

## ANALYSIS

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### A LATE PLEISTOCENE HUMAN SKELETON FROM LIUJIANG, CHINA SUGGESTS REGIONAL POPULATION VARIATION IN SEXUAL DIMORPHISM IN THE HUMAN PELVIS

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**Abstract:** This paper provides a description and analysis of a late Pleistocene human from Liujiang, China. Although most scholars have interpreted the cranium as male, sexing of the pelvis has been more problematic. I argue that this ambiguity reflects variation in the pattern of sexual dimorphism in the pelvis between human populations in different regions. Although the direction of the differences between males and females is generally the same, the magnitude of the male and female values differs regionally. When compared to appropriate Asian reference samples, the Liujiang pelvic specimen appears to be male, consistent with the cranium. Specifically, several conclusions result from this analysis: 1. The Liujiang specimen (including both the cranium and postcrania) is, in fact, male, 2. There are significant regional variations in pelvic morphology and furthermore, in the pattern of sexual dimorphism in pelvic morphology and finally, 3. The pattern of pelvic dimorphism seen today in Asia may extend into the past. More generally it appears that the well-established polytypic nature of human morphological variation can be extended beyond cranial morphology to include aspects of pelvic morphology and sexual dimorphism in pelvic morphology.

**Key words:** *Late Pleistocene, China, human pelvis, regional population variation, sexual dimorphism*

## Introduction

The Liujiang (Liukiang) human skeletal material was excavated in 1958 in Tongtianyan Cave, southwest of Luizhou in the Guangxi Zhuang Autonomous Region in southern China (Woo 1959). The Liujiang cranial material has been mentioned in discussions of the late Pleistocene human fossil record of China since the time when it was recovered, but there has been very little attention paid to the postcranial remains, including the pelvis. There has always been a considerable degree of uncertainty concerning this specimen with respect to several issues: 1. is the material from a single individual, 2. what is the sex of the individual(s) and 3. does this material show any “regional features”? Answers to these questions are essential if we are to evaluate the Liujiang specimen in light of hypotheses about modern human origins and/or continuity of the human evolutionary sequence in China. In this paper, I argue: 1. that the fossilized skeletal elements are the remains of a single individual, 2. that that individual is indeed male as generally assumed, and 3. that confusion over the innominate reflects a real (but hitherto poorly documented) pattern of regional variation in sexual dimorphism in the human pelvis.

## The Liujiang specimen

The Liujiang fossil remains were discovered in a cave which also contained the remains of a Pleistocene (*Ailuropoda-Stegodon*) fauna though they were apparently not in close association with that material. Uranium series dates from the site reported in the past include a stalagmitic crust layer (Layer II) of earlier than 67,000 + 6000, – 5000 BP and five specimens of animal teeth beneath that layer of 101,000–227,000 BP (Wu and Poirier 1995). Recent, new stratigraphic analysis and Uranium series dating of Tongtianyan Cave, the site where the Liujiang specimen was discovered suggest that the specimen could be even older (Shen et al. 2002). However, the provenience of the human remains has always been problematic as the “skull was reportedly embedded in deposits of unconsolidated breccia distinctly different from the hard yellowish deposits of Middle Pleistocene age usually found in Guangxi” (Wu and Poirier 1995: 192). Shen et al. (2002: 817) argue that depending on their precise provenience the human fossils could date to one of three time periods namely “at least 68,000 years old, but more likely to 111–139 ka. Alternatively they would be older than ~ 159 ka”. Thus, the date of 67,000 years old which has usually been attributed to the specimen in the past is plausible as a minimum, but by no means firmly established (Wolpoff 1999: 727) and more broadly, the human remains be considered Late Pleistocene in age at a minimum (Woo 1959; Wu and Zhang 1985; Wu and Poirier 1995, Shen et al 2002).

The Liujiang material consists of a well-preserved adult cranium, a right innominate (with the pubis absent), a complete sacrum, all lumbar vertebrae, the inferior four thoracic vertebrae with articulating ribs and two femoral mid-shaft fragments (Woo

1959; Wu and Poirier 1995). The ribs, thoracic vertebrae and first lumbar vertebrae were cemented together in the process of fossilization and the other lumbar vertebrae are cemented to the sacrum.

Woo (1959) argued that the cranium was male based on size, browridge robusticity, thickness at glabella and size of mastoid regions (though the mastoid processes themselves are small). He also considered the vertebrae and sacrum to be male because the auricular surface extends downward to the level of the third sacral vertebrae. Because the auricular surface of the innominate matched the sacrum and were obviously from the same individual, he considered the innominate to be male as well. The femoral fragments seemed to be slender and Woo (1959) considered that they might belong to a different individual but thought the most likely possibility was that they all represented a single individual: a middle aged male. Woo did not give much attention to the innominate other than to describe the iliac fossa as shallow and the acetabulum as facing forward. His conclusions about the specimen were that “on the whole, however, the Liujiang specimen shows clearly its Mongoloid racial affinities”.

Coon’s (1962: 469) discussion of the postcrania followed Woo’s. He remarked on the small size of the individual compared to living people which he estimated as 145–150 cm (“on the upper border of the Pygmy range” – Coon, 1962: 469–470). He agreed with Wu that the Liujiang specimen was a “Mongoloid form of *Homo sapiens* still in the process of evolution except that the skull deviates somewhat from the Mongoloid line in an Australoid direction, as one would expect from an ancient skull from southeast china, the contact zone between the Mongoloid and Australoid peoples”. Coon reiterated Woo’s (1959) statement that the acetabulum is rotated somewhat forward, and interpreted this as a regional feature of “Mongoloid pelves” although neither Woo nor Coon presented data to show that forward facing acetabula were in fact an Asian feature in modern populations. In addition, Coon wrote that the Liujiang sacrum was similar to the Sakai of the Malay Peninsula in having a triangular shape. These claims of population variation in pelvic morphology had not been documented and have still not been addressed.

Although the specimen has generally continued to be considered male (for example, Wolpoff, Wu and Thorne 1984), Howells (1977) noted the possibility (suggested in a conversation with Woo Ru-kang) that it was female, given the “form of the innominate and virtually all individual traits of the skull”. Like Woo, he emphasized the “Mongoloid” rather than “Australoid” character of the skull but did not comment on the postcrania, other than to say that the “small size of face and postcrania give no basis for a suggestion of Negrito racial affinity” (Howells 1977).

Wu and Zhang (1985) suggested that the Liujiang specimen reflects both “Mongoloid” and “Australoid” affinities, noting that the postcranial remains have been the basis of some controversy regarding racial affinity. Howells (1977), they say, so it should read “say affirmed that it is “Mongoloid”. The skull has continued to be generally regarded” as male and as showing “Mongoloid” cranial features (for example, Brauer 1989; Habgood 1989, 1992; Stringer 1989; Wolpoff 1989, 1999; Wu and Lin 1985; contra Brown 1998). However, the regional affinities of the postcranial portion

of the skeleton have not been discussed beyond the brief mentions by Coon and Woo.

This paper is an attempt to untangle geography and sex as sources of pelvic variation. Population variation in cranial morphology and sexual dimorphism in cranial morphology has been very well documented (for example, Howells 1973; Frayer and Wolpoff 1985). Attention to population variation in postcranial morphology and metrics has generally focussed on body proportions (both limb proportions and trunk to stature ratios) which seem to vary with climate as predicted by Bergmann and Allen Rules (for example, Ruff 1993). However other aspects of postcranial morphology and in particular, sexual dimorphism in postcranial morphology, which might also show population variation have received relatively little attention.

### Description and sex of the Liujiang specimen

The right innominate is complete except for the superior pubic ramus and ischiopubic ramus. The superior pubic ramus is broken just medial to the acetabulum and the ischiopubic ramus is broken just medial to the ischial tuberosity. The preservation of the bone is excellent with only one crack extending from the apex of the sciatic notch to the anterior inferior iliac spine. The sacrum is complete although it is impossible to examine or measure the superior articular surface since it is cemented to the fifth lumbar vertebra.

Measurements of the Liujiang innominate are given in Table 1. Overall, the bone is quite small. At the back of the acetabulum, the bone is very thin. The ischial tuberosity is gracile and the ischial spine is elongated and protuberant. The iliac crest is sinuous, rather than flat. The iliac buttress and cristal tubercle are not particularly well developed. The sacrum is broad and somewhat curved. There is no preauricular sulcus.

The individual is fully grown. All epiphyses are fused. The maxillary third molars have not erupted, although they may not have been present at all. There is no evidence

Table 1

Measurements of the Liujiang right innominate (first five measurements of Liujiang specimen are taken following Wu et al. 1982, but are very similar to those published in Wu 1997, Han data from Wu et al. 1982)

Measurement	Liujiang [mm]	Han Males	Han Females
Ischium length I	73		
Ischium length II	92	88.9 (73–99)	79.6 (74–87)
Sciatic notch breadth	45	48.8 (37–61)	56.8 (45–68)
Sciatic notch depth	32	36.3 (30–44)	33.6 (27–40)
OB measurement of sciatic notch	15	16 (5–27)	28.7 (20–38)
Acetabular vertical height	47.2	55.3 (46–64)	49.6 (45–55)
Maximum length of innominate	137.8		

of pathology on this specimen such as arthritis in the hip or on the auricular surface, though there is slight lipping on the lumbar vertebrae. All cranial sutures are closed and the teeth are fairly worn (Wu and Poirier 1995: 186). Woo's (1959) description of this individual as middle-aged is probably correct (Wu and Poirier 1995).

As mentioned above, Woo (1959) and Coon (1962) originally described the specimen as male, based primarily on the skull. The individual was certainly small in overall body size (Wu et al. 1984 estimate the stature as 152–157 cm, based on the reconstructed femur). The small size of the acetabulum and the wide sciatic notch might on first analysis, suggest that the individual may be female. The sciatic notch is fairly wide and the two parts are more symmetrical than J-shaped. The “arc composé” takes the form of a double curve which has been reported as more common in females than in males (Workshop of European Anthropologists, 1980, Bružek, 2002). In fact, when one looks quickly at the pelvis alone (perhaps especially from a western perspective?), one wonders how anyone could possibly have come to any conclusion other than that this individual was female.

How can this be reconciled with the almost universal agreement that the skull is male? One possibility is that the bones represent the remains of more than one individual. The facts that the bones were found together with similar color and state of fossilization and that there is no duplication of parts (Woo 1959) makes this unlikely. Alternatively, if the cranium is correctly sexed as male, and only one individual is represented, then the pelvis must also be male. Woo's (1959) and Coon's (1962) suggestion that the morphology of the pelvis show regional features is an intriguing hypothesis. I suggest that the “female-looking” nature of the pelvis in what is apparently a male individual might also be a regional feature.

Sexual dimorphism in the human pelvis has been studied in a wide range of recent populations [Akpan et al. (1998), Davivongs (1963), Derry (1923), Genovés (1954), Hager (1989), Hanna and Washburn (1953), Hauser and Jahn (1984), Howells and Hotelling (1936), Iscan (1981), Jovanović and Zivanović (1965), MacLaughlin and Bruce (1986), Novotný (1986), Orban (1980), Orban Segebarth (1984), Richman et al. (1979), Rosenberg (1988), Schulter-Ellis et al. (1983), Tague (1989, 1992), Taylor and DiBennardo (1984), Thieme and Schull (1957), Washburn (1948, 1949), Wu (1997), Wu et al. (1982)]. Although many of these studies make the point that there are population differences in sexual dimorphism, there have not been any systematic efforts to quantify this variation.

The most reliable portion of the pelvis for sex determination is the anterior portion, namely the pubic bone. Morphological features such as those described by Phenice (1969) have been shown to be highly accurate indicators of sex in a range of populations (Kelley 1978), though the method may be less accurate among older individuals (Lovell 1989). Similarly, measures of relative pubic elongation such as the ischiopubic index have been shown to distinguish males from females in a number of human populations – an elongated pubis in females relative to males is a concomitant of the expansion of the pelvic aperture as an adaptation to the birth process. However, population variation in the metric features of the pubis as well as

the sciatic notch have been widely acknowledged since Washburn's pioneering work in this area (Washburn 1948, 1949; Hanna and Washburn 1953).

Unfortunately as is often the case in archaeological specimens (Kelley 1979), the pubic bones of the Liujiang specimen are not preserved so we are forced to rely on other, less reliable portions of the innominate for sex determination. In all human populations, the sciatic notch is wider in females than in males (like the elongation of the pubis, this is a consequence of the expansion of the pelvic aperture as a birth canal in females) and the proportion of the notch which make up the anterior and posterior cords of the diameter differ between the sexes with males on average having more of the space taken up in the anterior cord (Hager 1996). However there is little systematic or synthetic work which compares the extent to which this is true across populations. One practical reason for this is that quantification of the size and shape of the sciatic notch is extremely difficult and has never been standardized. Such critical points as the tip of the ischial spine are very often broken on archaeological specimens and many other points which are often used for measuring the notch are difficult to define consistently.

Wu et al. (1982) published data from Han Chinese specimens that make an appropriate comparative sample for the Liujiang specimen. They measured not only the depth of the sciatic notch, but the length of the notch from the line between the posterior inferior iliac spine and the ischial spine perpendicular to the deepest point on the notch. Following Davivongs (1963) they refer to this dimension as OB, though their figure indicates that their measurement is slightly different from his (see below). Essentially, OB is an indication of the width of the posterior portion of the greater sciatic notch.

Wu et al. (1982) showed that there is a clear and significant sex difference in both the OB measurement and the OB measurement/width of the sciatic notch with almost perfect separation of males and females when this index is plotted against the ischio-pubic index in their Han sample.

Comparing the Liujiang specimen to Wu et al.'s (1982) data from the Han Chinese sample (see Table 1)<sup>1</sup>, we can see that for vertical height of the acetabulum, Liujiang falls at the lower end of the male distribution, but also at the lower end of the female distribution. Clearly, regardless of the sex, this was a small-bodied individual compared to modern populations (Wu 1997). For length of the ischium (essentially a measure of body size and not a direct reflection of birth canal expansion in females, Wu et al.'s ischium length I), the situation is the same. Interestingly for these two dimensions, the male range overlaps the female range completely; that is, the smallest males are as small as the smallest females, though the largest males are larger than the largest females and the means are significantly different. The OB measurement is an indication of that part of the sciatic notch which lies behind the perpendicular from the point of greatest depth that is, it indicates the width of the posterior

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<sup>1</sup> In order to assure comparability with published measurements, the measurements of the Liujiang sciatic notch which are used here were made in consultation with Professor Wu Xinzhi, first author of the relevant paper and are thus comparable to the data from his Han sample.

Table 2

OB/breadth of sciatic notch  $\times 100$ 

Populations	Females		Males	
	Mean	<i>SD</i>	Mean	<i>SD</i>
Han (Wu et al. 1982)	50.6	5.63 <i>N</i> = 54	32.7	8.21 <i>N</i> = 115
<b>Liujiang</b> (after Wu et al. 1982)	<b>33.3</b>			
Australian Aborigines (Davivongs 1963)	33.8	6.34 <i>N</i> = 100	13.4	6.55 <i>N</i> = 100
<b>Liujiang</b> (after Davivongs 1963)	<b>25.2</b>			
Czech (Novotný)	42.2	7.15 <i>N</i> = 119	23.2	7.57 <i>N</i> = 110
Uganda (Novotný)	43.5	6.37 <i>N</i> = 21	26.8	6.60 <i>N</i> = 30
<b>Liujiang</b> (after Novotný)	<b>32.5</b>			

portion of the sciatic notch (see Table 2 and Figure 1). For this dimension, males and females differ significantly in the Han sample, with males being smaller than females. The measurement for the Liujiang individual is close to the mean for the Han male distribution and completely outside the Han female distribution. When this measurement is expressed as a percentage of the total width of the sciatic notch, the Liujiang specimen (33%) is almost exactly equal to the male mean (32.7%) for the Han sample and well below the female mean (50.6%). This suggests that assuming that the Han material is an appropriate comparative sample, the Liujiang specimen probably represents a small male individual. In a similar analysis, Wu (1997) also reached this conclusion.

If the Liujiang pelvic specimen is male, when compared to the Chinese sample, why has it “looked” female when examined visually by so many observers? In order to address this question, measurements of the sciatic notch for the Liujiang specimen were compared with measurements from human populations from other parts of

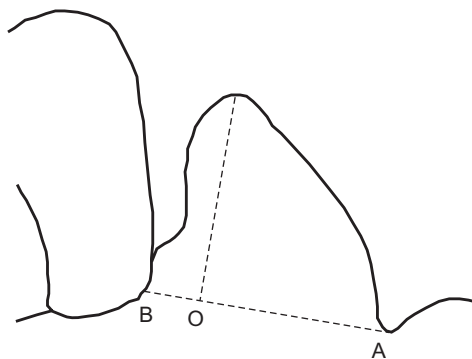


Fig. 1. This figure shows the measurement of sciatic breadth and the posterior portion of sciatic breadth, following Wu et al. (1982). The ilium is shown looking laterally at the interior surface, with anterior to the right

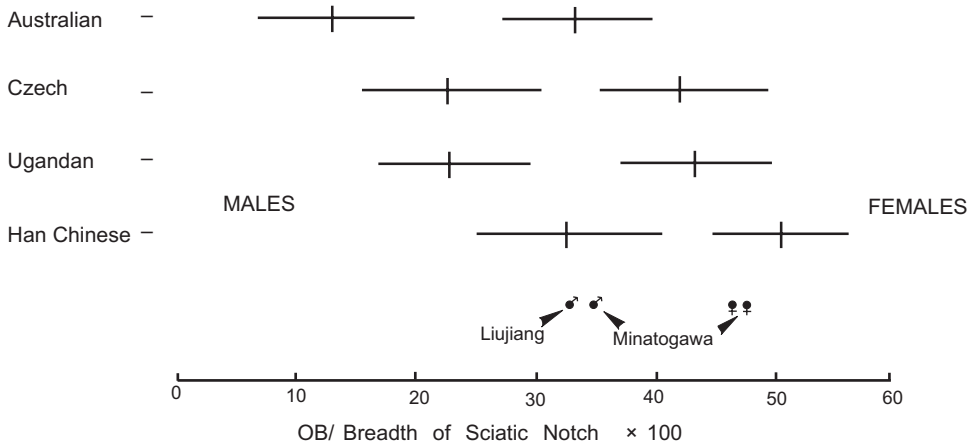


Fig. 2. Population variation in the relative breadth of the posterior portion of the sciatic notch. For each population, the bar indicates the sex specific mean and the line a standard deviation above and below the mean. As indicated in the text the measurement techniques are slightly different for different populations, but not enough to account for all the variation seen here

the world. Because the measurement techniques were slightly different in studies on other populations and because slight differences in technique have the potential to result in large differences in the measurements of the sciatic notch, the Liujiang measurements were retaken to conform as precisely as possible to the techniques used for other samples in order to ensure comparability.

Davivongs' (1963) technique differed from the measuring technique showed in Wu et al.'s (1982) Figure 1 in that he measured from the "pyramidal projection located at the termination of the posterior border of the greater sciatic notch" rather than from the inferior corner of the auricular surface. Davivongs reported "OB" measurements for Australian Aborigines which in extreme cases were actually negative, i.e., the posterior arm of the sciatic notch curved inward so much that the pyramidal projection was actually farther forward than the deepest point on the notch: an extreme J-shape. It is likely that Davivongs' measurements of the notch in Australian Aborigines are smaller than Wu, et al.'s in the Han Chinese sample because of **both** population variation **and** slight differences in measuring technique. If the Liujiang specimen is measured following Davivongs, we get a measure for the "relative size of the posterior portion of the sciatic notch" (Davivong's index II) which is 25.2%. This places it almost exactly between the male (mean = 13.45, s.d. = 6.55,  $N = 100$ ) and female (mean = 33.78, s.d. = 6.34,  $N = 100$ ) Australian Aborigine values.

Other comparisons can be made with data collected by Novotný from Czech and Ugandan populations. Novotný measured the width of the sciatic notch from the base of the ischial spine (the point of inflection along the lower arm of the sciatic notch) to the pyramidal tubercle on the upper arm of the sciatic notch. This is clearly not exactly the same measurement as taken by Wu and discussed above



but it is quite close and it is largely a measure of the same phenomenon, namely the width of the sciatic notch and the relative proportion of it that extends posteriorly. When measurements comparable to these were taken on the Liujiang specimen, the results show that the Liujiang specimen (32.5% – this is in fact quite similar to the index when measurements were taken following Wu et al. 1982) is midway between the male (23.2%) and female Czechs (42.5%) and midway between the male (26.8%) and female (43.5%) Ugandans.

By the standards of the Chinese sample, the Liujiang specimen is clearly male: by the standards of the Australian Aboriginal sample it would be intermediate (when measured following Davivongs) and by the Czech and Ugandan samples it is also intermediate between males and females. The lack of data taken systematically by a single researcher make it difficult to compare these samples more directly. Although data comparability is clearly a problem, it cannot explain all of the variation between populations. For example Davivongs (1963) reports values for OB (the posterior portion of the sciatic notch) which are actually negative in some males (that is the posterior arm of the notch curves around anteriorly so that it is actually in front of the point where a perpendicular from the deepest point on the notch would meet the diameter). Such a configuration is rarely if ever present in other populations examined. Although in all populations, it is clearly the case that the sciatic notch is wider in females than in males, and females are relatively wider in the posterior portion of that notch, it is also clear that populations differ from one another in the extent to which the breadth and posterior portion of the sciatic notch differs between the sexes (just as they do in other features such as the ischiopubic ramus). A more thorough examination of population variability in pelvic morphology and pelvic sexual dimorphism, will require data which is truly comparable (collected using consistent measurement technique) from different regions of the world. Aspects of pelvic morphology not considered here (such as acetabular angulation) should be included.

Interesting corroborative evidence of the hypothesis that the Liujiang specimen is a typical late Pleistocene East Asian male is provided by other late Pleistocene East Asian fossils, the Minatogawa specimens from Japan, dated to about 18,000 years (Suzuki and Hanihara 1982). Minatogawa 1 (a male) is very similar to the Liujiang specimen both in its small overall body size (stature is estimated at 153 cm) and in the OB/Breadth of the Sciatic Notch index, while Minatogawa 2 and 3 (both females) have higher indices in the range of the Han Chinese females (Baba and Narasaki 1991). These Japanese specimens show the pattern of dimorphism hypothesized for the population from which the Liujiang specimen is derived.

Kelley (1979) showed that an index of the greater sciatic notch to acetabular height was a good indicator of sex in American Whites, Blacks and Indians. This index has the important virtue of being measurable on even the most fragmentary remains and interestingly, the cut-off points for sex discrimination which Kelley used are almost identical for all three populations. This index has been criticized however, by Sullivan and Hall who found it less accurate in skeletal remains from

Table 3

## Ischiopubic Index

Populations	Females			Males		
	<i>N</i>	Mean	<i>SD</i>	<i>N</i>	Mean	<i>SD</i>
Han	54	98.2	4.25	115	85.8	4.08
Australian Aborigines	72	92.7	5.99	89	78.0	3.76
Czechs	114	104.3	5.99	112	90.4	5.38

Iroquoian populations. Interestingly, the Liujiang specimen is classified as male using this index, regardless of which cut-off point is used.

Further evidence that human populations vary in sexual dimorphism in the pelvis as a whole can be found by looking at the ischiopubic index (see Table 3). This is a much more consistently defined measurement and shows (as Washburn demonstrated) that the “cut-off” between males and females varies from one population to another. If this is true of the anterior portion of the pelvis, it may well be true as suggested here, of the posterior portion of the pelvis. Novtoný has described these two regions as independent morphology regions (Novtoný 1986) which can both influence the size of the pelvic aperture.

Several studies have examined populations differences in pelvic morphology, most often with an eye to aiding forensic work (Church 1995; DiBennardo and Taylor 1983; Iscan 1983a, b, 1991; Iscan and Cotton 1990; Patriquin et al. 2002; Sullivan and Hall 1984, Taylor and DiBennardo 1984). In general, these studies have examined differences between American Blacks and Whites (rarely, Native Americans, for example Sullivan and Hall 1984) so that information on Asian populations which might be relevant to this study is not available. Conclusions from these studies most often note that the main “population” component of pelvic variation is size related, however these studies have not systematically examined population variability in sexual dimorphism in pelvic morphology.

## Conclusions

This paper attempts to explain the apparent discrepancy between the male-appearing Liujiang cranium and the female-appearing pelvis. I reject the hypothesis that the skeletal elements represent two separate individuals in favor of the hypothesis that the female nature of the pelvis in a male specimen may be a regional feature in East Asian populations. More generally it appears that the well-established polytypic nature of human morphological variation can be extended beyond cranial morphology to include aspects of pelvic morphology and sexual dimorphism in pelvic morphology. One lesson from this analysis is a reminder of the importance of choosing an appropriate comparative sample, taking into consideration the polytypic nature of

the human species. Specifically, several conclusions result from this analysis: 1. The Liujiang specimen (including both the cranium and postcrania) is male, 2. There are significant regional variations in pelvic morphology and furthermore, in the nature of sexual dimorphism in pelvic morphology and finally, 3. The pattern of pelvic dimorphism seen today in Asia may extend into the past.

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