles are reported in *Figures 4* to *11.*

A clearly male kind and a female-like male one are reported in *Figures 4* and *5*. The analysis is performed comparing the inferior *ramus* (a) with the superior *ramus* (b) of the *incisura*. Whereas in *Figure 4* a highly asymmetric case (a typical male form) both for allometry and isometry with a high degree of chord slope are reported, the case in *Figure 5* is characterized by the prevalence of isometric differences with a lesser degree of chord slope and absence of allometries.

In *Figures 6* and *7* the results of the analysis performed on two extreme morphologies for the female form are reported. The case reported in *Figure 6*, typically female in form, is characterized by an almost perfect symmetric situation (allometry, isometry and chord slope are practically absent). The case reported in *Figure 7* is characterized by a medium degree of allometry, isometry and chord slope tending to represent a male-like situation.

Considering the results obtained by comparing each *ramus* with a straight line, the typical male form is highly asymmetric (*Figure 8*); the superior *ramus is* characterized by a high degree of allometry, light slope and low isometries; on the contrary, the inferior *ramus* is characterized by accentuated slope, elevated isometry and low allometries.

The female forms (*Figure 10*), typically, tend to be symmetric both for slope and isometries, whereas allometries are lightly prevalent for the superior *ramus*.

The female-like male case reported in *Figure 9* shows a situation simulating a female-like one, but because the

TABLE 3. Multivariate discriminant analysis. Results obtained by using metric data and symmetry analysis data in finding the linear combination of variables able to best separate the male and female groups of *incisurae*. The analysis was performed on the *inferior ramus* and on the *superior ramus* separately and on both *rami* together.

Rami	Data cases		Classified	Misclassified	Classified %
METRIC DATA					
	males	(97)	71	26	73.19
inferior arm	females	(98)	78	20	79.59
	total	(195)	146	49	76.41
	males	(97)	89	8	91.75
superior arm	females	(98)	82	16	83.67
	total	(195)	169	26	87.69
inferior	males	(97)	88	9	90.72
&	females	(98)	85	13	86.73
superior arm	total	(195)	173	22	88.72
PARABOLIC FITTING					
	males	(97)	71	26	73.19
inferior arm	females	(98)	75	23	76.53
	total	(195)	146	49	74.86
	males	(97)	87	10	89.69
superior arm	females	(98)	82	16	83.67
	total	(195)	169	26	86.68
inferior	males	(97)	90	7	92.78
&	females	(98)	90	8	91.84
superior arm	total	(195)	180	15	92.31

incisura is almost narrow, the slopes (mainly for the superior *ramus*) tend to be low.

A symmetric situation is shown by the male-like female case reported in *Figure 11*, but the allometries for both *rami* are accentuated.

As reported before, beside analytic evaluators, some metric evaluators (profiles length, area under the profiles, projection on the *abscissa* axis of the two compared *rami*) were also considered in performing multivariate discriminant analysis. Only primary data, not derivate fractions, were used.

In *Table 1* the mean values of these metric variables are reported.

Considering the inferior *ramus* the male group shows the highest values for all the three considered variables, whereas the superior *ramus* shows the prevalence of all three variables for the female group. This corresponds for the males to a more elongated inferior *ramus* (longer than the same *ramus* in the females), and to a shorter superior arm; in the females the *rami* diverge with quite equally long arms (the superior arm, anyway, is less elongated).

The mean values of the considered analytic variables are reported in *Table 2*; graphically, the results of the analysis are reported in *Figures 12* and *13*.

Considering the data obtained by comparing the inferior *ramus* against the superior *ramus*, the highest value of chord slope – 81° (90° corresponding to the absence of slope), is found in the female group; the same evaluator, due to the more elongated inferior *ramus*, is more accentuated in the males (69°).

The residual share of allometry is oriented, in both groups, towards the superior arm but it is lightly prevalent in the female group. The isometry value is greatest in the male (the negative sign indicating a prevalence of the inferior *ramus*) and, again is related to the more elongated inferior *ramus*.

If the analysis is performed by comparing separately the inferior *ramus* and the superior *ramus* to a straight line, the characteristics of the *rami* are obviously stressed due to the fact that the arc-chord complex is an exclusive function of the analyzed profile (*Figures 14* and *15*). It is clear that, in general, the arc of the parabola is more convex than in a comparison between two different profiles, because it is affected by one curve only, without being compensated by the other curve.

The results in the single descriptions, for the superior arm, show a higher degree of slope and a prevalence of isometric differences for the female, whereas the allometry value is slightly higher for the male *ramus*. The male superior *ramus*, usually narrower and affected by recursivity, is described by a lesser slope (tending to 90°) in the males, whereas a more elongated superior *ramus* determines in the females a more accentuated slope and isometry.

The inferior arm more elongated in the males than in the females gives, in the former, slightly higher values for all three considered variables.

Before performing multivariate discriminant analysis, a normality test was performed on both metric and analytic data (Kolmogorov-Smirnov two-tailed test). The lowest value of probability was given by the allometry value of the male group in the comparison of the two *rami* ($d = 0.80$, $P = 0.05$), thus the normality hypothesis was not rejected for any of the controlled variables and so raw data were used. The matrices of variance-covariance were judged almost equal.

The best result obtained in multivariate discriminant analysis by metric data, 89% of cases correctly classified, was obtained by using six variables as follows: lengths of the *rami*, projections of the *rami* on the ordinate axis, areas under the *rami* (*Table 3*). The result is mainly due to the information extracted by the superior arm, in fact, by using the three variates from the inferior *ramus*, 76% of cases only were correctly attributed, whereas by using the three variates obtained by the superior arm a correct attribution was reached in 88% of cases. We must remember that this significative increasing of correct attribution, in respect to the result mentioned in the introduction (70% of correct attribution for dimensional data of the *incisura* as reported in Novotný 1972), is not really related to size, as far as the used data are dimensionally normalized. This could mean that this is a case in which size information tends to hide shape information and the loss of size information underlines shape differences.

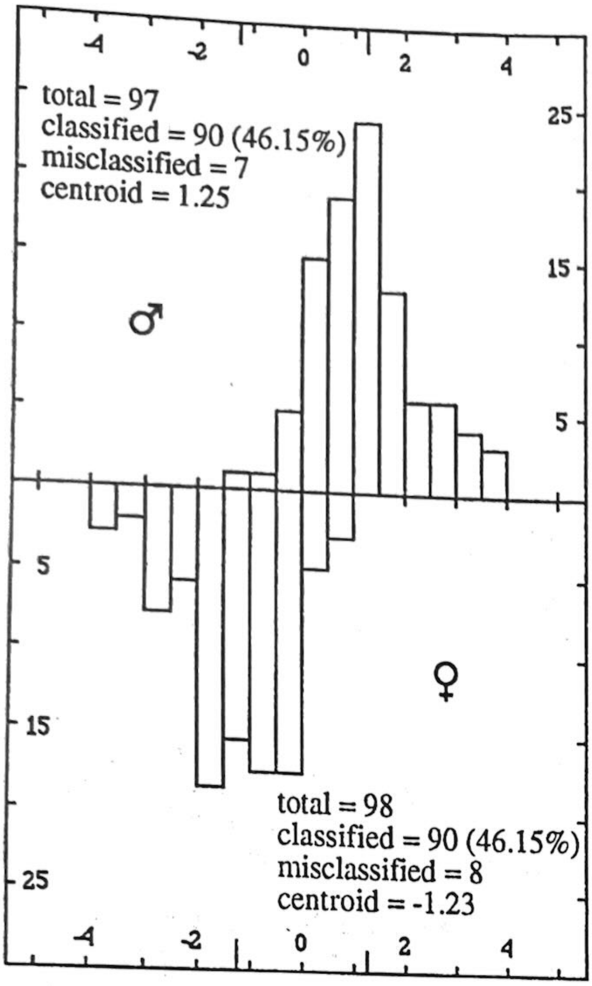


FIGURE 16. Distribution of discriminant scores obtained by using 9 variables (Slope, Allometry and Isometric Differences) obtained by symmetry analysis in double comparisons and in the single description of superior and inferior *ramus*. Error = 8%. F-statistic = 31.89; DF = 9, 185; P < 0.0005.

By using analytic shape evaluators only, the level of correct attribution increases. The best result in separating male and female groups was obtained by using variables given by symmetry analysis; the most informative for double and single comparisons were: chord slope, allometric area and isometric differences.

In *Table 3* the results obtained by using the above reported variables in finding the linear combination able to best separate the male and female groups of *incisurae* are reported.

Analyzing the two *rami* separately, the best result for the superior *ramus* is obtained, confirming that the main sexually differentiated shape characters of the sciatic notch are due to the superior arm: by using 3 variables 87% of cases were correctly classified. Using the same variables, obtained by the inferior *ramus*, only 75% of cases resulted as correctly classified.

By using the total of 9 variables obtained describing the whole *incisura* and, separately, the inferior and superior *ramus* a correct sex attribution was achieved in 92% of cases (*Figure 16*).

TABLE 4. Unstandardized coefficients of the two best discriminant functions obtained for metric and symmetry analysis data. The used variables are as follows: - metric: Area, Length and Projection on the abscissa axis for the Superior (S) and Inferior (I) arm (6 variables in all); - symmetry analysis: Slope, Allometry and Isometry for double comparisons (T) and for the Superior (S) and Inferior (I) arm (9 variables in all). The F and D^2 values for each equation are also reported.

METRIC DATA		SYMMETRY DATA	
AREA-S	0.000242	SLOPE-T	-0.211530
LENGTH-S	-0.047884	ALLOMETRY-T	0.642914
PROJECTION-S	-0.143864	ISOMETRY-T	-0.370467
AREA-I	0.001105	SLOPE-S	0.015728
LENGTH-I	-0.037950	ALLOMETRY-S	-0.637594
PROJECTION-I	0.002830	ISOMETRY-S	-0.042387
CONSTANT	5.095542	SLOPE-I	0.712043
		ALLOMETRY-I	0.569698
		ISOMETRY-I	0.373676
		CONSTANT	-46.833852
F = 40.7 df = 6, 188 D^2 = 5.1		F = 31.7 df = 9, 185 D^2 = 6.1	

Adding metric data to analytic data the level of correct sex attribution does not increase.

The unstandardized coefficients of the two best obtained linear discriminant functions to be used in sexing unknown pelves, are reported in *Table 4*. The F test performed on both equations gives values of 40.7 (6, 188 d.f.; P < 0.005) and of 31.89 (9, 185 d.f.; P < 0.005) respectively, that means that the selected variables are effective in separating the two groups; additional tests (Wilk's lambda, Hotelling-Lawley trace) give results in agreement with the F test.

CONCLUSIONS

Two kinds of results can be considered: the first one is related to the increasing of discriminant power of the analyzed morphometric variates; the second one is related to a better understanding of the form of the studied object, in our case of the sciatic notch.

Both kind of variables, metric and analytic, have shown an increasing of discriminant power. In the case of metric variables this seems due to the fact that they are dimensionally normalized, that is, the loss of size information stress shape differences. Beside this, we must consider that these metric variables are not usually present in the morphometrics of the *incisura*, commonly, only width and depth of the *incisura*, in various ways considered, or their derived indexes are used; so these variables (area under the profiles, length of the *rami*, projection of the *rami* on the ordinate axis) could, simply, be more informative.

The even more increasing discriminant power shown by variables given by parabolic fitting recall the problem of using variables suited for studying form (a further

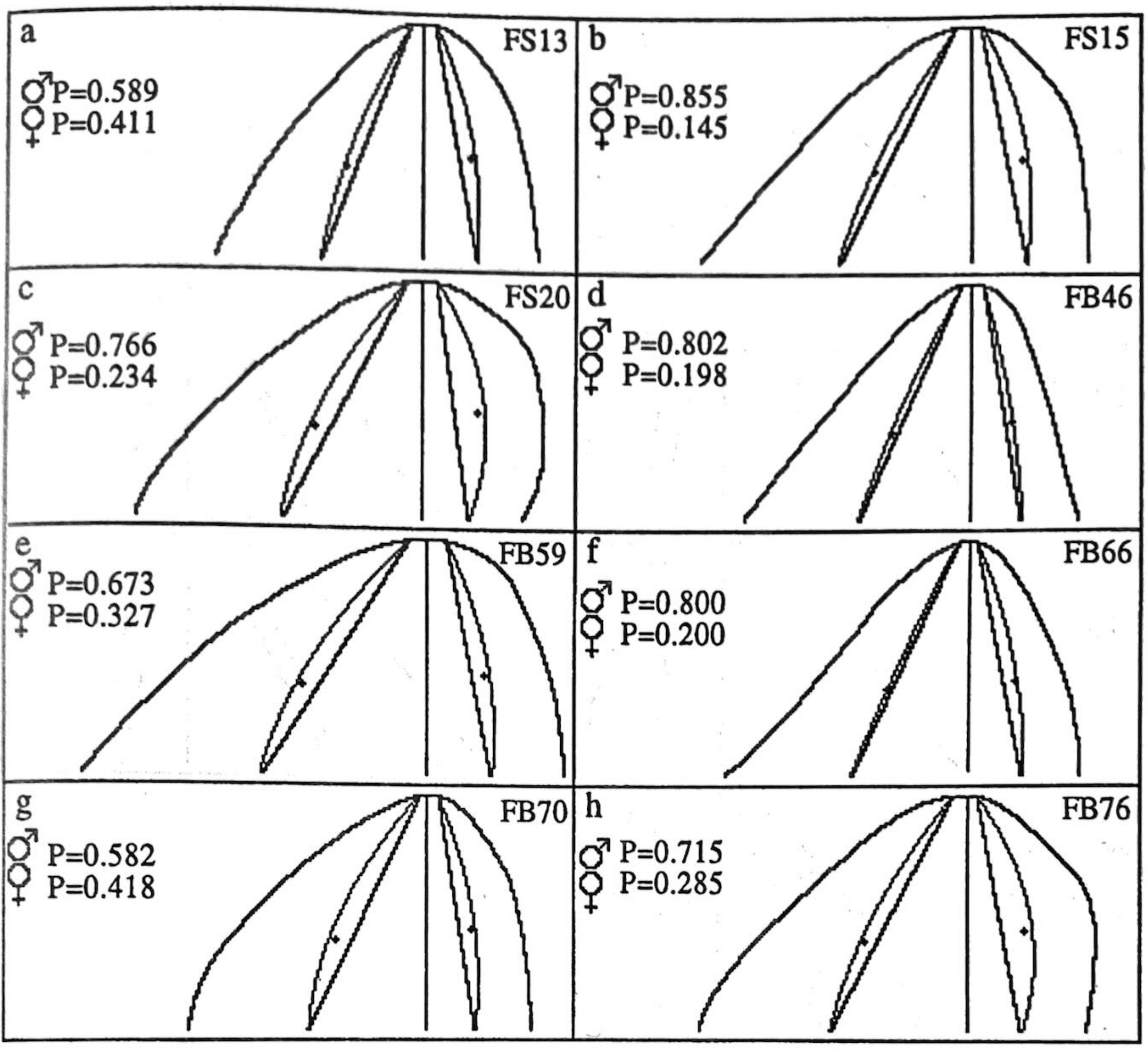


FIGURE 17. Misclassified female data cases; for each *incisura* the probability of group membership is reported; see the mean profiles reported in *Figures 14* and *15* for comparison.

increase of discriminant power was reached by using Fourier data: Vacca *et al.* in print). The relatively low efficacy of the morphoscopic and scoring analysis is, probably, related to the fact that whereas our visual perception is very effective in shape recognition, we are not so able in shape description. So tools able to help us in this second aspect of the analysis are needed. The perceptive logic we follow in recognizing form, in fact, is not easily definable but, probably, it is not necessary to fully understand it in reaching the goal, if we have tools (mathematic tools in our case) able to describe what we are able to see.

To join the first aspect of the results, that is the increasing of classificative power, to the second aspect of the results, that is, the better understanding of the morphology, these tools must be univocally referred to morphological features.

Considering our case we can ask: which aspect of the *incisura* morphology that escapes observation or with difficulty could be set, is revealed, instead, by the analytic evaluation of the symmetries?

We could try to have an answer by observing the morphologies of the outgroup data cases reported in *Figures 17* and *18.*

In some female outgroup data cases, despite a high symmetry between the two *rami*, the extreme elongation of the inferior *ramus* can cause misclassifications (*Figure 17*, data cases c, e, g); in some other cases (a, d, f) the extremely narrow profile, especially in the superior arm, prevails on the other aspects of the morphology driving the classification in a male sense; in some other cases (b, c, h) the placement of the maximum convexity of the *ramus*, rather high in the profile, affects slope and isometry values driving the description in a masculine sense. This element of the morphology, that is the position of the maximum convexity along the superior *ramus*, also seems to play a certain role in understanding why some male data cases are misclassified.

These cases, for the majority, are characterized by having the maximum convexity of the superior arm placed rather low (*Figure 18*); this feature, even if recursivity occurs, affects the slope of the arc-chord complex and the isometric rate emulating a female morphology.

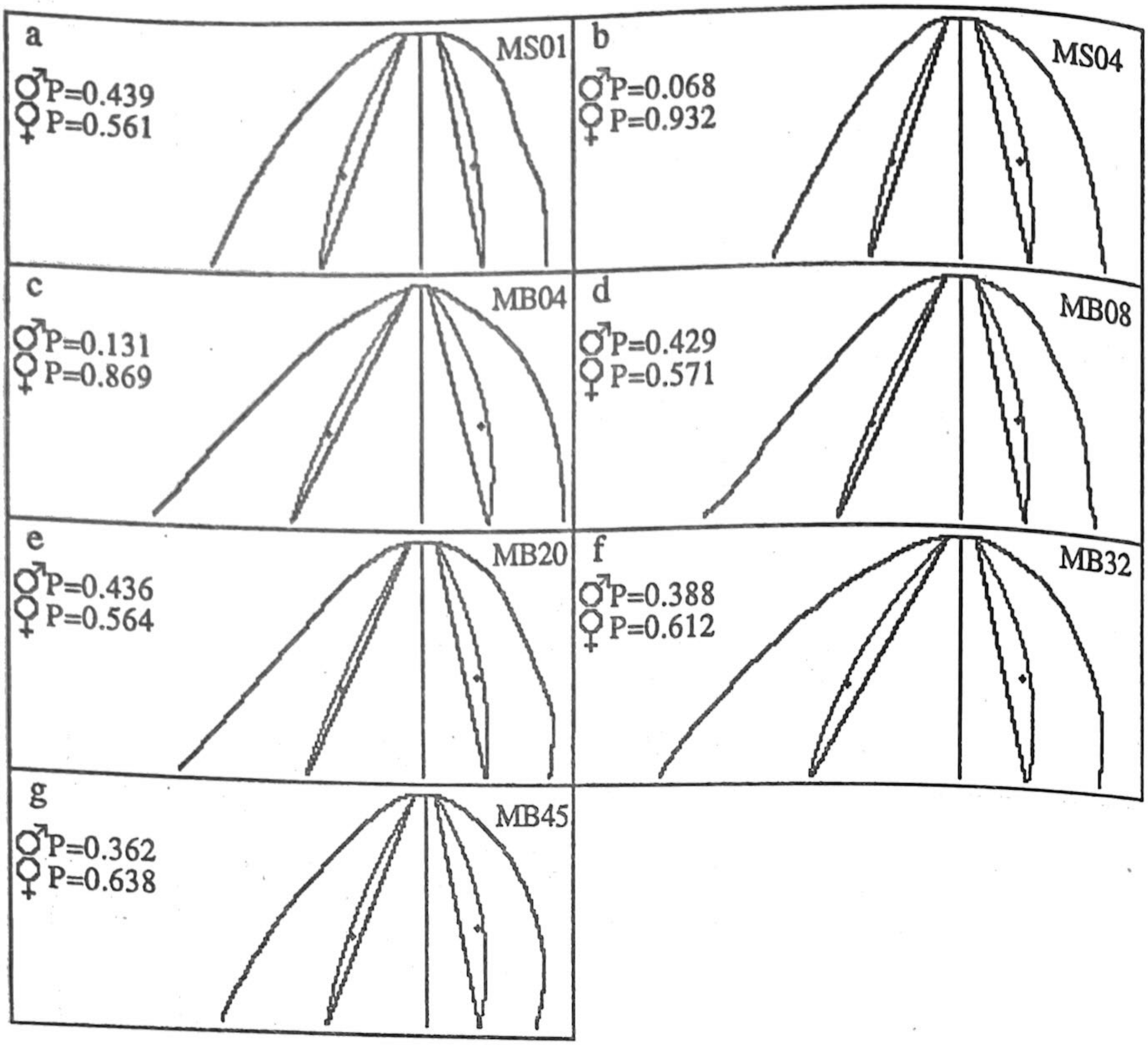


FIGURE 18. Misclassified male data cases, for each *incisura* the probability of group membership is reported; see the mean profiles reported in *Figures 14* and *15* for comparison.

The slope, really, is sensitive not only to the elongation of the profile but even to the camber position along the profile; a high allometric rate alone, could not be enough to drive the description in a male sense if the curvature causing the allometry were placed in the lower part of the profile.

In practice, that means that the maximum convexity placed rather high in the superior *ramus*, drives the description in a male sense; if the maximum convexity point is placed at the end of the profile, the *ramus* tends to be analytically defined in a feminine sense.

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