Cranium, jrg. 14, no. 1, pag. 37-46, april 1997

Traumatic skull damages in the woolly rhinoceros, *Coelodonta antiquitatis* BLUMENBACH, 1799.

Nina Garutt

SUMMARY
Description are given of various fossil skulls belonging to woolly rhinoceros (*Coelodonta antiquitatis* (Blum.) and mammoth (*Mammuthus primigenius* Blum.) which show traces of traumatic damage during life. These traces are discussed in comparison with some examples from extant rhinoceroses. Special attention is given to the role of environmental factors which might be related to the cause of the traumatic damage as observed in the fossil skulls.

SAMENVATTING
Beschrijvingen van verschillende schedels van de wolharige neushoorn (*Coelodonta antiquitatis* (Blum.) en de mammoet (*Mammuthus primigenius* Blum.) met sporen van traumatische beschadiging worden gegeven. Deze sporen worden bediscussiëerd in relatie met enkele voorbeelden in recente neushoorns. Speciale aandacht wordt geschonken aan de rol van milieu omstandigheden die in relatie zouden kunnen staan met de oorzaak van de geobserveerde traumatische beschadigingen.

Introduction

Rare finds of skeletal remains of extinct mammals, showing anomalies in the development of bones and teeth or pathological alterations resulting from diseases, are of great interest. They enable us to advance our understanding of complex interrelations between living organisms and environmental factors. At present there are only few works describing pathological bone alterations in large herbivorous mammals, such as mammoth, horse, bison, and elk, and in predators such as cave bear and tiger (PILAVSKY, 1956, SKORIK, 1979). The most thorough studies, carried out on material from archaeological sites, are devoted to human palaeopathology. The main types of pathology found on human bones and bones of the animals mentioned are the same. These are poor unions of broken bones, deforming arthrosis, ancylosis, osteomyelitic damages, and osteomas. The source of pathology is the same - the primary trauma of bones.

As to rhinoceroses, only one work devoted to traumatic damage of the ribs in *Dicerorhinus binagadensis* Dzafarov, 1955, from the Middle Pleistocene site Bihnagady (Azerbaijan), is known (GADZHIEV & GADZHIEV, 1951). Examining a big series of skeletal remains (more than 300 skulls and 200 postcranial bones) of the woolly rhinoceros, *Coelodonta antiquitatis* Blumenbach, I found 9 skulls with various damages which had occurred in the animal's life-time.

Description of the material

1. The first object for study is a skull of *Coelodonta antiquitatis* (specimen PIN RAN n170-8) from the vicinity of the town of Arzamas, Nizhny Novgorod province, the Middle Volga region, the parietal bones of which have a depression on the sagittal suture (at the point of knitting with the interparietal bone, Fig. 1,2). The dent is 40 mm long, 32 mm wide and 17.3 mm deep. On the right side the wall of the dent is abrupt, on the left side there is a cylindrical projection of crushed and shifted bone tissue. The position and structure of the dent suggest its traumatic origin. Probably the deformation occurred in the animal's life-time as a result of a strong blow with a conical object. The direction of the blow was lateral, because the depression is oriented to the left from the sagittal line.

A bone fragment of 61 mm by 90 mm was cut out to subject the damaged section to a more detailed study at the Department of Forensic Medicine of the Army Medical College, St.Petersburg. It was revealed that the underlying spongy tissue also had been damaged as a result of pressure. On the smooth surface of the sinus is seen a fissure, which had been obliterated in the animal's life-time and resulted in the formation of a crest 19 mm wide, 8 mm high, and 9-13 mm long. The top of the crest is compact, its base is loosened. The loosening of the smooth surface occurred as a result of a post-traumatic inflammatory process. Despite the strong blow on the parietal bones, their external compact tissue was not breached.

The parietal bones of *C. antiquitatis* are very massive; the external compact tissue is 12-18 mm thick. They are fitted by nature to protect the brain from strong blows. Behind it there are spacious sinus cavities, then the inner compact tissue (no less solid), and finally the cranial cavity (Fig.3).

The age at death of the animal was about 40 years. Judging by the P2-P3 alveoli, which were subjected to resorbtion, these teeth had already been lost because they were completely worn. P4 and M1 are worn down to the roots, M2 and M3 are more than half worn. Judging by its dimensions, by the development of the orbital processes and zygomatic arches, the skull belonged to a male. There are no doubts that the animal was injured when young. At this age the external compact tissue of the skull bones still retains its resilience, elasticity, and

Fig. 1: Skull of *C. antiquitatis* (Blum.) (PIN RAN n170-8) from Arzamas, Nizhny Novgorod province, Middle Volga with traumatic dent on the parie tal bone. a) lateral view, b) dorsal view.

Fig. 1: Schedel van *C. antiquitatis* (Blum.) (PIN RAN n 170-8) uit Arzamas, Nizhny Novgorod provincie, Midden Volga met traumatische deuk in het pariëtale. a) lateraal aanzicht, b) dorsaal aanzicht.

Fig. 2: Traumatic dent on the parietal bone of *C. antiquitatis* (PIN RAN n170-8).

Fig. 2: Traumatische deuk in het pariëtale van *C. antiquitatis* (PIN RAN n170-8).

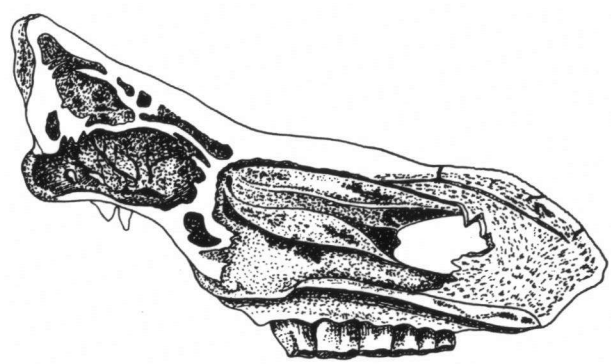

Fig. 3: Sagittal section of the skull of *C. antiquitatis*, showing the thickness of the skull bones and the spacious sinus cavities.

Fig. 3: Sagittale doorsnede van de schedel van *C. antiquitatis*, waarop de dikte van de schedel en de grootte van de sinussen zichtbaar is.

viscidity. An old animal's bones would have broken if they were subjected to such a strong blow. Judging by the smoothed edges of the dent and the degree of obliteration of the fissure, the animal lived for a long time after the trauma and died through other causes.

2. Adult male skull (specimen ZIN n10.713) from the vicinity of Krasnoyarsk, East Siberia (Fig. 4a, b). In the bregma area (at the union of the frontal and parietal bones) there are two dents. As in the previous instance, the compact tissue is shifted in the direction of the blow. The dent above the coronary suture is bigger and has an overhang of crushed bone tissue. The other dent is smaller.

The first two skulls (Figs. 1, 2, 4) bear traumas of the same type, which in both instances are confined to the parietal bones. The only difference is that in the first skull there was one strong blow, whereas in the second skull we have dents left by two blows, one stronger than the other, struck in different directions. The blows were of different directions because it is impossible to strike a direct blow in the coronary suture area, since the latter is shielded by the posterior horn.

3. Adult male skull (specimen BKM n5) from the Altai, the vicinity of Gornoaltaisk (Fig.5). The skull has shallow funnel-shaped dents. The blows were struck with a conical sharp object from a short distance.

4. Adult male skull (specimen AMBU n349) from the Altai with a dent in the middle of the parietal bones. The age at death was more than 35 years. The type of trauma represented on the four skulls mentioned did not lead to disorder of vital functions, because the injury to the soft tissue was only minimum. The muscles of

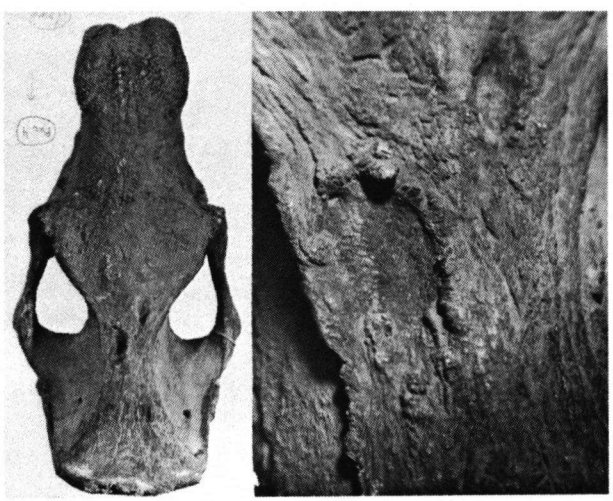

Fig. 4: Skull of *C. antiquitatis* (ZIN n10.713) from the Krasnojarsk area, E. Siberia. a) dorsal view. In the frontal region two traumatic dents are to be seen. b) closer view of the damaged area.

Fig. 4: Schedel van *C. antiquitatis* (ZIN n10.713) uit de omgeving van Krasnojarsk, Oost Siberië. a) dorsaal aanzicht. In het frontale gebied zijn twee traumatische deuken te zien. b) detail van het beschadigde gebied.

Fig. 5: Part of skull of *C. antiquitatis* (BKM n5) from Altai. In the frontal region a dent of traumatic origin is to be seen.

Fig. 5: Gedeeltelijke schedel van *C. antiquitatis* (BKM n5) uit Altai. In het frontale gebied is een deuk van traumatische origine te zien.

the temporal area are thin and covered with thick skin, so the wound quickly healed.

On the skulls discussed below, the blows were directed to the maxillary joint, orbital and nasal bones. In these cases the trauma had after-effects, mainly arthrosis and osteomyelitis. The above-mentioned areas of the skull are of vital importance. They bear functionally significant groups of muscles, copulas, cartilages, and numerous nerves and blood vessels. Injuries to these areas led to the smashing of soft tissues and destruction of organs. The healing of such injuries was a long process and often became complicated with infections.

5. Skull (specimen GM SP6GGI n 82/112) from the Perm province, West Siberia (Fig. 6). The skull has an intact mandible with the left M2-M3, which are heavily destroyed. Judging by the state of the molar alveoli one can conclude that at the moment of death the animal had the complete row of teeth from P2 to M3. In the upper jaw both the right and left M2 and M3 are preserved.

Fig. 6: Skull of *C. antiquitatis* (GM SP6GGI n82/112) from Perm province, W. Siberia. a) palatal view, b) lower jaw of the skull.

Fig. 6: Schedel van *C. antiquitatis* (GM SP6GGI n82/112) uit Perm provincie, West Siberië. a) palataal aanzcht, b) onderkaak behorende bij schedel.

The third molar is half worn. The animal died at a mature age. The left maxillary joint is pathologically deformed. Both the articulate cartilage and the bone were subjected to destruction. The condylus (caput mandibulare) of the left mandibular branch became flat and spread. The same happened with the articular surface (tuberculum articulare) of the zygomata (processus zygomaticus) of the temporal bone. The bony tissue of the injured areas became porous, the degenerative-dystrophic effect of deforming arthritis. Considerable bone expansion increased the size of the articular surface. Alongside with the edge expansion there are signs of grinding of the articular surfaces. After the destruction of the articulate cartilage the maxillary joint ground the surface of the articular surface of the zygomatic process. Neither asymmetry of the maxillae, nor any difference in the degree of tooth wear between the right and left (traumatized) sides can be observed. Therefore one may conclude that the animal was injured at a mature age, lived with the pathology for a short time and soon died.

6. Skull lacking the greater part of the face and both zygomatic arches (specimen GMM KGU n742) from the Kazan Province, the Middle Volga area. The maxillary bone between the orbit and infraorbital foramen is affected by osteomyelitis. It is known that bones affected by osteomyelitis in its early chronic phases do not preserve in soil for long. The destruction of the spongious tissue is characteristic of these phases. It is only in the chronic phase that the bone becomes thicker because of the periostal formations accumulating on it. These formations protect the bone against destruction even in the presence of numerous cloacas. This proves that the animal survived the trauma and, although inabled, lived for a long time. Osteomyelitic affections can be observed near the orbit. The animal was evidently blind in the right eye. There are no teeth in the skull, but considering the degree of injury there is no doubt that they were pathologically deformed on the right side.

7. Adult male skull (specimen TKM nP-62) from the Tumen region, West Siberia (Fig. 7). The second and third molar are only half worn. On the nasal bones, on the right side, at the point of accretion of the fronto-nasal suture, there is an osteomyelitic destruction of the bone tissue in the form of a crater-shaped depression. At the time of death the disease was in its chronic phase and the process of destruction of the cancellous tissue was in effect. The animal died soon after the trauma.

8. Adult female skull (specimen GMM KGU n747) from the Middle Volga area (Fig. 8a,b,c). On the left and right side all the teeth from P4 to M3 are preser-

Fig. 7: Part of skull of *C. antiquitatis* (TKM nP-62) from the Tumen region, W. Siberia. Osteomyelitic damage of the nasal bone.

Fig. 7: Gedeeltelijke schedel van *C. antiquitatis* (TKM nP-62) uit de Tumen regio, West Siberië. Osteomyelitische beschadiging van het nasale.

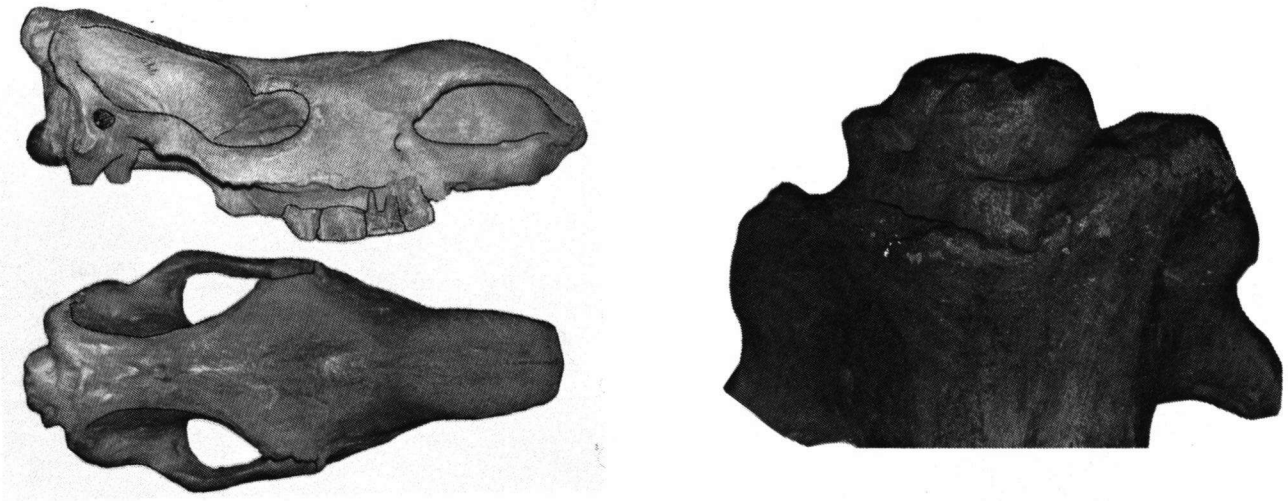

Fig. 8: Female skull of C. antiquitatis (GMM KGU n747) from the Middle Volga. a) lateral view, b) dorsal view, c) Osteoma on the parieto-occipital suture.

Fig. 8: Vrouwelijke schedel van *C. antiquitatis* (GMM KGU n747) uit Midden Volga. a) lateraal aanzicht, b) dorsaal aanzicht, c) osteoma op de parieto-occipitale sutuur.

ved. M3 is only slightly worn. On top of the skull, in the area of accretion of the parieto-occipital suture, there is an osteoma (120 mm by 1400 mm in size), which resembles a burl. Osteomas are benign new growth of bony tissue and are resistant to decomposition which follows an organism's death. In contrast to the majority of the malignant tumours, osteomas are preserved in the earth during hundreds and thousands of years (ROKHLIN, 1965). They arise as a result of anomalies in the development of bone and represent ossified cartilaginous exostoses. Osteomas form in areas where redundant spread of the cartilaginous growth zone is taking place. It usually is observed in young individuals from 5 to 20 years of age (REVELL, 1993).

In juvenile rhinos (from birth to 5 years), with incomplete knitting of the cranial sutures, in the area of accretion of the parieto-occipital suture there is a large synchondrosis articulation between the parietal and occipital bones. The localisation of osteomas is consistent with the view that a trauma to the upper part of the occipital area received at an early age cause their development.

Discussion and comparison

When we compare the localisation of the traumatic damages on the skull of woolly rhino and of other mammals, we see that the traumas are confined to the areas which are most open to strokes during fights (Table 1).

Elephants fight pressing their heads together while their trunks are twisted in tight knots. Fighting animals not infrequently seriously injure each other with their tusks (DERANIYAGALA, 1955).

The collection of the Zoological Museum of the Russian Academy of Sciences, St.Petersburg, includes a skull of *Mammuthus primigenius* Blum. (specimen ZIN n1006), showing a pathological asymmetry (Fig.9). It was found in 1811 on the Ob River, near the Sudzun works, the Altai region. On the frontal bones of the skull, above the nasal aperture, there is a spacious dent left by a strong blow. The animal was injured at an early age when cranial bones were still growing. Subsequently the right tusk alveolus degenerated because of innervation disorders. The animal was left with only one tusk.

Species	Trauma localization	Type of pathology
Elephantidae: extant elephants, mammoth	skull, bones of forelegs (often humerus)	deforming arthrosis, bone fractures, skull asymmetry
Equidae: horses	metapodials	arthrosis, ancylosis
Cervidae: elk	skulls, jaws, metapodials	arthrosis, ancylosis (Skorik 1979)
Bovidae: aurochs	metapodials, ribs, lumbar vertebrae, pelvic bones, long bones of hind legs	arthrosis, ancylosis, rib fractures (Pilavsky 1956)

Table 1: Localization of traumas and types of pathology.

Tabel 1: Plaatsing van trauma's en typen pathologie.

Fig. 9: Skull of *M. primigenius* Blum. (ZIN n1006) from the Sudzum works, Ob River, Altai. a) anterior view, b) lateral view showing traumatic damage, c) view of non-damaged side.

Fig. 9: Schedel van *M. primigenius* Blum. (ZIN n1006) van de Sudzum fabrieken, Ob, Altai. a) anterieur aanzicht, b) lateraal aanzicht met traumatische beschadigingen, c) aanzicht van de niet beschadigde zijde.

Fig. 10: Skull of *M. primigenius* (ZIN without number) from the Adycha River, Yakutia. a) anterior view, b) lateral view (left side), c) palatal view.

Fig. 10: Schedel van *M. primigenius* (ZIN without number) uit de Adycha rivier, Yakutia. a) anterieur aanzicht, b) lateraal aanzicht (linker zijde), c) palataal aanzicht.

The right zygomatic arch is increased because the masticatory muscles of this side bore the main working load. The right half of the nasal aperture is distorted and its entrance is strongly narrowed.

Another skull (without number) is kept in the Zoological Museum, Moscow (Fig. 10). It was found on the Adycha River, Yakutia. The skull bears a trauma of the same type as in the previous case, but its bones are less deformed.

Fights between mammoths are testified by Upper Palaeolithic engravings on bones. One such engraving, representing fighting mammoths, comes from the Upper Palaeolithic site Laugerie-Haute, France (Fig. 11). Another picture represents a mammoth prepared for action, with its head and tail raised (Fig. 11).

Fighting horses rear up, bite the enemy and strike it with their hind legs. Elks fight with their antlers, their heads inclined. The blows are directed to the forelegs and muzzle. Bisons fight with their horns and forehead. The animal pursues its enemy and strikes blows to its pelvic area. Because of the crowded herd, the retreating animal may not be able to escape quickly enough and its trunk and hind legs are also subjected to blows. So we see that in each case the localization of traumatic damages directly depends on fighting positions and behaviour.

Rhinos are the most agressive of all herbivorous species. Of the extant rhinos only the African two-horned species, *Diceros bicornis* L. and *Ceratotherium simum* Burchell, use their front horns in fights. The Indian rhino, *Rhinoceros unicornis* L., though having a horn on its nasal bones (this horn sometimes grows very big), does not use it in fights. In stead it strikes blows with its well developed incisors, which leave deep, lacerated and strongly bleeding wounds. The Indian rhino, defending itself with its incisors, represents an exception among the extant rhinos. Its way of fighting can be considered archaic, characteristic of the ancestral forms of rhinos, which did not yet have horns or had very small ones. As to the two-horned rhinos, both extant and Pleistocene extinct forms, their principal weapon is the front horn. It is twice as long, or longer, as the hind one.

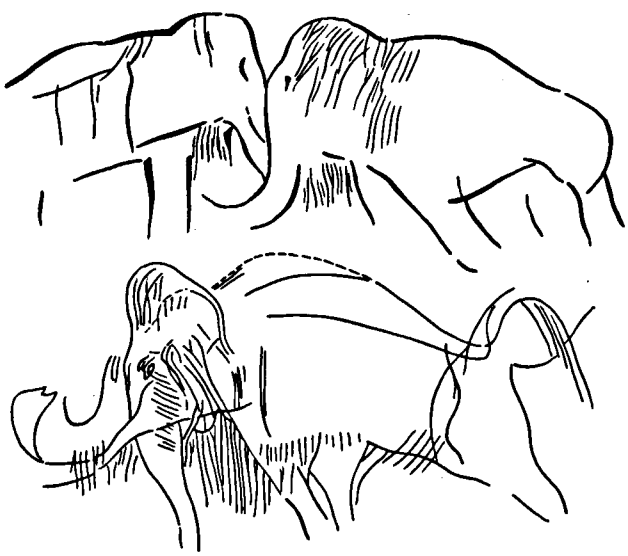

Fig. 11: Late Palaeolithic engraving from Laugerie-Haute, France, showing mammoths and mammoth in threatening pose.

Fig. 11: Laat Paleolithische gravure uit Laugerie-Haute, Frankrijk, waarop te zien zijn enkele mammoeten en een mammoet in dreighouding.

It is well known that in the deer the presence of antlers is a sexual character. Their growth is directed and stimulated by the male sex hormone, whereas females are antlerless. The only exception is the reindeer, *Rangifer tarandus* L., the females of which have antlers. They use them in fighting with the males for feeding areas in winter, when it is difficult to get forage from under the snow. The antlers in the female reindeer appeared in the process of their evolution as a result of increasing concentration of male hormone, which top the treshold level. This hormone also predetermines the more agressive behaviour of female reindeer (SEVERTSOV, 1945).

In extant African rhinos both males and females have very large front horns and cows are record holders in this respect. The front horn of woolly rhinoceros often exceeded the skull length by 200-250 mm. This could, in the author's opinion, indicate high concentration of sexual hormone during the evolution of the Rhinocerotidae, which predetermined the strong agressivity of rhinos in general.

Of the extant African rhinos the black rhino, *D.bicornis*, is considered the most agressive. It attacks not only conspecific individuals, but often also other animals (elephants, buffaloes). This behaviour is accounted for by the specifics of its habitat (dense shrubbery) and its weak sight. If the rhino has not scented an approaching animal of another species in time, it suddenly attacks the approacher without trying to make out what is in front of it. Conspecific males, especially young animals, are often engaged in fierce fights with each other. However, as specialists assert (GRZIMEK, 1972), these fights do not lead to serious injuries.

The changes in behaviour of rhinos kept in zoological gardens are of special interest. While in natural conditions males and females treat one another more or less peacefully, held in captivity they become very agressive towards their mates. Usually the cows behave agressively. The more agressive animal provokes struggle. Sometimes this leads to fierce fighting in which the more peaceful animals become victims and die. In 1976 in the zoo of former West Berlin, a male African white rhino killed a female. Death ensued from a strong blow struck by a horn in the solar plexus. In 1992 to the zoo of Tallin was transferred an adult cow of *D.bicornis*. Earlier it had lived for a long time together with a male in the Alma-Ata zoo. After the death of the male it was deci-

Fig. 12: Male white rhinoceros (*Ceratotherium simum* Burch.) in Rostov Zoo. On the head fresh traces of battle with a female white rhinoceros can be seen. The injuries are located on the forehead, near the eyes, jaw articulation, and the area between the horns.

Fig. 12: Mannelijke witte neushoorn (*Ceratotherium simum* Burch.) in Rostov Zoo. Op de kop kunnen verse sporen van een gevecht met een vrouwelijkle witte neushoorn worden waargenomen. De verwondingen bevinden zich op het voorhoofd, bij de ogen, het kaakgewricht, en het gebied tussen de hoorns.

ded to match the cow with another male kept in Tallin. However, from the first day on the new mate behaved agressively and undertook repeated attempts to attack the she-rhino. The latter was continually on the alert and defended herself. In the autumn of 1993 the zoo attendants noticed that the male was in rut and showed interest in the female. The beginning of the nuptial play boded nothing bad. The animals ran around a pool in an open-air cage and rubbed their heads against one another. In the evening the male rhino became very excited and began to attack the female, striking blows in its stomach, sides and head. The cow tried to take shelter in a room. The attendants were able to draw the male's attention away from the female and to lock her in the room. Examination of her revealed numerous injuries to her head and body. Long stripes of torn skin hung down from her sides and the wounds bled.

In the zoo of Rostov-on-Don, a pair of African white rhinos, *C. simum*, lived during a long period. They never had offspring. The zoo workers' dream to get offspring of this couple has still to materialize. The female rhino behaves agressively towards the male. At times she does not let him have a minute's peace, drives him off his manger, and beats him. These actions are accompanied with threatening hollow growls. On the photo (Fig. 12) one may see fresh traces of beating on the male's head. The injuries are localized to the sinciput and maxillary articular areas, between the horns, and near one eye.

The agressive behaviour of rhinos held in captivity can probably be accounted for by their being held in insufficiently spacious enclosures. If the open-air cage is small, the animals begin to compete with each other for living space. In zoos, where rhinos have plenty of space, they reproduce and do not behave agressively.

The analysis of traumatic damages on the skulls of *Coelodonta antiquitatis* and the comparison with damages observed on the skeletons of other animals leave no doubt that the rhinos received the traumas during fights. In each case, excepting one skull with an osteoma (GMM KGU n742), the traumatizing blows were struck by the front horn.

The skull with an osteoma stands apart. The only feature which it shares with the other skulls is that the osteoma developed on the upper part of the occipital bone where the latter had been injured. As already mentioned above, such type of pathology could have developed if the animal was traumatized at a very early age.

It is known that adult rhinos seldom are attacked by large predators, but that rhino calves often become the object of predation. Lions and hyaenas do not miss the opportunity to take the young from rhino cows weakened by birth. The localization of the trauma on the skull n742 coincides with the place which is usually injured by big cats attacking their prey. The site where the skull was found yielded also bones and skulls of the cave lion, *Panthera leo spelaea* Goldfuss. The available data indicate that the rhino calf may have been injured by a large cat. Probably the mother was successful in defending her young and it survived the attack. The osteoma, which appeared on the spot of the injury, did not hamper the animal's further development. It reached mature age and died through other causes.

On the skull of the extant rhinos traumatic damages are found very seldom. Possibly the Late Pleistocene rhinos were more agressive as compared with the extant ones, which live under climatic conditions characterised by small seasonal fluctuations in temperature. The severe and unstable climatic conditions of the Late Pleistocene may have increased the degree of inter- and intraspecific competition among rhinos.

In the Late Pleistocene, when an abundance of grasses created favorable conditions for the reproduction of herbivorous mammals, woolly rhinoceros had many competitors. Huge herds of bisons, horses, mammoths, reindeer, and saigas lived on periglacial tundras. *Coelo-*

donta antiquitatis was certainly a part of these animal communities. Like extant African rhinos, which often graze with antelopes and other herbivores, the woolly rhino pastured among bisons, horses, and mammoths.

The Late Pleistocene was a period of dynamic climatic changes (GRICHUK, 1961, ARSLANOV *et al.*, 1981). Within a short period of time (microcycle) numerous rises and falls in temperature occurred. In lower latitudes the borders of the forest steppe zone continually fluctuated. In western and eastern Europe, climatic instability was stronger than in the Asiatic part of Eurasia. On the geochronological scale the climatic microcycles may seem small, but compared with animal life-time they were enormous periods of time, during which many generations changed. Undoubtedly the conditions which arouse when transitions between the microcycles occurred were not favorable for the herbivores adapted to living in open steppe landscapes. Migratory animals could have sought for other pastures, but rhinos do not migrate. To some extent woolly rhinoceros probably could have adapted to feeding on mixed forage, including some quantities of twigs and leaves, and thus to a new environment.

As studies in population genetics have shown, the periods unfavorable for mammals are characterized by a disequilibrium in the male/female ratio. Under normal conditions this ratio is 1:1. When unfavorable conditions set in, a greater number of males than females are born. The increase in the number of males in a population is a good indicator of unstable and unfavorable environments. Males bear more new genes and can adapt to change easier than females. These are males on whom nature "work through" the most adequate adaptations, selecting the fittest and eliminating less fit individuals (GEODAKYAN, 1976, 1987). During unfavorable periods the number of male rhinos would, in some regions, have increased. This would lead to stronger intraspecific competition and agressivity in the species in general. Maybe this was the reason why fights between male woolly rhinos were so frequent in the Late Pleistocene. It is interesting that all the skulls with traumatic damages due to fighting belong to males. Mapping of the finds shows (Fig.13) that all the skulls are confined to latitudes 60-50, where the climatic conditions were particularly unstable during the Late Pleistocene.

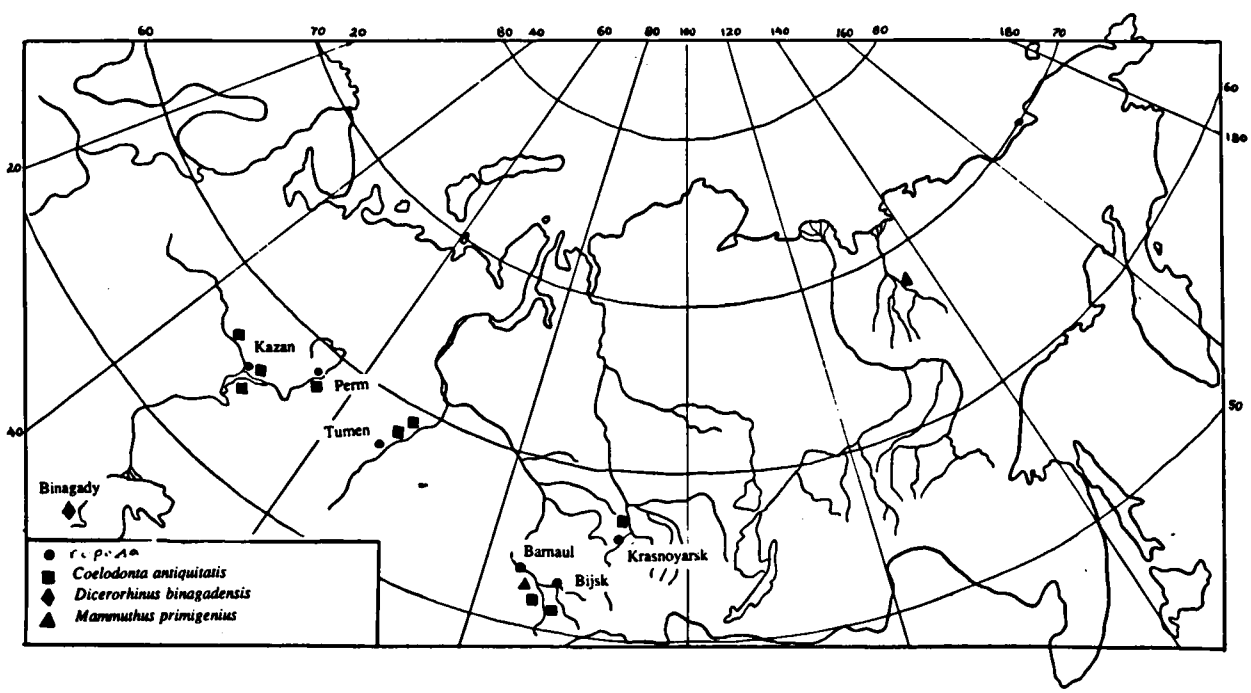

Fig. 13: Map with localities from where the skulls with traumatic injuries of woolly rhinoceros (*C. antiquitatis*) and mammoth (*M. primigenius*) have been found.

Fig. 13: Kaart met daarop aangegeven de locaties waar schedels van wolharige neushoorn (*C. antiquitatis*) en mammoet (*M. primigenius*) met traumatische beschadigingen zijn gevonden.

Abbreviations

PIN RAN - Paleontological Institute, Russian Academy of Sciences, Moscow

ZIN RAN - Zoological Institute, Russian Academy of Sciences, St.Petersburg

GM SP6GGI - The Mining Museum, St.Petersburg State College of Mines

AMBU - The Archaeological Museum, Barnaul Institute

GMM KGU - The Geological and Mineralogical Museum, Kazan State University, Kazan

BKM - The Bijsk Museum of Regional Studies, Bijsk

TKM - The Tumen Museum of Regional Studies, Tumen

ZM - The Zoological Museum, Moscow

References

DERANIYAGALA, 1955: Some extinct elephants, their relatives and the two living species. The Government Press, Ceylon.

GADZHIEV, G.V. & GADZHIEV, D.V., 1951: Traumatic damage of ribs in the fossil rhino from Bihnagady. Reports of the Azerbaijan Academy of Sciences, VII (10):375-377 (in Russian).

GEODAKYAN, V.A., 1976: Ethological sexual dimorphism. Group behaviour of animals. Abstract, II Conference on animal behaviour, Moscow, pp. 64-67 (in Russian).

GEODAKYAN, V.A., 1987: The evolutionary logic of sexual differentiation in phylogeny and ontogeny. Abstract of doctoral dissertation, Moscow (in Russian).

GRICHUK, V. 1961: The principles of stratigraphic division of the Pleistocene period on the basis of paleofloristic materials. In: The Relief and Stratigraphy of Quaternary Deposits of the North-Western Part of the Russian Plain. Moscow (in Russian).

PILAVSKY, B. 1956. Deformacse szkieletu ob serwowane na szesein okazach zubra *Bison bonasus* L. Folia morphologia, 2. (in Polish).

REVEL, P.A., 1993: Bone pathology. Moscow (in Russian).

ROKHLIN, D.G., 1965: Diseases of ancient people. Moscow-Leningrad (in Russian).

SKORIK, A.F. 1979: A trial to analyse osteopathology in fossil mammals. Vestnik Zoologii, 3:63-66 (in Russian).

Address of the author:

N. Garutt
College of Mines
Saint Petersburg
Russia