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PROBLEMS AND DILEMMAS CONCERNING THE IDENTIFICATION OF THE FOSSIL BOVINE ATLAS IN COMPARISON WITH RECENT BOVINES

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During gravel exploitation from the river Sava near Županja an isolated bovine atlas was found. After palaeontological study (morphometric characteristics, brown colour, strong petrification) it was determined to pertain to the Upper Pleistocene bovines (*Bison seu Bos*). Detailed anatomical, metrical and radiological comparison was made between the fossil atlas from Županja and the atlas of recent Istrian cattle (*Bos taurus primigenius*), which is the representative of the most primitive primogenetic bovine form, osteologically completely akin to the original fossil species *Bos primigenius*. Using the literature data both atlases were metrically correlated with the atlases of the following fossil and recent species: *Bison priscus*, *Bison bonasus*, *Bos primigenius* and *Bos taurus*. It was not possible to determine the fossil atlas generically, while the recent one is well defined. All analyses indicate that problems concerning the identification of isolated atlases, which were hitherto studied on the fossil and recent bovine species mentioned above, are equally expressed both on the fossil atlas from Županja as well as on the atlas of the primitive recent Istrian cattle species *(Bos taurus primigenius)*.

Key words: Mammals, Bovines, Upper Pleistocene, Alluvium, Sava river near Županja, Croatia.

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Pri eksploataciji šljunka iz rijeke Save kod Županje, pronađen je izolirani atlas bovina, kojem je paleontološkom obradom (morfometrijska obilježja, smeđa boja, izražena petrifikacija),

određena pripadnost (Bison seu Bos). Učinjena je detaljna anatomska, metrijska i rentgenološka usporedba fosilnog atlasa iz Županje s atlasom recentnog goveda-Istarski podolac (*Bos taurus primigenius*), predstavnikom najprimitivnije primigene forme goveda, osteološki potpuno bliske ishodišnoj fosilnoj vrsti *Bos primigenius*. Pomoću podataka iz literature, oba atlasa materijski su korelirana i s atlasima fosilnih i recentnih vrsta *Bison priscus, Bison bonasus, Bos primigenius* i *Bos taurus*. Fosilnom atlasu nije bilo moguće odrediti generičku pripadnost, recentnom je potpuna odredba poznata, a sve učinjene analize pokazale su kako se problematika prisutna pri odredbama izoliranih atlasa, do sada istraživana na spomenutim fosilnim i recentnim vrstama bovina, podjednako iskazuje kako na fosilnom atlasu iz Županje, tako i na atlasu primitivne recentne vrste Istarski podolac (*Bos taurus primigenius*).

Ključne riječi: sisavci, Bovinae, gornji pleistocen, naplavina, Sava kod Županje, Hrvatska.

INTRODUCTION

The determining of differences concerning the atlas in *Bison* and *Bos* usually presents some serious problems. This feature was discussed by HILZHEIMER (1921), LEHMAN (1949), ROSKOSZ (1962), GUENTHER (1962), STAMPFLI (1963). The generic osteological characteristics of bovines are mostly based on LEHMANN (1949).

Facing such a problem and at the same time having in mind some specificities due to the way of life of the bovines, those of the recent period as well as the fossil ones, the authors of this paper were trying to apply paleontological, anatomical and radiological methods in order to obtain more accurate criteria for their distinction.

While extracting gravel from the bed of the river Sava near Županja, a complete and well conserved fossil bovine atlas appeared presenting some slightly eroded edges, which may indicate that it had been drifted along by the river, i.e. that its finding place was the secondary one. In fact, well conserved fossil osteological bovine remains sometimes may be found among the alluvion material deposited by several bigger rivers in Croatia. For instance, the Croatian museum of natural sciences in Zagreb (inv. nr. 36, 37, 5O) keeps in custody three fossil atlases of the *Bison priscus* species such as it was identified by GUENTHER (1962) and equally proceeding from the river Sava.

Besides the fossil atlas item from Županja, the comparative study is based on metric data from literature (LEHMANN 1949, STAMPFLI 1963) and on recent material provided by an Istrian cattle atlas (*Bos taurus primigenius*), the most primitive primogenetic domestic bovine form, osteologically completely akin to the original fossil species *Bos primigenius*.

DESCRIPTIONS

Paleontological description of the fossil (*Bison seu Bos*) atlas

The slightly and equally eroded edges were observed on the complete and well-preserved atlas, which suggested its transport to a secondary finding place. The petrification is very intensive and identically manifested throughout the element. The bone colour is light-brown (according to the MUNSELL' s table of colours 10 Y R 7/2), and

due to its morphological characteristics the fossil atlas is found to pertain to the Upper Pleistocene bovines.

The cranial incision of the upper arch is narrow and on its dorsal side it is laterally bounded by two protuberances of the dorsal arch. A thorny ending steeply descends towards the cranial part. The apical parts on left and right side of the caudal arch are rather weakly developed. The ventral cranial lower incision is mildly deep with well developed lateral apical parts. The facies articulares caudales are shaped ovally and they are medianly separated by a groove.

The morphologic study showed that the shape of the dorsal cranial incision is typical of Bos, which is considered to be confirmed as its characteristic (HILZHEIMER 1921, LEHMANN 1949, STAMPFLI 1963). On the other hand, the thorny ending such as it was described appears more often in bisons, although LEHMANN (1949) considers this characteristic to be variable as to the possibility of determining the bovine genus and species.

The appearance of less manifest apical parts on left and right side of the dorsal caudal arch is more frequent in bisons. In general, the ventral cranial incision is more shallow and wider in *Bison* than in *Bos*.

Since the fossil atlas from alluvion of the river Sava near Županja shows morphological (and metrical) similarities both to the genus *Bos* and the genus *Bison*, it is not possible to make any exact generic determination, therefore the element is identified as the Upper Pleistocene bovine (*Bison seu Bos*) fossil atlas.

Anatomical description of the fossil (*Bison seu Bos*) atlas

The arcus dorsalis on its cranial edge has a shallow and moderately wide incision, its lateral edges laying laterally-cranially and ending with considerable thickenings. The tuberculum dorsale is wide and solid, and in its cranial part it steeply reaches the mentioned incision of the dorsal arch. On the arcus ventralis the cranial edge is also incised, but this incision is twice as deep and it is wider than the one on the dorsal arch. The foveae articulares craniales are shaped like a half-moon and their dorsal and ventral parts are of an equal size. The fossa nudata between the dorsal and the ventral part is wide. The left and the right joint surfaces on their ventral and medial parts are separated by a shallow incision, its lateral edges being evenly convex, and they both continue into the ventral surface of the ventral arch forming smaller and half-moon shaped joint facets. The arcus ventralis in its basal part is moderately wide supporting a wide and solid tuberculum ventrale. The foveae articulares caudales are smooth and in their ventral and medial parts they are separated by a well marked cavity, fossa nudata. These joint surfaces partly reach an undivided joint facet of the foramen vertebrae forming the articulatory match with the tooth of the second neck vertebra. A deep cavity is manifest in the immediate part orientated cranially from the joint surface within the foramen vertebrae

that stands laterally on the legs of the dorsal arch -- pediculus arcus vertebrae. The ala atlantis are solid tablets being slightly concave in the central part of their dorsal surface.

The lateral edge of the wing is elevated and thickened in its cranial and caudal part. The lateral edge of the wing also continues being slightly concave. There is a marked deep fossa atlantis situated on the ventral side of the wing, and on its bottom there are two orifices in cranio-medial position: one is the foramen alare, and the other one continues into a short channel ending within the foramen vertebrae. The foramen vertebrale laterale is twin. The caudal thickened ending of the wing continues medially within the tuberculum ventrale, so that these endings lay on the ventral side of the caudal joint surfaces.

Anatomical description of the recent Istrian cattle (*Bos taurus primigenius*) atlas

On the cranial part of the arcus dorsalis there is a narrow deep incision, its lateral edges being almost parallel and they end slightly thickened in their cranial part. On the arcus ventralis there is a considerably wider and deeper incision, its lateral parts being slant and considerably thickened. On the dorsal arch there is the tuberculum dorsale situated medially and descending steeply in its cranial part. The foveae articulares craniales are evenly half-moon shaped, their fossa nudata being small and narrow. These joint surfaces in their ventral part are medially separated by a shallow incision with smooth parallel sagittal edges. Both joint surfaces slightly reach the ventral surface of the ventral arch. The dorsal part of the half-moon shaped joint surfaces is half as narrow as the ventral one. The arcus ventralis in its basal ventral part is considerably narrowed and twisted laterally. In its medial and ventral part it supports a narrow and high tuberculum ventrale. The foveae articulares caudales are slightly concave and they largely reach the foramen vertebrae. They are medially united by a scarcely discernable fossa nudata. The ala atlantis (massa lateralis seu processus transversus) are the smooth tablets thin in their cranial part and gradually thickening towards their caudal part which ends strongly thickened.

The lateral edge of the wing is slightly convex. In the cranial part along the arcus dorsalis the wings have a circular orifice which on its bottom splits into two orifices: one orientated laterally -- foramen alare, and the second oriented medially -- foramen vertebrale laterale. There is a spacious cavity, the fossa atlantis, on the ventral side of the wing.

A spacious circular outlet from the foramen alare can be seen in the middle of the cranial part of the fossa atlantis. Immediately by this orifice and situated caudally there is another, considerably narrower orifice continuing into a channel and ending within the foramen vertebrae. There are several foramina nutritia on the bottom of the fossa atlantis.

Anatomical differences noted in the atlas belonging to a fossil bovine (*Bison seu Bos*) and to a recent Istrian cattle (*Bos taurus primigenius*):

	Fossil bovine (*Bison* seu *Bos*)	Recent Istrian cattle (*Bos taurus primigenius*)
* arcus dorsalis	The incision is shallow and moderately wide. Its lateral edges lay laterally-cranially, their endings being considerably thickened.	Cranially, it is a narrow and deep incision, its lateral edges being almost parallel, and its cranial ending being slightly thickened.
* arcus ventralis	The incision is twice as deep and wider than the one on the dorsal arch. It is moderately wide.	It is a wide and deep cranial incision, its lateral edges being slant and considerably narrowed. It is narrow and it is particularly narrowed laterally in its medial basal part.
* foveae articulares craniales	The incision has regularly convex edges. Both parts are equal. The fossa nudata is wide (and deep laterally). There are some marked half-moon shaped joint surfaces.	They are medially separated by a shallow incision with smooth, sagittal and parallel edges. The joint surface has a dorsal part twice as narrow as the ventral one. There is a narrow and small fossa nudata between these two parts. The joint surfaces only slightly reach the ventral surface of the ventral arch.
* foveae articulares caudales	They are smooth slightly reaching the foramen vertebrae.	They are insignificantly concave largely reaching the foramen vertebrae.

* ala atlantis	They are solid tablets slightly concave in the central part of their dorsal surface. The lateral edge of the wing is elevated and considerably thickened in its cranial and caudal part, being slightly concave alongside.	They are smooth and thin in their cranial part, gradually thickening towards the caudal part. The lateral edge continues slightly convex.
* fossa atlantis	It is rather narrov and markedly deep.	It is wide, spacious and moderately depressed.
* foramen vertebrae	By the foveae articulares, there is a cavity on both sides cranially.	There is no cavities.
* thickened caudal ending of atlas wing	It continues medially into the tuberculum ventrale, the endings laying on the ventral side of the caudal joint surfaces.	There is no endings.

METRICS (MEASURES, INDEXES, HISTOGRAMS)

Table 1. Measurements (harmonized after LEHMANN 1949) made on the atlas belonging to a fossil bovine (*Bison seu Bos* -- from Županja) and to recent bovines (*Bos taurus* -- LEHMANN 1949; *Bos taurus primigenius* -- Istrian cattle)

MEASURES expresssed in millimeters			
	Bison seu Bos (Županja)	*Bos taurus* (LEHMANN 1949)	Istrian cattle (*Bos taurus primigenius*)
1. Facies articularis cranialis (width)	136.0	107.1	132.5
2. Facies articularis cranialis (height)	70.0	60.0	70.7

3. Facies articularis caudalis (width)	133.0	108.6	130.3
4. Facies articularis caudalis (height)	71.0	65.5	73.6
5. Minimal ventral medial length (=intercentrum)	54.6	49.8	53.5
6. Distance from ventral apical parts on the facies articularis cranialis	80.0	69.0	80.0
7. Index 1 (I_1)	68.2	72.3	63.3
8. Index 2 (I_2)	51.5	56.0	53.3
9. Index 3 (I_3)	53.4	60.4	56.5

The indexes (harmonized after LEHMANN 1949) were calculated as follows:

I_1 -- Incisura anterior et inferior $= \frac{\text{measure } 5 \times 100}{\text{measure } 6}$

I_2 -- Fovea articularis anterior $= \frac{\text{measure } 2 \times 100}{\text{measure } 1}$

I_3 -- Fovea articularis posterior $= \frac{\text{measure } 4 \times 100}{\text{measure } 3}$

Table 2. Compared limit values of indexes I_1, I_2 and I_3 in fossil and in recent bovines:

LEHMANN (1949)			
INDEX	*Bos primigenius*	*Bison priscus*	*Bison bonasus*
I_1	68.3 -- 85.1	60.6 -- 69.2	54.3 -- 72.7
I_2	45.9 -- 54.0	44.8 -- 48.9	41.3 -- 51.2
I_3	53.5 -- 67.6	45.3 -- 50.5	42.3 -- 55.3

	STAMPFLI (1963)	Županja	LEHMANN (1949)
INDEX	*Bison bonasus*	*Bison seu Bos*	*Bos taurus*
I_1	51.3 -- 75.8	68.2	72.3
I_2	45.4 -- 54.9	51.5	56.0
I_3	45.0 -- 59.0	53.4	60.4

INDEX	Istrian cattle (*Bos taurus primigenius*)
I_1	63.3
I_2	53.3
I_3	56.5

Histogramic accounts of index values (I_1, I_2, I_3) in fossil and in recent bovine atlas

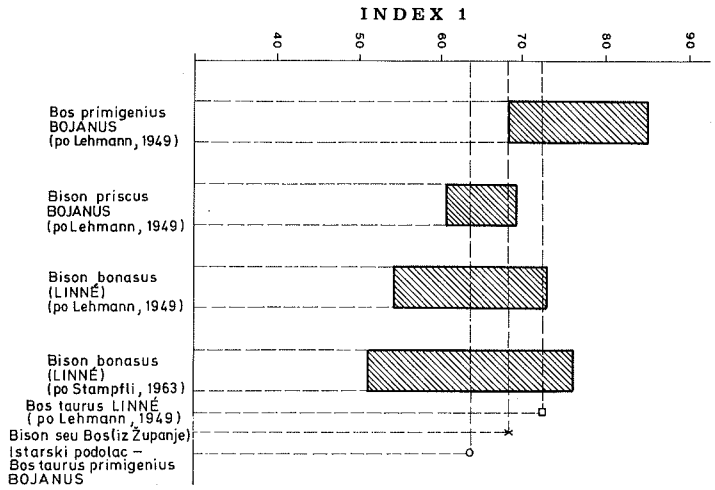
The comparative account of index values (I_1, I_2, I_3) in fossil and in recent bovine atlas as shown by the histograms (a -- c) permits the following conclusions:

Histogram (a): The shape of the ventral cranial incision can be numerically expressed by the values of I_1. This incision is more shallow and more open in *Bison* than in *Bos*, which is manifested in the corresponding lower values. The histogram shows that the fossil atlas from Županja completely matches the parameters corresponding to *Bison bonasus*, being almost identical to the lower limit parameters corresponding to Bos primigenius and close to the upper limit parameters corresponding to *Bison priscus*. The recent Istrian cattle atlas, as to its characteristics, corresponds exclusively to bisons while, after Lehmann, the Bos taurus would correspond to the *Bison bonasus* and *Bos primigenius*.

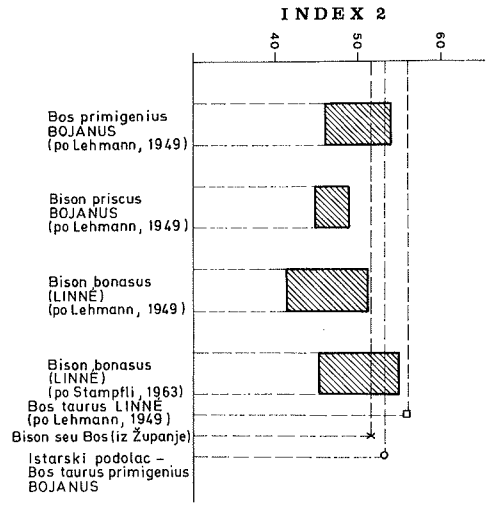
Histogram (b): The value of I_2 expresses the proportion of width and height concerning the cranial joint surface. This histogram shows that the fossil atlas from Županja as well as the recent Istrian cattle atlas match the I_2 values corresponding to both *Bos primigenius* and *Bison bonasus*, being totally different in *Bison priscus*. Nevertheless, according to Lehmann, in *Bos taurus* this parameter would surpass all considered values.

Histogram (c): The proportion of width and height of the caudal joint surface expressed by the I_3 values shows that the fossil atlas as to its characteristics is very close to *Bos primigenius*, that it matches *Bison bonasus* but that it doesn't correspond to *Bison priscus*. The recent Istrian cattle atlas is also found to match optimally the range of I_3 values corresponding to *Bos primigenius* and *Bison bonasus*. According to Lehmann, in this histogram *Bos taurus* would match the range of values corresponding to *Bos primigenius*.

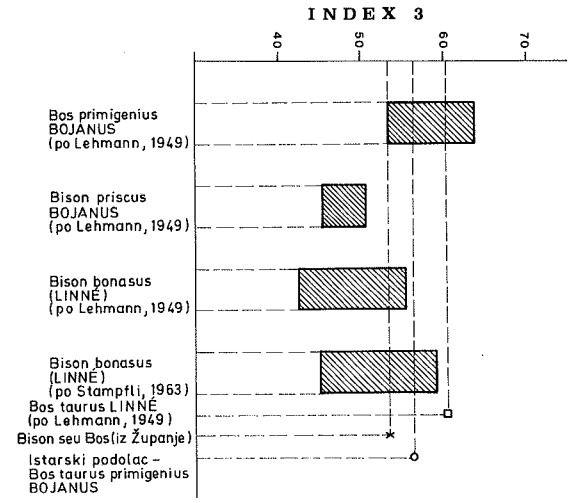
Histogram (a)



Histogram (b)



Histogram (c)



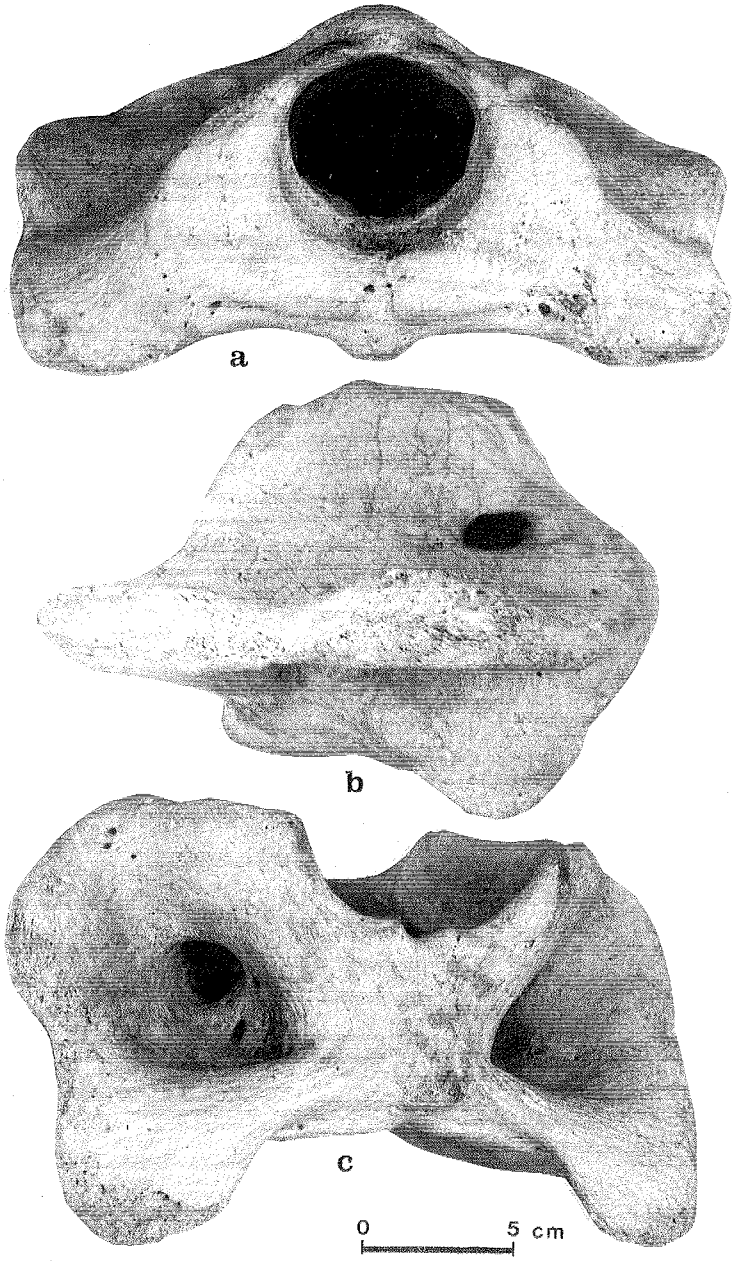


PLATE I

Fig. 1 *Bison* seu *Bos*, Županja, Upper Pleistocene Atlas a - Norma dorsalis b - Norma ventralis c - Norma cranialis

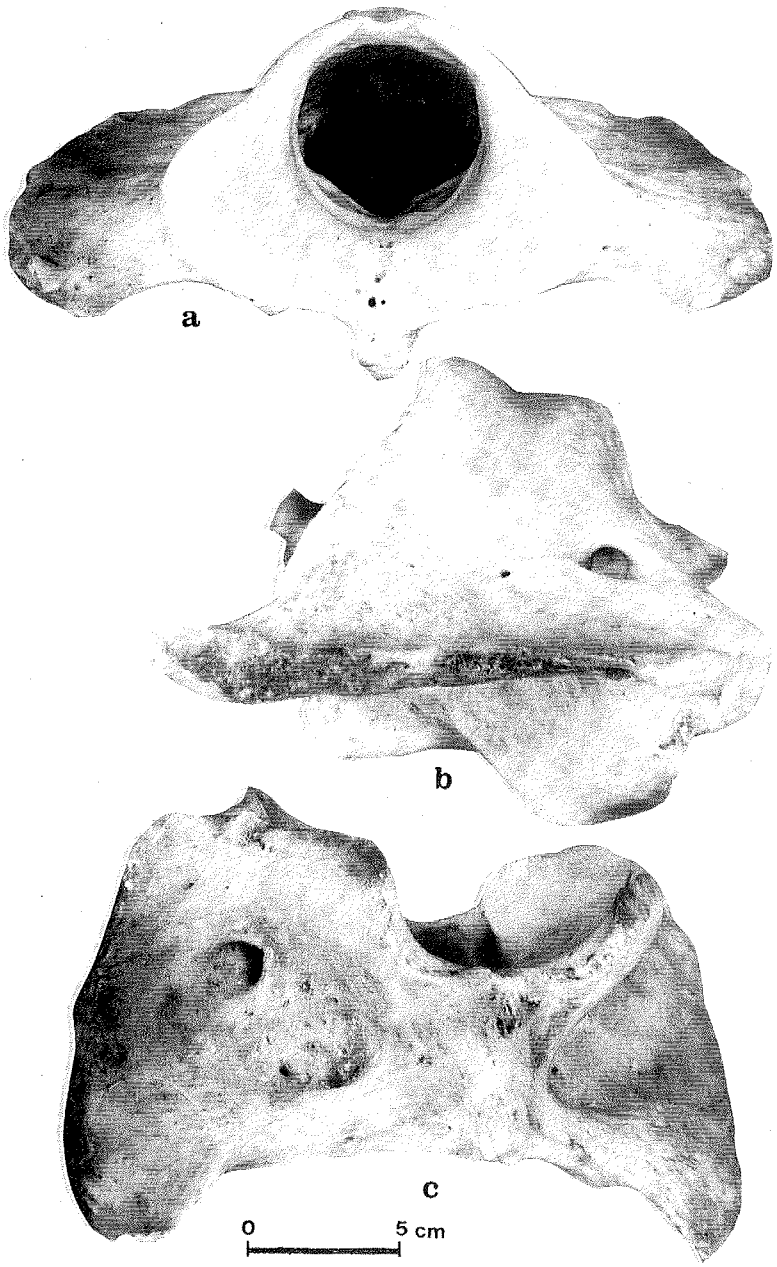


PLATE II

Fig. 1 Istrian cattle -- *Bos taurus primigenius* BOJANUS Atlas a - Norma dorsalis b - Norma ventralis c - Norma cranialis

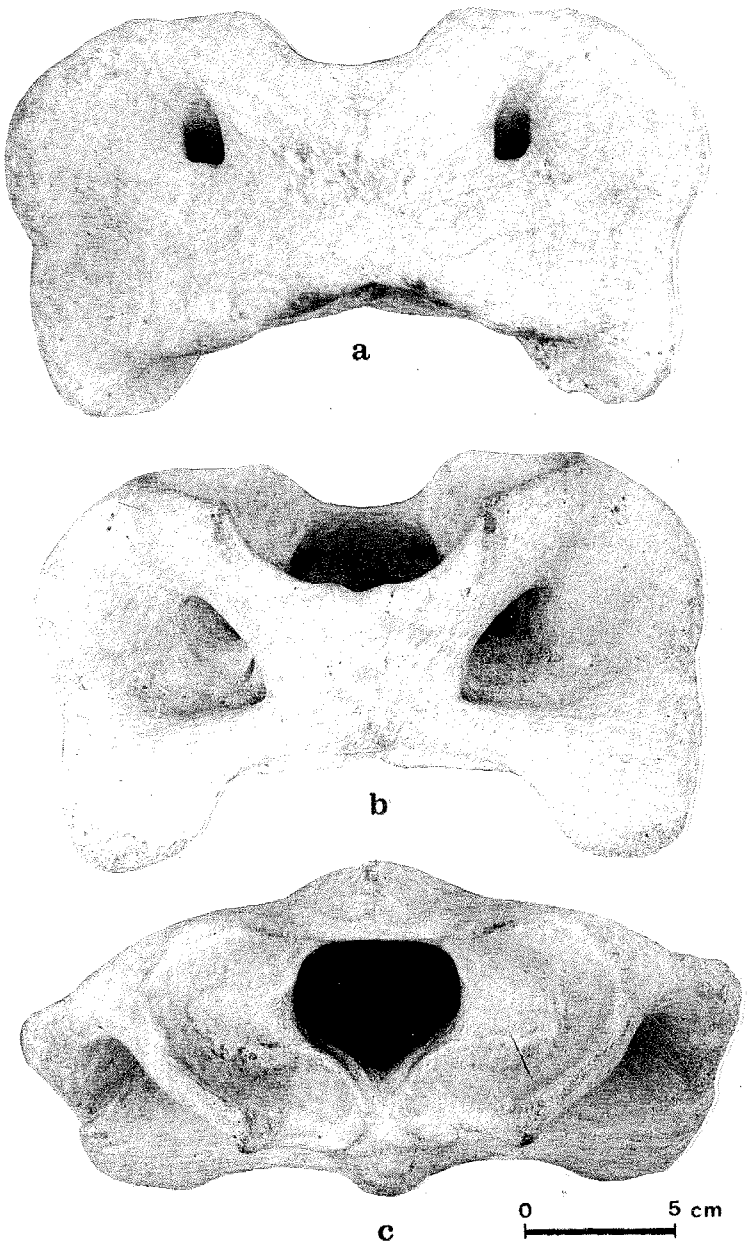


PLATE III

Fig. 1 *Bison* seu *Bos*, Županja, Upper Pleistocene Atlas a - Norma caudalis b - Norma lateralis c - Norma ventro-lateralis

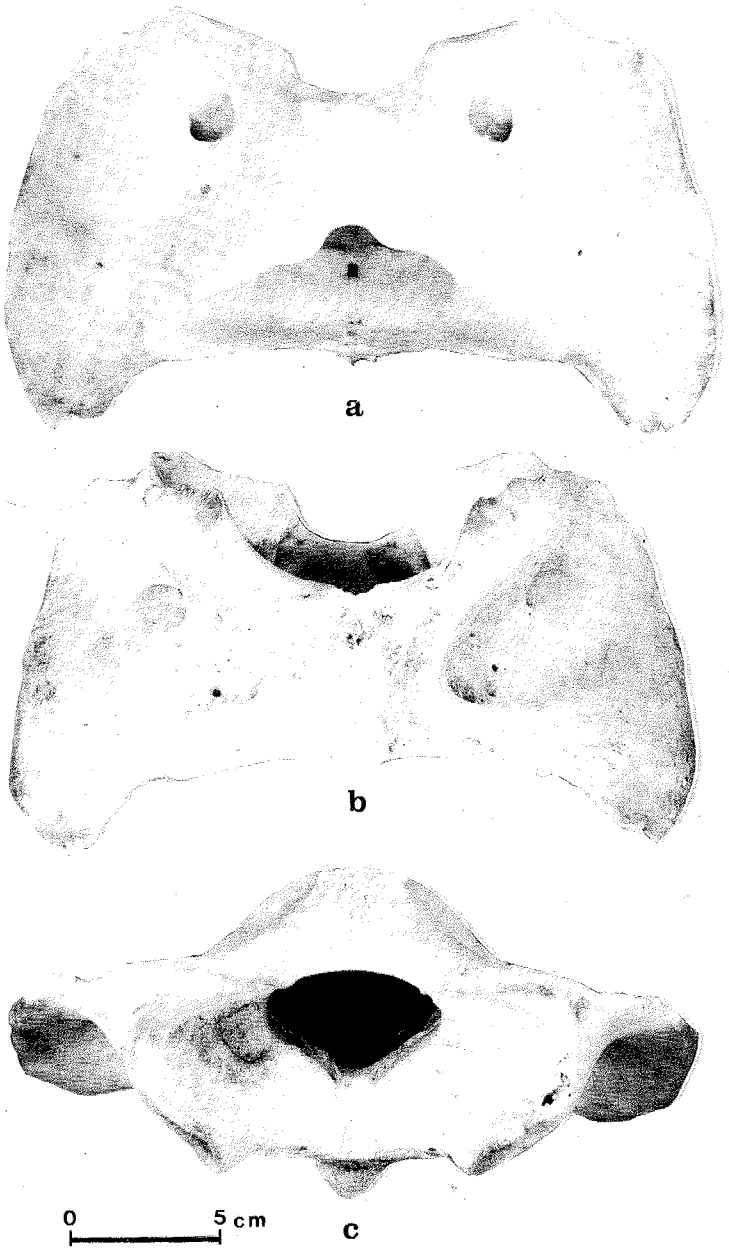


PLATE IV

Fig. 1 Istrian cattle -- *Bos taurus primigenius* BOJANUS a - Norma caudalis b - Norma lateralis c - Norma ventro-lateralis

RADIOLOGICAL ANALYSES

In order to obtain the best radiographs of the atlas the employed electronical devices were: 44 KV and 64 mAs by the X-ray tube, model "Gigantos Optimatic" 1000 of the "Siemens" firm.

Radiological description of the fossil (*Bison* seu *Bos*) atlas

Distance between the external edges of the processus costo-transversarius is 24.7 cm. Distance between the dorsal and ventral tubercles is 10.2 cm. The transversal diameter of the foramen vertebrae is 6.4 cm. The tuberculum dorsale is less marked and it slightly stands out as a small gnarl. The foramina costo-transversaria have 1.5 cm in diameter. The facies articularis cranialis is excavated and wide, the facies articularis cranialis itself slightly leaning down and farward in its frontal parts. The foramen costo-transversarium reaches 1.5 cm.

Radiological description of the recent Istrian cattle (*Bos taurus primigenius*) atlas

Distance between the external edges of the processus costo-transversarius is 23.8 cm. Distance between the dorsal and ventral tubercles is 11.0 cm. The transversal diameter of the foramen vertebrae is 6.0 cm. The tuberculum dorsale is rather marked. The facies articularis cranialis is slightly leaning down and farward. The foramen costo-transversarium reaches 0.8 cm.

By employing the electronical devices mentioned above, it was noted that the most prominent feature in the recent Istrian cattle atlas was a fine reticular structure of the osseous joints of the lateral mass within the atlas itself. On the other hand, although the electronical conditions of filming have been changed, such a fine, rich and detailed osseous structure couldn't be noted in the same parts of the fossil bovine (Bison seu Bos) atlas because of the very sclerotic state of this vertrebra.

The differences found between the osseous structures in the fossil and recent atlas partly may be due to the specimen's different age and to diverse biotopes in which they used to live. However, considering the finding place itself, the sclerotic state of the fossil atlas was certainly due to the process of fossilization and, particularly, of petrification to which this element should have been intensively exposed during very long time.

DISCUSSION AND CONCLUSION

The morphological characteristics, the measured parameters values as well as the indexical correlations show that the fossil atlas from the alluvial material drifted by the river Sava near Županja was more akin to *Bison bonasus* and *Bos primigenius* than to *Bison priscus*. A sure generic decision was not possible because of frequent and strong individual variations within various bovine species, which can be more pronounced than the ones on generic or species-specific scale.

The manifestation of the identical characteristics within the individual fossil atlases in european bisons and in fossil bovines was already noted by HILZHEIMER (1921) and minutely explained by LEHMANN (1949) finding out that the shape of the atlas was decisevely influenced by the gravity centre and the position of the head and not by the weight of their horns. It was equally found that the atlas in the *Bison bonasus* species was functionally identical to *Bos primigenius.*

In order to analyze all aspects of their relationship the bovine (*Bison* seu *Bos*) fossil atlas from Županja has been anatomically, metrically and radiologically compared to the atlas of the most primitive primogenetic recent Istrian cattle (*Bos taurus primigenius*), which is osteologically completely close to the original fossil species *Bos primigenius.* Considering that no comparison of Istrian cattle atlas, as a distinctively primitive form, with the atlases of the other bovines is so far known, both elements were also metrically correlated to the literature data relevant to the fossil and recent species *Bison priscus, Bison bonasus, Bos primigenius* and *Bos taurus.* It has been pointed out that problems concerning identification of the fossil atlases, hitherto studied on the bovine species mentioned above, are equally manifested (histograms) both in the fossil atlas from Županja (*Bison* seu *Bos*) and in the atlas of the primitive primogenetic recent form Istrian cattle (*Bos taurus primigenius*).

As to the radiological approach, in the recent atlas a fine reticular structure of the osseous joints of the lateral mass within the atlas itself could be well noted being even emphasized towards the medial parts of the vertebrae. Although the electronical conditions of filming were changed, such a detailed structure couldn't be noted within the same parts of the fossil atlas owing to its marked state of sclerosis.

The advanced state of sclerosis found in the fossil atlas is certainly in great part due to the natural process of fossilization. Considering the finding place itself, one may conclude that this particular specimen was exposed to a long lasting and very intensive petrification. So far there still remains the problem whether and to what extent the sclerotic character of the osseous tissue did appear during the life of the animal as a consequence of its age as well as of the paleoecological conditions.

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PROBLEMI I DVOJBE PRI ODREDBAMA ATLASA U FOSILNIH BOVINA I USPOREDBA S RECENTNIM GOVEDOM

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Fosilni atlas bovina (*Bison* seu *Bos*) pronađen je pri eksploataciji šljunka iz korita rijeke Save kod Županje. Želja autora ovog članka bila je, da se taj atlas usporedi s njemu sličnim recentnim atlasom Istarskog podolca (*Bos taurus primigenius*), formom koja nije do sada osteološki analizirana niti komparirana, u bilo kojem segmentu, ni s fosilnim a ni s recentnim rodovima i vrstama bovina.

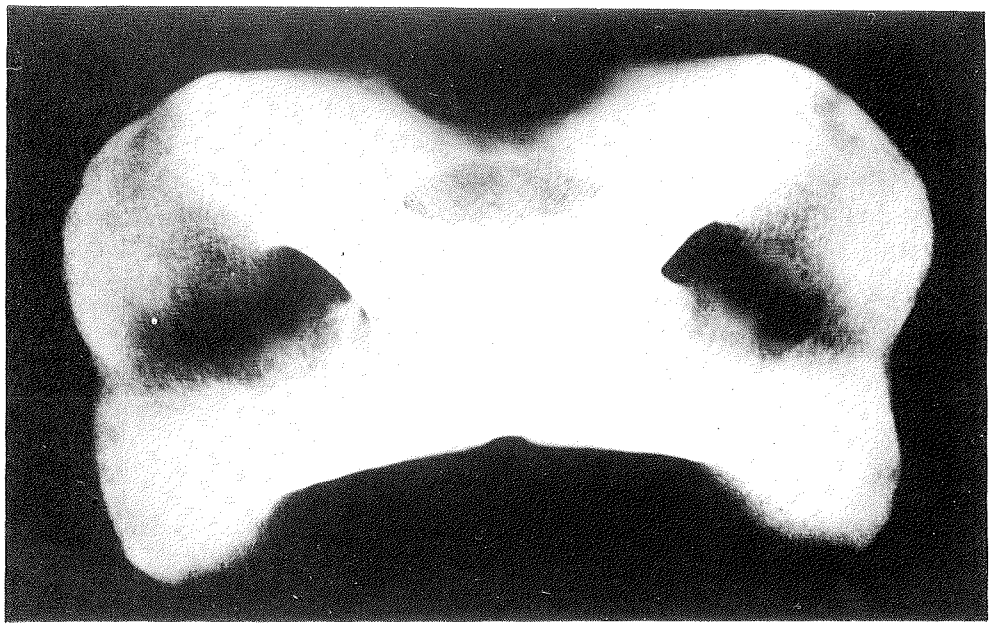
Oba atlasa analizirana su s paleontološkog, anatomskog i rentgenološkog aspekta, kao i uspoređena s podacima iz literature. Ovakav multidisciplinarni pristup primijenjen je u svrhu objektivizacije odredbi imajući pri tome u vidu kronični problem u određivanju razlika između atlasa rodova *Bison* i *Bos*.

Morfološke značajke, vrijednosti izmjerenih parametara, kao i odnosi indeksa, pokazali su da fosilni atlas iz naplavina Save kod Županje pokazuje veću sličnost s vrstama *Bison bonasus* i *Bos primigenius* nego s vrstom *Bison priscus*. Pouzdanu generičku odredbu nije bilo moguće zasigurno utvrditi zbog čestih i jakih individualnih varijacija unutar pojedinih vrsta bovina, koje mogu biti izraženije od generičkih ili specifičkih. Pojavu istovjetnih obilježja na pojedinačnim fosilnim atlasima evropskih bizona i fosilnih goveda zamjećuje još HILZHEIMER (1921), a podrobno tumači LEHMANN (1949), utvrđujući kako na formu

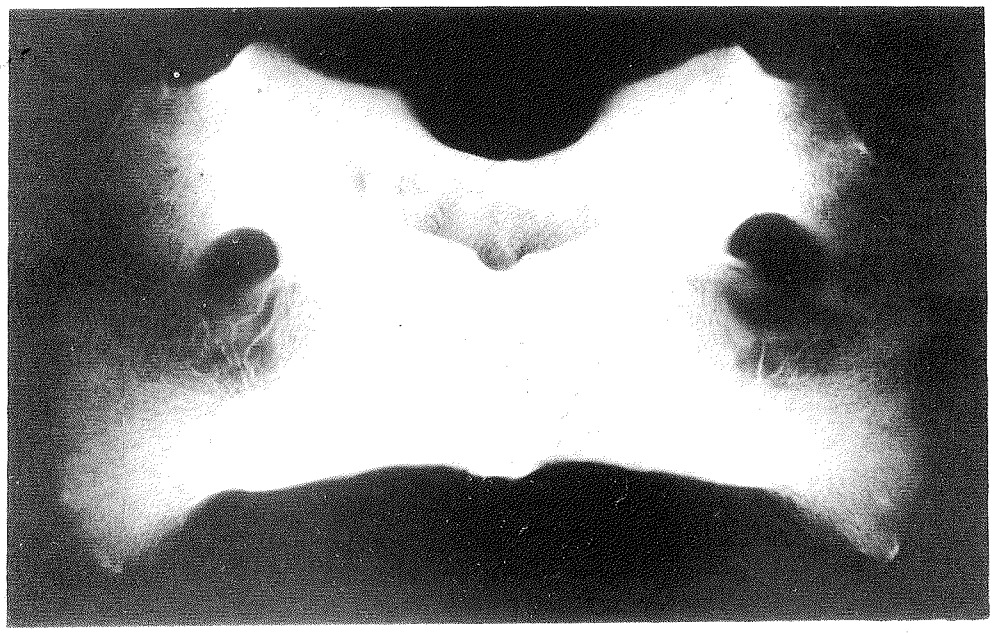
atlasa odlučujuće utječu težište i položaj glave a ne težina rogovlja, te kako se atlas vrste *Bison bonasus* odnosi funkcionalno istovjetno atlasu vrste *Bos primigenius*.

Što se rentgenološkog pristupa tiče, uočeno je, da se kod recentnog atlasa vrlo lijepo ističe fina mrežolika struktura koštanih gredica lateralnih masa atlasa, koja je izražajna čak prema medijanim dijelovima kralješka. Međutim, takvu detaljnu strukturu na istim dijelovima fosilnog atlasa nismo mogli uočiti, koliko god smo mijenjali kondicije električnih uvjeta snimanja, zbog izrazite sklerotizacije fosilnog atlasa.

Utvrđena sklerotičnost fosilnog atlasa zasigurno je dobrim dijelom nastala uslijed prirodnih procesa fosilizacije, a obzirom na nalazište, možemo ustvrditi kako je ovaj element bio izložen dugotrajnoj i osobito intenzivnoj petrifikaciji. U kolikoj se pak mjeri sklerotičnost koštanog tkiva pojavila još tijekom života individue, kao posljedica starosne dobi i paleoekoloških uvjeta - ostaje za sada otvoreno pitanje.



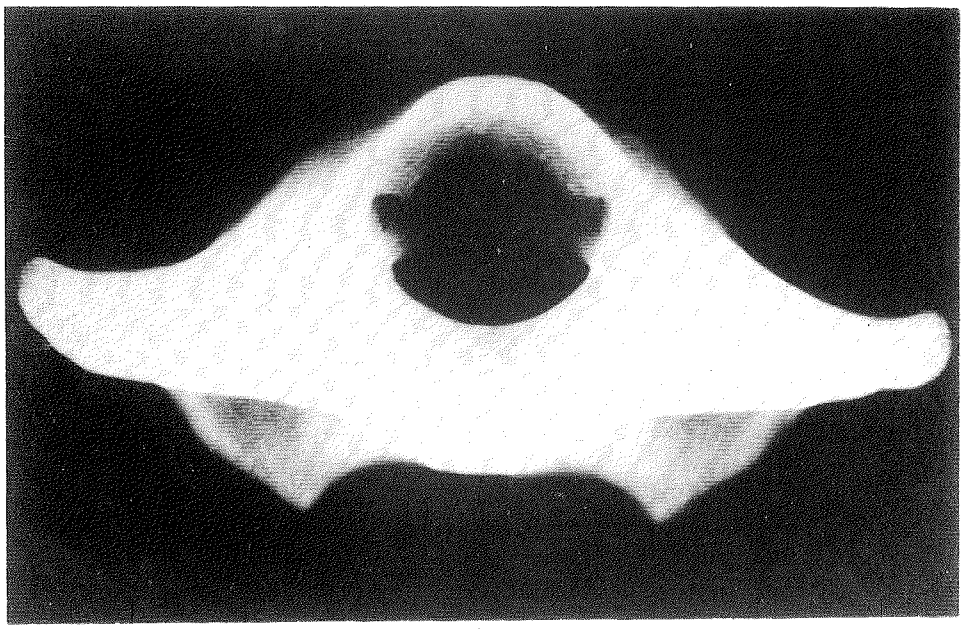
a



b

PLATE V

Fig. 1 Atlas: dorso-ventral view. a - *Bison* seu *Bos*, Županja, Upper Pleistocene. b - Istrian cattle -- *Bos taurus primigenius* BOJANUS 1/2



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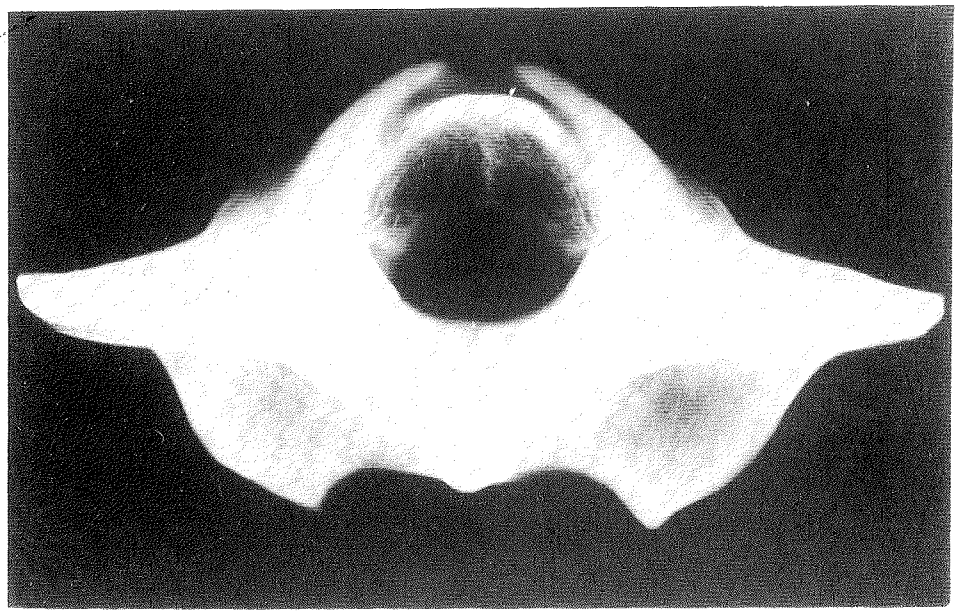
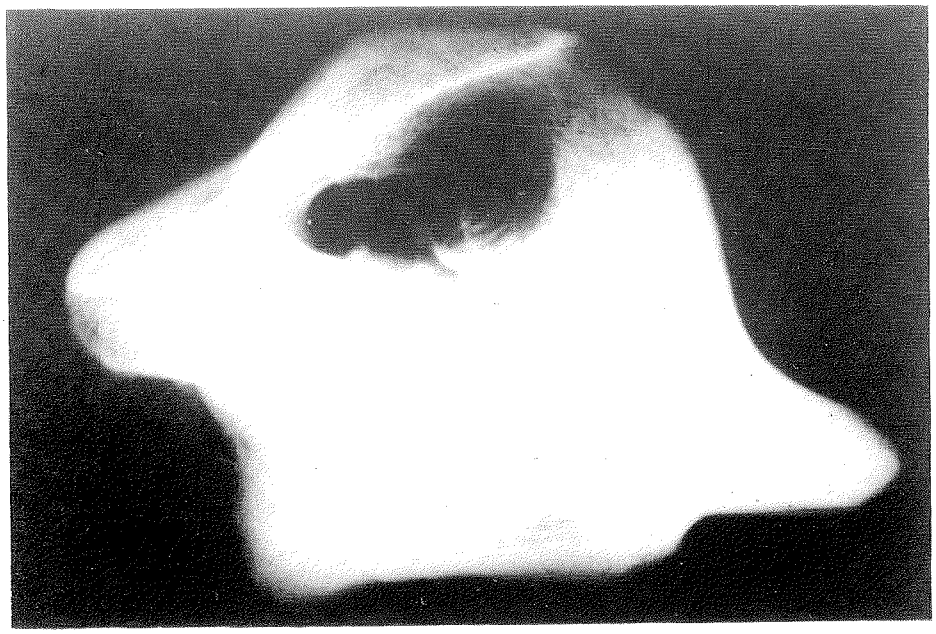


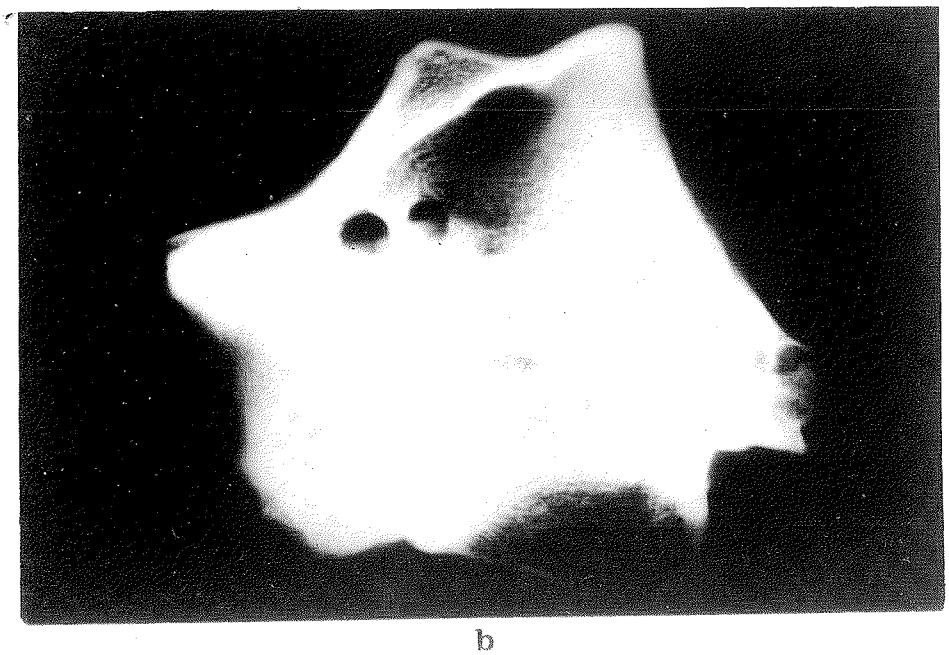
b

PLATE VI

Fig. 1 Atlas: cranio-caudal view. a - *Bison* seu *Bos*, Županja, Upper Pleistocene. b - Istrian cattle -- *Bos taurus primigenius* BOJANUS 1/2



a



b

PLATE VII

Fig. 1 Atlas: lateral view. a - *Bison* seu *Bos*, Županja, Upper Pleistocene. b - Istrian cattle - *Bos taurus primigenius* BOJANUS 1/2