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THE NEOGENE RHINOCEROSES OF NAMIBIA

by

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ABSTRACT:

Since 1991 the Namibia Palaeontology Expedition has excavated four Miocene sites in the Sperrgebiet, three of which (Arrisdrift, Fiskus and Auchas Mine) are new.

Only the material from Arrisdrift and a single bone from Langental are specifically determinable. All but one of the 81 rhinocerotid fossils from Arrisdrift constitute a homogeneous sample pertaining to a very large species of cursorial rhino. The exception is an isolated magnum which suggests a small to medium-sized short legged form, perhaps *Chilotheridium pattersoni*.

A magnum from Langental probably represents *Brachypotherium heinzelini*.

The large form from Arrisdrift seems to be the largest of the Miocene African Rhinos; the size and proportions of the metapodials and the other limb bones suggest an analogy with *Diceros* gr. *pachygnathus-neumayri* of the Upper Miocene of the Near East; the type of construction of the upper cheek teeth, namely the fourth premolar, is of Dicerotine type and presents, as do the dimensions, close resemblances with *Diceros douariensis* of the Upper Miocene of North Africa and Italy; the mandible shows analogies with the Dicerotines, especially the apparently short symphysis. This Rhino is *Diceros australis* nov. sp., so far the oldest known species of the subfamily.

KEYWORDS: Neogene, Namibia, Sperrgebiet, Arrisdrift, Perissodactyla, Rhinocerotidae, *Diceros australis* sp. nov.

INTRODUCTION

Since 1991 the Namibia Paleontology Expedition, led by B. Senut and M. Pickford, has excavated Miocene sites in the Sperrgebiet (Pickford *et al.* 1995). Rhinos were found at four sites, one of them, Arrisdrift, being very important. I had the good luck to find among about 85 fossils three specimens of the same carpal bone, the magnum, showing that three different species are present, one at Langental and two at Arrisdrift (Figure 1: 3-5; Figure 2). The bulk of the Arrisdrift material (80 pieces) belongs to a new species, *Diceros australis*. *D. australis* is the oldest species of the Dicerotine subfamily, whose present day representatives are the black and the white rhinos of Africa.

Previously, some mammalian remains were recovered from South West Africa and sent to Germany, where they were studied by E. Stromer (1926); the only published fossil rhino was assigned to "Rhinocerine g. et sp. indet". Several papers were later published reassessing some mammalian species and describing others. Hamilton & Van Couvering (1977) synthesized the preceding works and brought the faunal list up to date. In that list the only identified rhinocerotid was *Brachypotherium heinzelini*, based on a report by K. Heissig (1971) on the half-mandible found at Langental and described without determination by E. Stromer.

Among the undescribed rhino fossils from Namibia found prior to the work of the Namibia Palaeontology Expedition, there is a weathered but complete metatarsal III from a large *Brachypotherium* housed in the



Figure 1. 1: right calcaneum (AD 50'97) of *Diceros australis* nov. sp.; 2: left astragalus (AD 619'94) of *Diceros australis* nov. sp.; 3-5: the three magnums of the Miocene rhinoceroses from Namibia: 3: cf. *Chilotheridium pattersoni* (AD 618'97), 4: *Diceros australis* nov. sp. (AD 638'97); both from Arrisdrift, 5: *Brachypotherium heinzelini* from Langental (LT 384'96). Scale bar is 3 cm.

collections of the South African Museum (SAM PQ 2517) and recovered 8 km southeast of Bogenfels (probably the sites of Glastal 1 or 2) by J. Schneider in 1983.

Finally some Quaternary rhino remains also are known from Namibia: an M3/ of *Ceratotherium* (South African Museum SAM PQ 2126) was found in 1978 by G. Corvinus in the "brown grits in the Upper Grillental". A skull, a mandible and some rhinoceros tracks attributed to *Diceros bicornis* were recovered near Kolmannskuppe (= Kolmanskop) and Charlottenthal and briefly described by R. Heinz (1933) and reviewed by C. Guérin & G. Demathieu (1993).

THE SITES

Four lower or middle Miocene rhino sites were worked by the Namibia Paleontology Expedition in the Sperrgebiet, three of which are new : Arrisdrift, Fiskus and Auchas Mine.

Arrisdrift

This very rich site, near the Orange River, 35 km east of Oranjemund, is about 17 Ma old and yielded numerous vertebrate remains (Pickford *et al.* 1996). All but one of the 81 fossil rhino specimens from Arrisdrift constitute a homogeneous sample pertaining to a very large species of cursorial rhino, *Diceros australis*. The exception is an isolated magnum which is totally different from the magnum assigned to *D. australis*: it is shallow and very wide and suggests a small to medium sized short-legged form, perhaps *Chilotheridium pattersoni*, which was defined at Loperot, Kenya, the age of which is about the same as that of Arrisdrift.

Langental

In this 18 to 19 Ma old site one rhino specimen, a complete magnum, was recovered. This fossil probably represents *Brachypotherium heinzelini* which was recognized by Heissig in 1971 on the basis of half a mandible found at the same site.

Fiskus

A deeply worn upper premolar was found in Fiskus, with an age of about 20 Ma.

Auchas Mine

Auchas Mine is an alluvial diamond-bearing deposit 50 km upstream from Oranjemund (Pickford *et al.* 1995), about 19 to 20 Ma old. Among seven mammalian species found in pit AM 02 is an undetermined rhinoceros of which two specimens were recovered: an atlas vertebra and a mandible fragment.

MIOCENE RHINOS OF AFRICA

Six rhino lineages (comprising a total of seven genera and eleven species) are so far known from the African Miocene (Hooijer 1973, 1978; Guérin 1980 b, 1989; Prothero *et al.* 1989). The ages of numerous African sites are based on the results of M. Pickford (pers. comm.).

Aceratheres

Aceratheres are medium to large-sized, hornless, tapir-like cursorial rhinos with four toes in the forelimb. They possess strong lower tusks, and their cheek-teeth are very brachyodont with the upper ones possessing an outer wall which is more or less flat. They are recorded from East and North Africa:

Aceratherium acutirostratum (Deraniyagala 1951) is medium-sized: It is known from the Alengerr Beds (14 to 12 Ma), Chemeron Formation-Northern Extension (5 to 4.5 Ma), Karungu (18 Ma), Moruaret Hill near Losidok (ca 16 Ma), Ngorora Formation (11 to 12 Ma), Ombo (15 Ma), and Rusinga (18 Ma) in Kenya; Napak (19.5 Ma) in Uganda; Karugamania (older than 7 Ma) and Sinda (more than 6 Ma) in Congo.

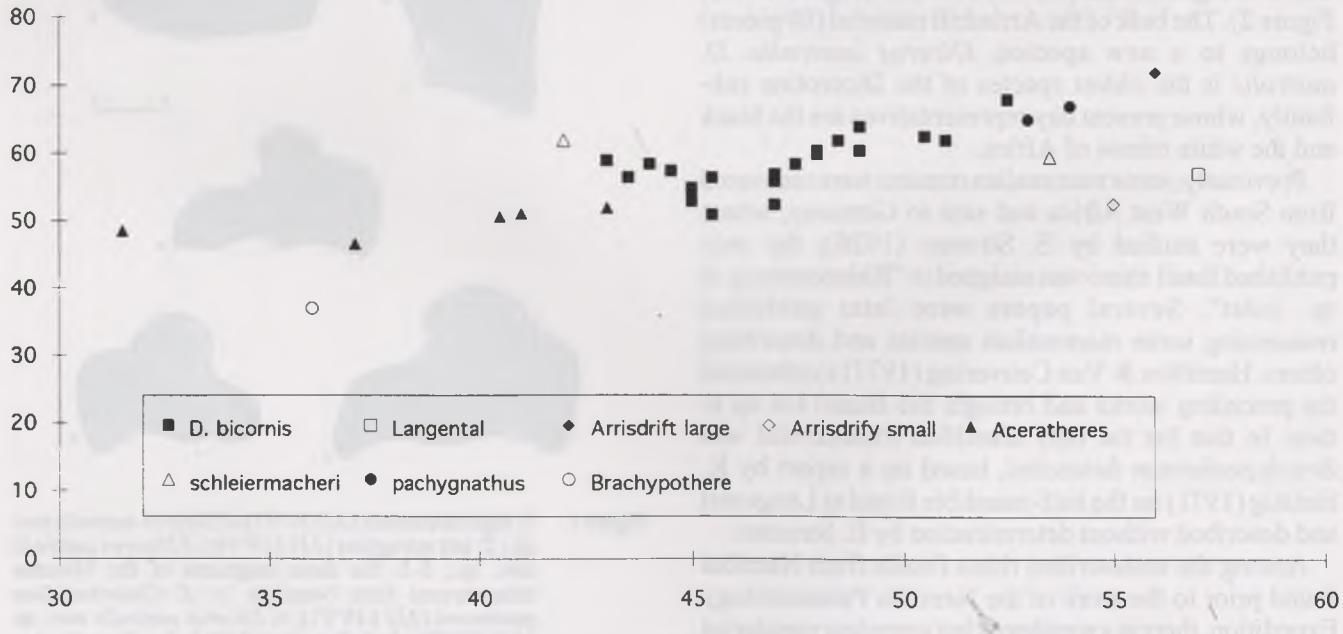

Figure 2: Scatter diagram of the anterior width (Y axis) versus the sus-articular height (X axis) of the three magums of Miocene rhinoceroses from Namibia, other Miocene rhinoceroses and the present day *Diceros bicornis*.

Aceratherium campbelli Hamilton 1973 is very large: it is recorded from Jebel Zelten (ca 16 to 17 Ma) in Libya.

Dicerorhines

Dicerorhines are two-horned medium- to large-sized cursorial rhinos with well developed lower tusks; the upper cheek teeth are relatively brachyodont with an outer wall presenting (especially in the two last premolars) two powerful vertical folds (paracone and metacone folds). They possess long faces. It is known from East Africa:

Dicerorhinus leakeyi Hooijer 1966 is medium-sized: it has been recorded from the Alengerr Beds (14 to 12 Ma), Chemeron Northern Extension (ca 5 Ma), Karungu (18 Ma), Maboko (15.5 Ma), Ombo (15 Ma), Rusinga (18 Ma) in Kenya and Napak (19.5 Ma) in Uganda. Note that in most of these sites *D. leakeyi* is sympatric with *Aceratherium acutirostratum*.

An Upper Miocene Algerian species, *Dicerorhinus primaevus* Arambourg 1959, has a controversial generic status (Geraads 1986).

Large species of *Dicerorhinus* are so far unknown in the African Miocene but are present in Europe with *D. schleiermacheri* and others (Guérin 1980).

Dicerotines

This subfamily includes the two extant African rhinos *Diceros bicornis* ("black" rhino) and *Ceratotherium simum* ("white" rhino). *Ceratotherium* is much more evolved and dates from the Uppermost Miocene. Species of the less specialized genus *Diceros*, which appears during the Middle Miocene, are large and heavily-built two-horned rhinos. The face is short; they possess short mandibular symphysis and there are no incisors. The outer wall of the brachyodont upper cheek teeth possesses only one marked vertical fold, the paracone. Miocene forms are known from Northern Africa, Southern Spain, Italy and the Near East (Guérin 1980):

Diceros douariensis Guérin, 1966: This species has been reported from Douaria (9.5 Ma), and possibly Djebel Krechem el Artsouma (Upper Miocene) in Tunisia (Geraads 1989), and Baccinello V3 (zone MN 13) in Italy (Guérin 1980). Material from Gravitelli (Upper Miocene) in Sicily (Italy), Cenes de la Vega and Los Hornillos (both MN 13) in the Granada Basin (Spain) clearly represents *Diceros* but is not sufficient for a determination at the specific level. The two Near-East Upper Miocene *Diceros* species, whose discrimination and affinities are somewhat controversial, are *D. pachygnathus* from Pikermi (Greece) and *D. neumayri* from Turkey. All these species of *Diceros* are much younger than the Arrisdrift fauna.

Paradiceros mukirii Hooijer 1968 is a small rhino of the Dicerotine group known from Fort Ternan (about 13 Ma) and perhaps Maralal in Kenya, Kisegi (13 to 14 Ma) in Uganda, and Beni Mellal (12.5 Ma) in Morocco (Hooijer 1968; Guérin 1994).

Iranotheres

Iranotheres are very large and heavily built rhinos from Eurasia with (for the time) extremely hypsodont cheek-teeth whose folded enamel is characteristic. Only one species has so far been found in Africa, and it is poorly known (Aguirre & Guérin 1974):

Kenyatherium bishopi Aguirre & Guérin 1974 is recorded from Nakali (9.5 Ma) and Samburu Hills in Kenya (9.5 Ma) (Nakaya *et al.* 1999).

Brachypotheres

Brachypotheres are large hippopotamus-like hornless rhinos with very shortened but powerful legs. The outer wall of the upper cheek teeth show a trend to flattening. The tusks are large. The way of life was hippopotamus-like. As noted by M. Pickford *et al.* (1993, p. 109) the African species need revision. They are known from North, East and South Africa:

Brachypotherium snowi (Fourtau 1920) is known from Wadi Moghara, Egypt and Jebel Zelten (17 to 16 Ma) in Libya.

Brachypotherium heinzelini Hooijer, 1963 is reported from Arongo Uyoma (Early Miocene), Chemeron Formation-Northern Extension (5 to 4.5 Ma), Karungu (18 Ma) and Rusinga (18 Ma) in Kenya; Bukwa (between 17.5 and 18.5 Ma) and Napak (19.5 Ma) in Uganda; Karugamania (older than 7 Ma) and Sinda (more than 6 Ma) in Congo and Langental (18 Ma) in Namibia.

Brachypotherium lewisi Hooijer & Patterson, 1972 is recorded from Kanapoi (4.5 Ma), Lothagam (7 Ma), Mpesida (6.5 Ma), Ngorora (12 to 11 Ma) in Kenya and Sahabi (6.5 Ma) in Libya.

Chilotheres

Although pertaining to a different subfamily *Chilotheridium* presents many convergences with the preceding group. It is a small short-legged rhino with small tusks, but there is one small horn in both sexes, and the manus is four-toed. The cheek teeth are hypsodont. It is known from East Africa (Hooijer 1971).

Chilotheridium pattersoni Hooijer 1971 is present at Kirimum (15 Ma), Loperot (17 Ma), Ngorora (12 to 11 Ma), Ombo (16 Ma) and Rusinga (18 Ma) in Kenya; and Bukwa (ca 18 Ma) in Uganda.

Reference material

I had the opportunity to study a great number of specimens of Miocene rhinos from Africa, particularly material preserved in the Natural History Museum, London. I had the possibility to study all the known material of *Chilotheridium pattersoni* from Loperot when it was in Holland. The holotype of *Diceros douariensis* is in Lyon, and the material from Baccinello V3 is preserved in Basle, Switzerland. Among the material in London there are different pieces from the three African species of *Brachypotherium*, good casts of skulls and teeth of *Paradiceros mukirii*, some specimens of *Aceratherium campbelli*, skulls and mandibles of *Aceratherium acutirostratum* and *Dicerorhinus leakeyi*.

Unfortunately, in the original description of *Dicerorhinus leakeyi*, D.A. Hooijer (1966, 1973) wrote that it is impossible to distinguish the postcranial material of that species from *Aceratherium acutirostratum*. Consequently postcranial bones of the two species are not separated in the London collections, and they are not numerous enough to enable distinction. But, although I have not seen it, I am convinced that such a distinction will be possible on the original material housed in the National Museums of Kenya in Nairobi. In the following tables the undifferenciated *D. leakeyi/A. acutirostrartum* material is named MSUR. To cover up the absence of references for the postcranials of medium-sized African *Aceratherium*, I thus use a mixture of measurements taken on the European species *Aceratherium tetradactylum* (Middle Miocene) and *A. incisivum* (Upper Miocene), which pertain to the same lineage, for comparison; in the tables the mixture is labelled Aceratheres. Because large species of *Dicerorhinus* are so far unknown in the Miocene of Africa, I utilise *Dicerorhinus schleiermacheri* from the Upper Miocene of Europe for comparisons. Finally, to have a sample of large Miocene *Diceros*, I used the material from Pikermi (widely scattered in all the Natural History Museums of Europe) which is *D. pachygnathus*, and the material from Turkey which is housed in the Museum of Munich, Germany; the last one belongs to *Diceros neumayri*. In order to avoid the problems of disorder in the nomenclatural designation of *D. pachygnathus*, and of the differentiation between *D. pachygnathus* and *D. neumayri* (in my opinion close to but somewhat distinct from each other) I will refer to the regrouped material by the name *Diceros* gr. *pachygnathus-neumayri*.

THE LARGE RHINOCEROS FROM ARRISDRIFT,

Diceros australis sp. nov

Material

2 large and 5 small fragments of mandibles with more or less important elements of their respective tooth-rows;
2 lower incisors;
10 isolated upper cheek-teeeth;
13 isolated lower cheek-teeth;
1 radius;
3 ulnae (including 1 complete);
6 carpals (2 magnums, 2 pyramidals, 1 semilunar, 1 pisiform);
4 metacarpals (1 Mc II, 2 Mc III, 1 Mc IV);
1 tibia;

TABLE 1.
Compared dimensions of the mandible of *Diceros australis* nov. sp.
ap= anteroposterior; artic= articular; diam= diameter; dist= distal; horiz= horizontal; prox= proximal; tr= transverse.

ARRISDRIFT							*Diceros douariensis*			
n°	AD 556'94	AD 300'97	AD 313'98	AD 437'97	AD 223'97	AD 478'95	n	mean	min.	max.
symmetry	R	L	R	R	R					
Distance symphysis-heel		462					1	396		
Depth horiz. ramus P2-P3		67		67.5			1	82.00		
Depth horiz. ramus P3-P4		80			77		2	84.50	80	89
Depth horiz. ramus P4-M1	87.5	81					2	96.50	95	98
Depth horiz. ramus M1-M2	93.5	93					2	108.00	106	110
Depth horiz. ramus M2-M3	99	102.5	108				1	100.00		
Depth horiz. ramus M3	107	105					1	107.00		
Width horiz. ramus P4-M1		60			about 43,5		2	49.75	49.5	50
Width horiz. ramus M3	67	60.5	50				2	57.50	57	58
AP diam. ascending ramus	167									
Transv. diam. condyle						125.5				

Chilotheridium pattersoni					*P. mukirii*	*B. heinzelini*	MSUR
	n	mean	min.	max.	Fort Ternan	Langental	Karungu
Distance symphysis-heel	2	423.00	404	442			
Depth horiz. ramus P2-P3	1	92.00			59.5		60
Depth horiz. ramus P3-P4	3	84.50	71	98	64		59
Depth horiz. ramus P4-M1	3	89.00	77	99	70		64
Depth horiz. ramus M1-M2	3	91.67	77	104	82.5		66
Depth horiz. ramus M2-M3	3	91.67	85	103	88.5	est. 82	70
Depth horiz. ramus M3	2	101.75	101.5	102	92		78
Width horiz. ramus P4-M1					45		37
Width horiz. ramus M3					47	54	41.5
AP diam. ascending ramus							
Transv. diam. condyle							98

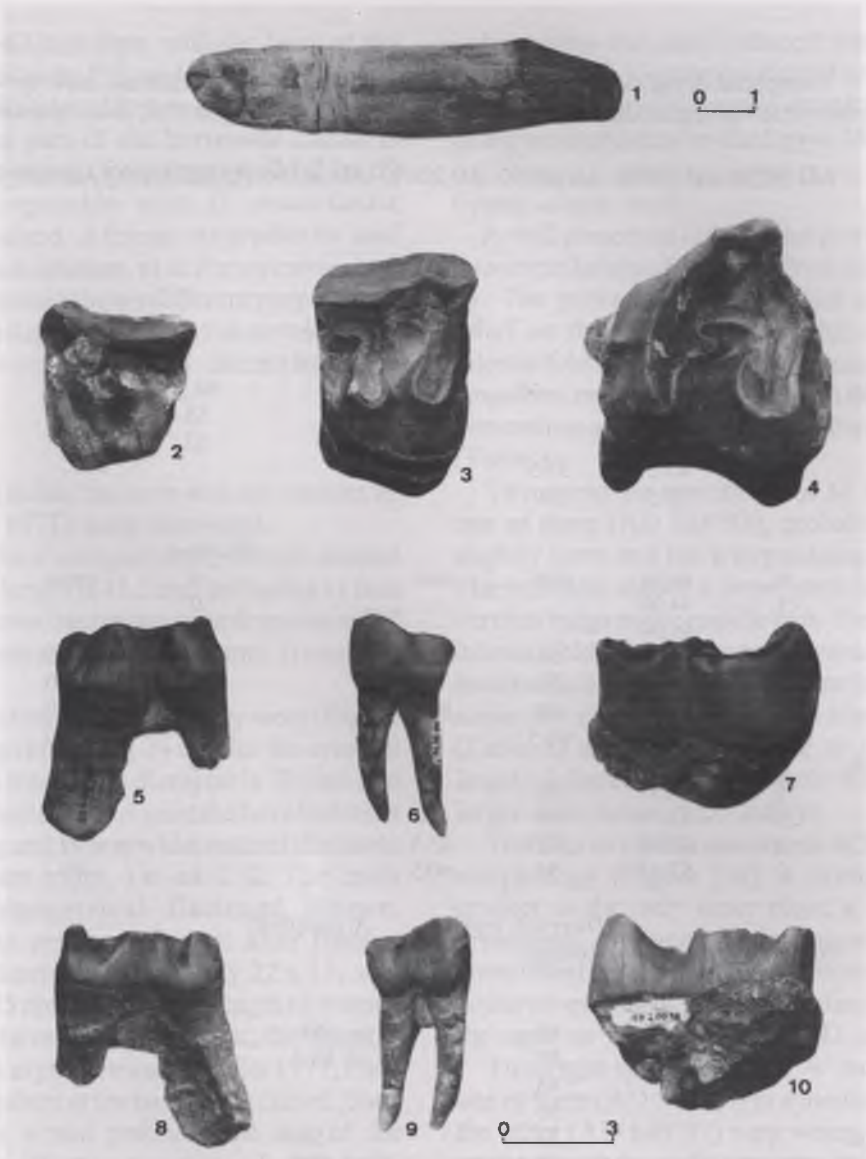

Figure 3: Teeth of *Diceros australis* nov. sp. 1: lower tusk AD 87'98 (photo V. Eisenmann); 2: Left D 4/ AD 292'94; 3: Right P 4/ AD 578'98; 4: Right M 3/ PQ AD 339; 5 and 8: Left D /3 PQ AD 635 (respectively labial and lingual view); 6 and 9: Left P /2 AD 86'98 (respectively labial and lingual view); 7 and 10: Left M /3 AD 200'98 (respectively labial and lingual view). Scale bar is 1 cm for the tusk and 3 cm for the cheek-teeth.

1 patella;

11 tarsals (3 tali, 4 calcanea, 1 cuboid, 2 naviculars, 1 first cuneiform);

9 metatarsals (4 Mt II including 2 complete, 4 complete or subcomplete Mt III, 1 complete Mt IV);

9 phalanges;

3 sesamoids.

Systematic Palaeontology

All but one of the 81 fossil rhino specimens from Arrisdrift constitute a homogeneous sample pertaining to a very large species of cursorial rhino. The large rhino from Arrisdrift can be characterized as follows:

- with the possible exception of *Kenyatherium*, whose teeth are totally different, it is the largest of the known African Miocene rhinos;
- size and proportions of the metapodials and the other limb bones suggest an analogy especially with the *Diceros* gr. *pachygnathus-neumayri* of the Upper Miocene of the Near East, and to a lesser extent with *Dicerorhinus schleiermacheri* from the Upper Miocene of Europe;
- the type of construction of the upper cheek teeth, especially the fourth premolar, is of Dicerotine type and presents strong resemblances to *Diceros douariensis* of the Upper Miocene of North Africa and Italy;
- the mandible shows analogies with the Dicerotines, especially the apparently short symphysis.
- the small reduced lower tusk could represent an evolutionary stage prior to the loss of the entire anterior dentition.

Thus this rhino is a large new species of Dicerotine, which I name *Diceros australis* nov. sp.; it is so far the oldest known species of the sub-family. Its definition is as follows:

TABLE 2.

Compared dimensions of the upper cheek teeth of *Diceros australis* nov. sp

ap= anteroposterior; artic= articular; diam= diameter; dist= distal; horiz= horizontal; prox= proximal; tr= transverse.

ARRISDRIFT		AD 292'94	AD 578'98	AD 649'97	AD 228'97	AD 285'95 PQ	AD 339 PQ	AD 2697 PQ	AD 2661 PD	AD 1103
D 4/	ap	47								
	tr	47								
M 1/	ap				59					
	tr				56.5					
M 2/	ap					58				
	tr					62.5				
M 3/	absolute length						64.5	65.5	66.5	65.5
	anat. length						55	53	52	54
	tr						62	62	61	60
P 4/	ap		43.5	37.5						
	tr		60.5	54						

D. douariensis		n	mean	min.	max.	*B. snowi* n	mean	min.	max.
D 4/	ap	1	44.00			0			
	tr	1	49.00			0			
M 1/	ap	2	60.25	59	61.5	2	61.50	55	68
	tr	3	61.33	59	64	1	71.00		
M 2/	ap	3	62.83	60	67.5	2	67.00	63	71
	tr	2	68.75	66.5	71	2	76.50	74	79
M 3/	absolute length	1	63.00			0			
	anat. length	3	57.33	50	64	1	63.00		
	tr	3	61.17	59	64	0			
P 4/	ap	2	40.50	37.5	43.5	1	49		
	tr	2	57.25	54	60.5	1	69		

Paradiceros mukirii		Fort Ternan	*Dicerorh. leakeyi* Rusinga	*A. campbelli*
D 4/	ap			
	tr			
M 1/	ap		40	58
	tr		50	68.5
M 2/	ap		48	
	tr		56	
M 3/	absolute length		53	54
	anat. length		43	47.5
	tr		56.5	49.5
P 4/	ap	31.5		48
	tr	45		63

Diagnosis: a very large cursorial rhinoceros of the Dicerotine type. Upper cheek teeth brachyodont, with a more or less continuous crenellated inner cingulum, and a crochet as the only or main internal fold. Ectoloph of the upper premolars with a strong parastyle, paracone fold thick but not very prominent and no mesostyle nor metacone fold. Upper molars possess on their ectoloph a large paracone fold and a weak vertical bulge in the middle of it, and a protocone weakly constricted on its anterior face. Tall and slim but sturdy limb bones. Lateral and medial metapodials very long with respect to the central one.

Locus typicus and Stratum typicum: Arrisdrift, Sperrgebiet, Southern Namibia; Lower Middle Miocene, about 17 Ma.

Derivatio nominis: from «austral» = southern; *D. australis* is the most southern Tertiary *Diceros* ever found.

Holotype: Left third metacarpal AD 52'97 (Figure 5: 3 and 4).

Ascribed material: Left half mandible AD 300'97; right upper fourth premolar AD 578'98 (Figure 3: 3); left upper fourth milk molar AD 292'94 (Figure 3: 2); right upper third molar PQ AD 339 (Figure 3: 4); left lower second premolar AD 86'98 (Figure 3: 6 and 9); left lower third molar AD 200'98 (Figure 3: 7 and 10); left lower third milk molar PQ AD 635 (Figure 3: 5 and 8); left radius PQ AD 3099; AD 52'97; left astragalus AD 619'94 (Figure 1: 2); right calcaneum AD 50'97 (Figure 1: 1); right third metatarsal AD 618'94 (Figure 5: 1 and 2).

The material is housed in the Geological Survey of Namibia in Windhoek.

Description

Mandible

Of the six specimens which are all incomplete, two possess an important part of the horizontal ramus, with probably a very short symphysis (none showing the anterior end) whose maximum height is 35 mm. In the two cases the posterior border of the symphysis at the middle P /2 level; for *Diceros douariensis* the symphysis

is 100 mm long and 43 mm high, with the level of the posterior border is between P /2 and P /3; the posterior border is at the anterior part of P /4 in *D. pachygnathus*. Whereas the anterior part of the horizontal ramus is shallower, the posterior part (from about the M /2 level) has dimensions comparable with *D. douariensis* (Table 1). Middle-sized African Aceratheres and Dicerorhines are much smaller, as is *Paradiceros*, and *Chilotheridium pattersoni* shows different proportions. Symphysis shortness suggests a very weak development or an absence of lower incisors, a character of the Dicerotine group.

Lower incisors

Two lower tusks (in fact incisors and not canines as reported by Hooijer 1971) were recovered.

AD 88'98 looks like a vestigial tooth, is knob-shaped and unworn. Its total length is 41.5 mm including 11 mm for the crown, the crown base transverse diameter is 9.5 mm, and its dorso-ventral diameter is 11 mm. It could be a dI /1.

AD 87'98 is a right lower incisor, feebly worn (Figure 3:1), it is 84 mm long (including 24 mm for the crown); at the crown base the transverse diameter is 19 mm, and its dorso-ventral diameter is 13.5 mm; the bevelled wear surface is 11 mm long and 10 mm wide; enamel thickness indicates a permanent tooth, i.e. an I /2. The cross section is an asymmetrical flattened ellipse. *Chilotheridium* tusks are much larger: after Hooijer 1971, the cross sections are respectively 22 x 17, 30 x 18, 30 x 15 and 40 x 25 mm, with crown length (for much worn specimens) between 44 and 55 mm; the shape is different, being more asymmetrical (Hooijer 1971, Plate 6), and there is a cingulum at the base of the crown. Such reduced dimensions would preclude the use of the Arrisdrift tusk as an effective weapon, whereas tusk-bearing living (and thus fossil) rhinos have much larger tusks and use them as bayonets.

I consider the small reduced lower adult tusk from Arrisdrift to be a representative of an evolutionary stage prior to the loss of the entire anterior dentition, the loss being accomplished in the Upper Miocene Dicerotine.

Upper cheek teeth

A well preserved D 4/ is weakly worn (Figure 3:1): its maximum height of 38 mm gives it a hypsodonty index of 81. The powerful paracone fold constitutes the sole relief on the outer wall, and the crochet is the only internal fold. There is a discontinuous crenellated lingual cingulum, mainly under the mouth of the inner valley. Its dimensions are about the same as these of *D. douariensis* (Table 2).

Two complete specimens of M 1/ or 2/ are known; one of them (AD 228'97), probably an M 1/, is only slightly worn and has a hypsodonty index of about 85. The ectoloph shows a large paracone fold and a weak vertical bulge in the middle of it. The crochet is the only internal fold. The protocone is weakly constricted on its anterior face. There is a weak crenellated inner cingulum under the mouth of the inner valley. The dimensions (Table 2) are slightly inferior to *D. douariensis* and largely inferior to *A. campbelli* but the two teeth are larger than those of *D. leakeyi*.

The four available specimens of M 3/ show the same morphology (Figure 3:4): a strong paracone fold, a crochet as the only inner pleat, a weakly constricted protocone, an incomplete lingual cingulum and a crenellated postero-labial cingulum extending onto the posterior quarter of the outer surface. Its dimensions are the same as for three M 3/ of *D. douariensis*.

Two right specimens of P 4/ have been recovered, one of them (AD 578'98) in a medium state of wear and the other (AD 649'97) very worn. The ectoloph has a strong parastyle, and a paracone fold which is thick but not very prominent; there is no mesostyle nor metacone fold. The sole inner fold is a strong crochet (but AD

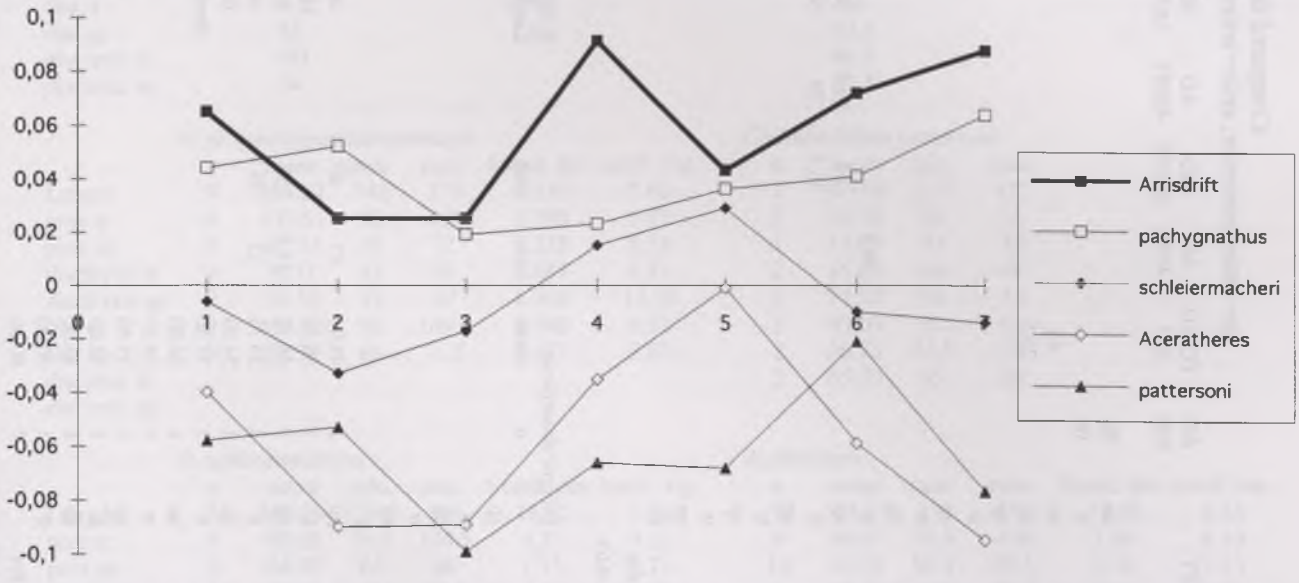

Figure 4: *Diceros australis* nov. sp: Simpson diagram of the radius compared with that of other Miocene rhinoceroses. Reference is *Diceros bicornis*. 1: Length; 2: proximal transverse diameter; 3: proximal anteroposterior diameter; 4: diaphysis transverse diameter; 5: diaphysis anteroposterior diameter; 6: distal transverse diameter; 7: distal anteroposterior diameter.

TABLE3

Compared dimensions of the lower cheek teeth of *Diceros australis* nov. sp

ap= anteroposterior; artic= articular; diam= diameter; dist= distal; horiz= horizontal; prox= proximal; tr= transverse.

ARRISDRIFT		AD 8'98	PQ AD 635	AD 44'98	AQ 200'98	AD 468'97	AD 163'97	AD 378'94	PQ AD 134	AD 86'98	AD 157'95	AD 432'95	PQ AD 827	PQ AD 330	AD 556'94	AD 300'97	AD 313'98	AD 437'97	AD 223'97
D /2	ap	30																	
	tr	18																	
D /3	ap		45																
	tr		25.5																
D /4	ap																		
	tr																		
M /1	ap														45	46.5			
	tr															37.5			
M /2	ap														50.5	55	58		
	tr			38.5											37	39	33.5		
M /3	ap				59	52.5	60								59	about 60			
	tr				36.5	39	35								35.5				
P /2	ap							31.5	33	30								32	
	tr							20.5		19.5								22	
P /3	ap										38	39	38			39		43	
	tr										28	29	27.5			29			
P /4	ap													40.5	40	44.5			46
	tr														32.5	35.5			37
Length P/3-P/4																83			
Length M/1-M/3															156.5	157			

		Diceros douariensis				*B. heinzelini*	*B. snowi*	*Chil. pattersoni*				MSUR	*P. mukirii*
		n	mean	min.	max.	Langental		n	mean	min.	max.	East Africa	Fort Ternan
D /2	ap											28.50	
	tr											16.00	
D /3	ap												
	tr												
D /4	ap												
	tr												
M /1	ap	2	48.00	47	49	48		2	42.00	40.5	43.5	39.00	35
	tr	1	30.50			34.5		2	30.00	27	33	30.00	27
M /2	ap	2	56.75	55.5	58	50	51.50	3	54.50	50.5	57	47.00	42
	tr	2	33.75	32	35.5	36	35.00	3	31.00	29.5	32.5	32.00	26
M /3	ap	1	54.00			60	58.00	2	59.50	56	63	54.00	43.5
	tr	1	31.50			about 38	36.50	2	30.75	27.5	34	31.00	25
P /2	ap	1	26.00				30.00	4	23.12	20	25	22.00	24
	tr	1	18.50				22.00	2	16.00	14	18		14
P /3	ap	1	35.50				36.50	4	33.62	25.5	38.5	32.50	27.5
	tr	1	33.00				26.50	4	21.12	18.5	24	23.50	19.5
P /4	ap	1	43.00				44.50	4	37.50	34	39	37.50	30.5
	tr	1	30.00				31.50	3	26.17	25.5	27	27.50	24.5
Length P/3-P/4		1	80.00					3	67.00	53	74.5	66.00	59
Length M/1-M/3		1	155.00			about 154	169.00	4	152.25	144	159	130.00	121

649'97 shows a closed medifossette). There is a strong, continuous and crenellated lingual cingulum, and no trace of constriction of the protocone (Figure 3:3). Such a morphology, especially that of the outer wall - the best odontological character for rhino determinations, see Guérin 1980 a - is very close to that seen in *Diceros douariensis* and *D.* gr. *pachygnathus-neumayri* from Pikermi, as are the dimensions (Table 2).

Lower cheek teeth

Lower deciduous molars include one D /2 and one D /3. The latter tooth, which is weakly worn, shows sharp V-shaped internal valleys with no difference in level; traces of a labial cingulum are to be seen on the posterior lobe (Figure 3: 5 and 8). Dimensions (Table 3) are very similar to those (43 x 24 mm) of an isolated D /3 from Pikermi (Museum of Bologna, Italy).

There is one incomplete isolated M /2, and there are three isolated M /3, the latter in a good state of preservation (Figure 3: 7 and 10). These are wider than the only known M /3 of *D. douariensis*, and are about as large as those of *Brachypoptherium heinzelini* and *B. snowi*, but much wider than *Chilotheridium*, *Paradiceros* and the medium-sized African Acerathere and Dicerorhinine (Table 3). The internal valleys have, for the anterior one, a sharp V-shaped transverse profile; the posterior valley is V-shaped in one case, U-shaped in the other two, the difference of level being moderate or strong. There are no lingual or labial cingula, but all the M /3 present a crenellated posterior cingulum of a very diverse shape.

Two isolated specimens of P /2, three of P /3 and one of P /4 were available for study. The P /3 n° AD 157'95 shows no trace of wear and possesses a hypsodonty index of 108; the two internal valleys are V-shaped with a strong level difference; there are no labial nor lingual cingula but the anterior and posterior ones run slightly onto the labial surface, as also observed in the P /2 (Figure 3: 5 and 8).

Lower cheek teeth included in tooth rows present the same characters; the most complete row (AD 300'97) has the lengths of the molar segment and of the two last premolars very close to the values observed in *D. douariensis* (Table 3) and *D.* gr. *pachygnathus-neumayri*.

Radius and ulna

The radius is longer than those of the largest *D.* gr. *pachygnathus-neumayri* and *D. schleiermacheri*, the last being more slender. The undifferentiated Acerathere/ Dicerorhine from Rusinga, which possesses the same dimensions and proportions as the middle-sized Upper Miocene Aceratheres of Europe, is smaller and with different proportions. The radius of *Chilotheridium* and especially *B. snowi* is stockier and much shorter (Table 4; Figure 4).

TABLE 4.

Compared dimensions of the radius of *Diceros australis* nov. sp
ap= anteroposterior; artic= articular; diam= diameter; dist= distal; horiz= horizontal; prox= proximal; tr= transverse.

	ARRISDRIFT PQ AD 3099	MSUR Rusinga	*B. snowi* Jebel Zelten
Length	435	305	286.5
prox tr	113	95	86.5
prox ap	70.5	57.5	51.5
diaphysis tr	64.5	51.5	48.5
diaphysis ap	42	47.5	40
dist tr	115	92	86
dist ap	83	69	53.5
dist artic tr	103		80.5
dist artic ap	54		41.5

	D. gr. pachygnathus/neumayri					*Chilotheridium pattersoni*			
	n	mean	min.	max.	Stand. dev.	coeff. var.	n	mean	min.	max.
Length	9	364.22	342	375	9.536	2.62	1	327.00	327	327
prox tr	9	100.61	95	107	3.790	3.77	2	94.50	94	95
prox ap	9	65.00	55	72	5.315	8.18	1	53.00	53	53
diaphysis tr	9	59.11	55	63	2.667	4.51	2	45.00	44	46
diaphysis ap	9	38.78	33	47	4.402	11.35	2	32.50	32	33
dist tr	9	104.00	95	109.5	4.488	4.32	2	93.00	91	95
dist ap	9	65.78	60	71.5	3.833	5.83	2	56.75	54.5	59
dist artic tr							2	85.50	85	86
dist artic ap										

	D. schleiermacheri					Aceratheres					
	n	mean	min.	max.	Stand. dev.	coeff. var.	n	mean	min.	max.	Stand. dev.	coeff. var.
Length	5	369.30	351.5	396	18.62	5.04	6	341.17	316	348	12.46	3.65
prox tr	4	99.38	94.5	104.5	4.33	4.35	9	86.67	78.5	100	7.96	9.19
prox ap	3	64.00	63	66	1.73	2.71	10	54.25	50.5	59.5	2.78	5.13
diaphysis tr	5	54.20	48	57.5	3.78	6.98	6	48.33	44	52.5	3.66	7.56
diaphysis ap	5	40.60	38	43	1.78	4.39	6	37.92	33	42.5	3.65	9.63
dist tr	5	95.20	87	100	5.71	6.00	6	85.17	75	103.5	10.61	12.45
dist ap	5	65.60	61	69	3.99	6.08	7	54.50	50	61	3.93	7.20
dist artic tr	4	82.12	79	88.5	4.39	5.34	5	72.60	68.5	79.5	4.89	6.74
dist artic ap	4	44.75	44	45	0.50	1.12	5	38.70	36.5	42.5	2.41	6.24

The proximal articulation does not possesses the very undulating anterior border nor the large re-entrant angle at the level of the coronoid process which characterize the genus *Ceratotherium*. But it shows a transversely elongated lateral facet the anterior border of which is only slightly retracted in relation to the anterior edge of the medial facet, and whose posterior border, regularly concave, constitutes moreover an obtuse angle with the posterior edge of the medial facet. These last characters speak in favour of the proximity of the large Arrisdrift rhino to the Dicerotine subfamily.

Three ulnae have been recovered from Arrisdrift of which one only (AD 273'97) is complete; for a total length of 533 mm its proximal articular diameter is 95 mm and the proximal antero-posterior diameter is 157 mm. The other two pieces are a distal epiphysis of an adult specimen and the proximal end of a juvenile one.

Carpus

The semilunar presents an anterior surface whose width (42 mm) is similar to the height. The distal point of that surface, sited near the midline, is rounded. The length is 69.5 mm.

One of the two known pyramidals (= cuneiforms) is well preserved; it is very large, and markedly wider (71.5 mm) than tall (63 mm).

The only pisiform in the collection has a length of 70 mm, and is 29 mm wide; the height is 52 mm.

One only of the two magnums found at Arrisdrift (AD 538'97) is attributable to the large rhino species. Its dimensions are as follows:

Total length:	104 mm
Anterior width:	56 mm
Anterior height:	45 mm
Maximum height:	74 mm
Sus-articular height:	72 mm

Such dimensions and proportions differ from those of *D. schleiermacheri* but are close to those of three magnums of *Diceros* gr. *pachygnathus-neumayri;* they are totally different from that of the other magnum recovered in the same site (Figure 1: 3-5 and Figure 2). In anterior view the bone presents a rhomboidal outline, rounded distally, and is higher than wide; the distal articulation is about as wide in its fore part as in its posterior part.

Metacarpal II

The only known specimen, a left one, is longer than the largest known specimens of *Diceros* gr. *pachygnathus-neumayri* and *Dicerorhinus schleiermacheri*, and is distinctly slender. That of *Chilotheridium* is very short and stocky, and that of true Aceratheres is shorter and shows very different proportions (Table 5).

The proximal articulation is long and narrow, crescent-shaped with a distinct notch on its posterior edge. On the lateral surface of the proximal epiphysis there is only one

TABLE 5.

Compared dimensions of the second metacarpal of *Diceros australis* nov. sp
ap= anteroposterior; artic= articular; diam= diameter; dist= distal; horiz= horizontal; prox= proximal; tr= transverse.

	ARRISDRIFT AD 536'97
Length	188
prox tr	41
prox ap	54
diaphysis tr	32.5
diaphysis ap	25
dist max tr	43
dist tr artic	42
dist ap	45.5

	D. gr. pachygnathus/neumayri					*Chilotheridium pattersoni*			
	n	mean	min.	max.	Stand. dev.	coeff. var.	n	mean	min.	max.
Length	9	156.33	140.5	169	8.842	5.66	2	129.50	129.5	129.5
prox tr	9	44.67	37	54	5.385	12.06	2	43.00	42	44
prox ap	4	46.50	40	51	4.231	9.10	2	37.25	37	37.5
diaphysis tr	9	40.78	33.5	44.5	4.374	10.73	2	31.75	31	32.5
diaphysis ap	9	24.33	20	26	1.750	7.19	2	16.50	16	17
dist max tr	9	48.89	40	54	5.355	10.95	2	39.75	37	42.5
dist tr artic	9	43.17	34.5	48.5	4.644	10.76	2	34.00	31	37
dist ap	9	42.39	38.5	46	4.583	6.09	2	36.25	36	36.5

	D. schleiermacheri						Aceratheres					
	n	mean	min.	max.	Stand dev.	coeff. var.	n	mean	min.	max.	Stand	coeff.
Length	3	168.83	156.5	179	11.41	6.76	5	133.20	120.5	148	13.30	9.98
prox tr	3	43.00	40	47	3.61	8.39	3	33.67	32	36	2.08	6.18
prox ap	3	42.50	40	44	2.18	5.13	3	33.17	29.5	40	5.92	17.86
diaphysis tr	4	36.88	34	40.5	2.72	7.37	4	32.38	28.5	36	3.09	9.55
diaphysis ap	4	22.50	18.5	27	3.54	15.71	4	19.00	17	21.5	1.96	10.30
dist max tr	3	44.67	40	47	4.04	9.05	4	37.75	36	40	1.66	4.39
dist tr artic	3	40.17	39	41	1.04	2.59	4	34.38	32.5	36	1.49	4.34
dist ap	3	40.33	39.5	41.5	1.04	2.58	4	35.62	32	38.5	2.69	7.55



Figure 5. Third metapodials of *Diceros australis* nov. sp. 1: Mt III AD 618'94, front view; 2: Mt III AD 618'94, posterior view; 3: Mc III AD 52'97, front view; 4: Mc III AD 52'97, posterior view. Scale bar is 3 cm.

articular facet, constricted in its medium part and expanding onto the whole height of the bone. The transverse section of the diaphysis is a rounded triangle.

Metacarpal III

Two left Mc III have been recovered complete and the largest is marginally longer than the largest known specimens of *Diceros gr. pachygnathus-neumayri* and *Dicerorhinus schleiermacheri*, but are a little more slender. *Brachypotherium snowi* and *B. heizelini* are shorter and stockier, as is *Chilotheridium*. True Aceratheres show more or less analogous proportions but are much smaller.

The Simpson diagram shows that the Arrisdrift Mc III does not belong to a Brachypothere, nor to an Acerathere, whereas analogies with *Diceros* gr. *pachygnathus-neumayri* and *Dicerorhinus schleiermacheri* are noticeable (Table 6, Figures 5 and 6).

The proximal articulation is very wide, triangular, and with a rectilinear anterior edge. There are two articular facets on the lateral surface of the proximal epiphysis; the anterior one is pentagonal with two parts, the lowest of which is more or less expanded anteroposteriorly according to the observed specimen; the posterior facet, located lower than the anterior one, is a rounded triangle whose width varies on each specimen. On the medial surface of the epiphysis there is a small inverted S-shaped facet whose height is variable. The transverse section of the diaphysis is trapezoidal, with a slightly convex anterior edge and a slightly concave posterior one; the lateral edge is straight and longer than the medial edge whose profile is more or less straight.

Metacarpal IV

This bone is much more longer and more slender than the largest measured specimens of *Diceros* gr. *pachygnathus-neumayri* and *Dicerorhinus schleiermacheri* (Table 7).

The proximal articulation is triangular, a little longer than broad; such a width/height ratio is inverted for short-legged rhinos such as *Brachypotherium* and *Chilotheridium*. On the medial surface of the proximal epiphysis there are two articular facets; the anterior one is long and low, and semi-elliptical, while the posterior one is a vertical ellipse, much taller than broad.

Tibia

Only one tibia was found, and it is badly damaged especially the proximal epiphysis, but the total length can nevertheless be measured. As for the Mc IIIs the tibia is marginally longer than the largest known specimens of *Diceros* gr. *pachygnathus-neumayri* and *Dicerorhinus schleiermacheri*, and is more slender (Table 8). Surprisingly enough, the dimensions of a broken distal epiphysis of a *Diceros* cf. *douariensis* from Baccinello V3 are identical to those of Arrisdrift!

Astragalus

Three astragali have been recovered of which two are complete (Figure 1: 2). Dimensions (Table 9) and proportions (Figure 4) are close to those of *Diceros* gr. *pachygnathus-neumayri*, and do not differ much from *Dicerorhinus schleiermacheri*. The astragalus of *Brachypotherium snowi* is slightly larger but markedly lower, and it is proportionally the same for

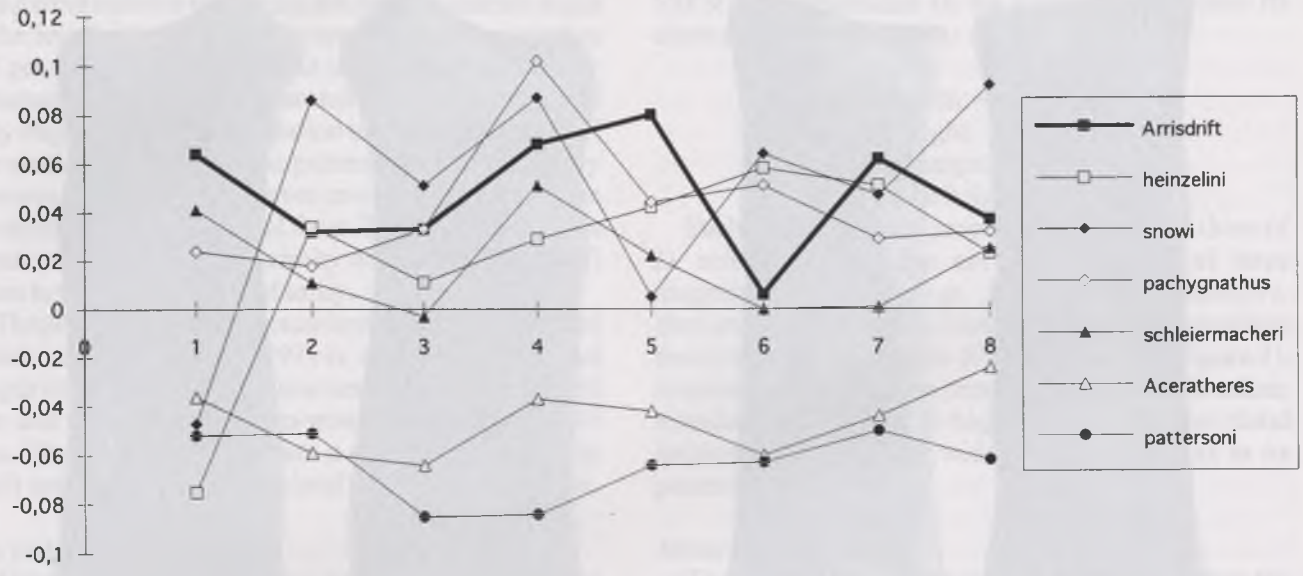

Figure 6: *Diceros australis* nov. sp: Simpson diagram of the third metacarpal compared with that of other Miocene rhinoceroses. Reference is *Diceros bicornis*. 1: length; 2: proximal transverse diameter; 3: proximal anteroposterior diameter; 4: diaphysis transverse diameter; 5: diaphysis anteroposterior diameter; 6: distal maximal transverse transverse diameter; 7: distal transverse articular diameter; 8: distal anteroposterior articular diameter diameter.

TABLE 6.

Compared dimensions of the third metacarpal of *Diceros australis* nov. sp.

ap= anteroposterior; artic= articular; diam= diameter; dist= distal; horiz= horizontal; prox= proximal; tr= transverse.

	ARRISDRIFT		*B. snowi*	*B. heinzelini*
	AD 52 '97	AD 243 '95	Jebel Zelten	Rusinga
Length	200	212	159.5	149.5
prox tr	68	63.5	74.5	66
prox ap	58	51.5	57	52
diaphysis tr	57.5	58.5	60.5	53
diaphysis ap	27	26.5	22.5	24.5
dist max tr	65	63.5	73.5	72.5
dist tr artic	60	60	58	58.5
dist ap	48		54.5	46.5

	D. gr. pachygnathus/neumayri					*Chilotheridium pattersoni*			
	n	mean	min.	max.	Stand. dev.	coeff. var.	n	mean	min.	max.
Length	9	187.17	181	198	5.668	3.03	3	157.67	150	169
prox tr	6	65.50	62.5	74.5	4.461	6.81	3	54.33	50	61
prox ap	8	54.94	52	59	2.427	4.42	3	41.67	37	45
diaphysis tr	11	63.55	59	69	3.020	4,75	3	40.83	39	43
diaphysis ap	9	24.56	22	26.5	1.333	5.43	3	19.17	17.5	21.5
dist max tr	9	71.22	66.5	76	2.705	3.80	3	54.83	51	61
dist tr artic	10	56.15	52	59	2.174	3.87	3	46.33	44.5	49.5
dist ap	10	48.05	45	53	2.619	5.45	3	38.17	37.5	39

	D. schleiermacheri						Aceratheres					
	n	mean	min.	max.	Stand. dev.	coeff. var.	n	mean	min.	max.	Stand. dev.	coeff. var.
Length	6	195.42	181	204	8.55	4.37	10	163.75	139.5	181	13.38	8.17
prox tr	9	62.67	58	69	3.70	5.90	10	53.35	50	59.5	3.09	5.80
prox ap	5	50.30	47.5	52	1.99	3.95	10	43.80	40	47.5	2.41	5.49
diaphysis tr	9	55.78	49.5	66	5.36	9.61	11	45.55	42	49	2.25	4.95
diaphysis ap	8	23.38	22	25.5	1.19	5.08	10	20.20	17	24.5	2.16	10.71
dist max tr	7	63.50	60	69	3.15	4.96	10	55.25	49.5	60.5	3.68	6.65
dist tr artic	7	52.14	49	56	2.48	4.75	10	47.00	38.5	52	3.89	8.29
dist ap	7	46.71	45	49	1.41	3.02	7	41.71	38	44.5	2.56	6.15

TABLE 7:

Compared dimensions of the fourth metacarpal of *Diceros australis* nov. sp.

ap= anteroposterior; artic= articular; diam= diameter; dist= distal; horiz= horizontal; prox= proximal; tr= transverse.

	ARRISDRIFT AD 404'97
Length	about 188
prox tr	55
prox ap	51.5
diaphysis tr	37.5
diaphysis ap	27
dist max tr	51
dist tr artic	45
dist ap	53

	MSUR			
	N	moyenne	mini	maxi
Length	2	158.75	152.5	165
prox tr	1	52.00		
prox ap	1	46.00		
diaphysis tr	2	34.00	34	34
diaphysis ap	2	21.25	20.5	22
dist max tr	2	46.25	42	50.5
dist tr artic	2	43.00	40	46
dist ap	2	38.75	37	40.5

	D. gr. pachygnathus/neumayri					*Chilotheridium pattersoni*				
	n	mean	min.	max.	Stand. dev. coeff. var.	n	mean	min.	max.	Stand. dev.
Length	8	144.81	134	156	9.059 6.26	3	125.17	121.5	129.5	4.04
prox tr	8	47.81	43	53	3.535 7.39	2	35.50	34	37	2.12
prox ap	8	42.12	37	47,5	3.410 8.09	2	38.00	32	44	8.49
diaphysis tr	8	37.69	31.5	41	3.162 8.39	3	26.17	23	30.5	3.88
diaphysis ap	8	24.75	20	29	2.726 11.01	3	18.00	17.5	18.5	0.50
dist max tr	8	46.69	39	52.5	4.166 8.92	3	42.17	37	47.5	5.25
dist tr artic	8	43.06	37.5	47	3.590 8.34	3	35.50	33.5	37	1.80
dist ap	8	41.00	37.5	46	2.712 6.62	3	34.33	33	37	2.31

	D. schleiermacheri				Aceratheres					
	n	mean	min.	max.	n	mean	min.	max.	Stand. dev.	coeff. var.
Length	1	145.00			5	144.50	141.5	147.5	2.48	1.71
prox tr	2	49.25	47.5	51	7	42.86	38.5	48	3.58	8.35
prox ap	1	43.00			7	39.21	32	42	3.32	8.45
diaphysis tr	2	32.50	32.5	32.5	5	30.10	27.5	32.5	2.38	7.91
diaphysis ap	2	21.50	21	22	5	22.40	19	25	2.33	10.40
dist max tr	2	45.25	43	47.5	5	39.00	37.5	40	0.94	2.40
dist tr artic	2	42.25	38.5	46	5	38.90	36	43	2.90	7.46
dist ap	2	40.50	40	41	5	37.60	34	40	2.38	6.34

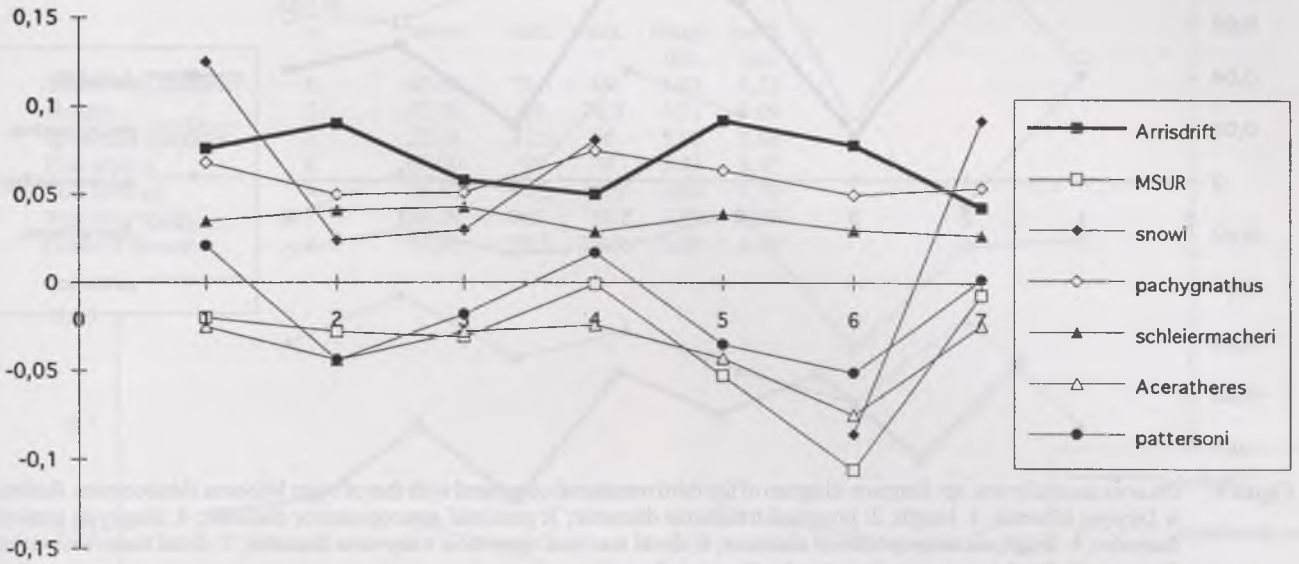

Figure 7: *Diceros australis* nov. sp: Simpson diagram of the astragalus compared with that of other Miocene rhinoceroses. Reference is *Diceros bicornis*.1: transverse diameter; 2: height; 3: anteroposterior medial diameter; 4: distal articular transverse diameter; 5: distal articular anteroposterior diameter; 6: trochlea upper width; 7: distal maximal transverse diameter.

Chilotheridium. The dimensions are inferior and the proportions are different for the true Aceratheres, and also for the undifferenciated sample of *D. leakeyi-A. acutirostratum*, whose similarity with true Aceratheres is noticeable.

Among the qualitative characters, the tubercle on the lower part of the medial surface is located in the middle, well above the articular edge. Individual variation observed in the three astragali from Arrisdrift concerns mainly the height of the neck, the obliquity of the medial edge of the distal articulation, and the posterior development of the upper end of the medial lip.

Calcaneum

A damaged juvenile and three adult calcanei are known, of which two are complete (Figure 1: 1). As for the astragalus, their dimensions (Table 10) and proportions are close to *Diceros* gr. *pachygnathus-neumayri* and

TABLE 8.

Compared dimensions of the tibia of *Diceros australis* nov. sp

ap= anteroposterior; artic= articular; diam= diameter; dist= distal; horiz= horizontal; prox= proximal; tr= transverse.

	ARRISDRIFT PQ AD 561	*Chilotheridium pattersoni* min.	max.
Length	440	319	355
diaphysis ap	57	47	
dist tr	100	88	
dist ap	80	66	
dist artic tr	87		
dist artic ap	75		

	D. gr. pachygnathus/neumayri n	mean	min.	max.	Stand. dev.	coeff. var.	*D. cf. douariensis* Baccinello V3
Length	5	390.40	368	420	19.97	5.12	
diaphysis ap	7	58.36	49	73	8.80	15.07	58
dist tr	6	107.92	99	115	7.09	6.57	101
dist ap	7	79.00	71	99	10.72	13.57	80
dist artic tr							
dist artic ap							

	D. schleiermacheri n	mean	min.	max.	Aceratheres n	mean	min.	max.	Stand. dev.	coeff. var.
Length	2	398.00	386	410	9	361.22	328	383	20.66	5.72
diaphysis ap	2	58.25	57.5	59	9	47.39	38	53	5.82	12.28
dist tr	2	103.50	101	106	9	86.17	72.5	91.5	6.26	7.26
dist ap	2	72.25	69	75.5	11	62.55	53	68	5.01	8.01
dist artic tr	1	82.50			3	71.00	60	79	9.85	
dist artic ap	1	60.00			3	50.67	46	55	4.51	

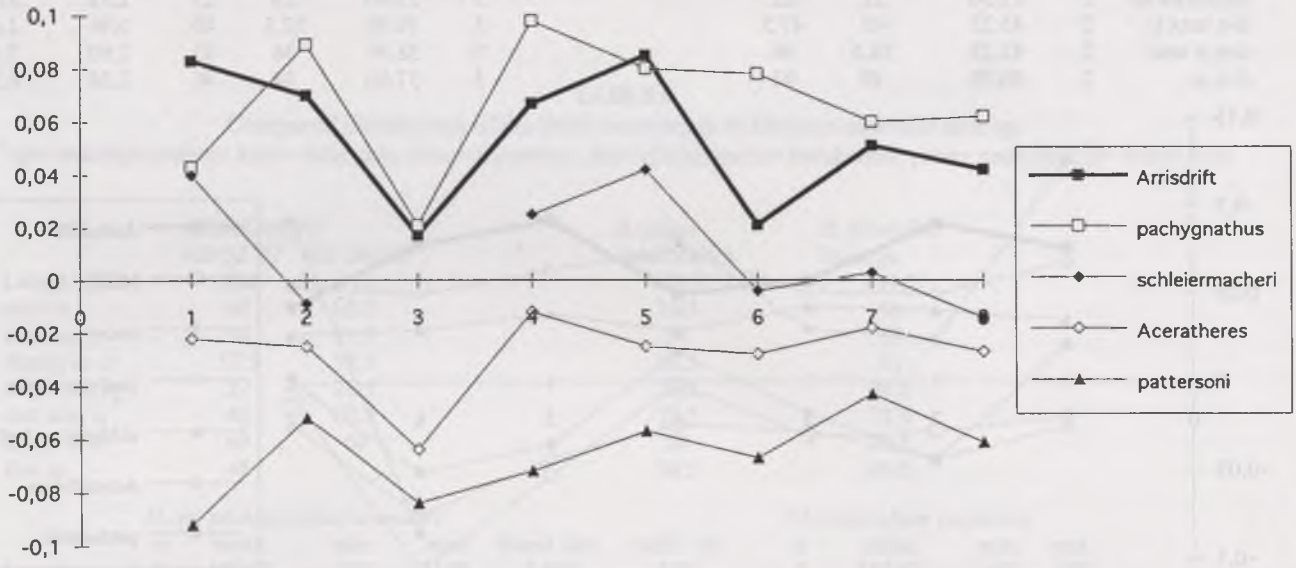

Figure 8: *Diceros australis* nov. sp: Simpson diagram of the third metatarsal compared with that of other Miocene rhinoceroses. Reference is *Diceros bicornis*. 1: length; 2: proximal transverse diameter; 3: proximal anteroposterior diameter; 4: diaphysis transverse diameter; 5: diaphysis anteroposterior diameter; 6: distal maximal transverse transverse diameter; 7: distal transverse articular diameter; 8: distal anteroposterior articular diameter diameter.

D. schleiermacheri, having nothing to do with those of *Paradiceros*, *Chilotheridium* nor Aceratheres.

In posterior view the sustentaculum axis makes a right angle with the axis of the body of the bone.

In lateral view the front of the tuberosity is situated well behind the beak (= foremost part of the bone), the anterior edge between the two points being oblique and slightly concave. The posterior edge of the surface is globular for the upper two thirds of its height, and depressed for the last third, especially in specimen PQ AD 601.

Individual variation is noticeable in the proximal part of the bone when observed from the posterior surface: shaped as an inverted V for PQ AD 601, it is flat for AD 50'97.

Other tarsals

The cuboid is very large: its total length is 77 mm, its total height 61 mm, and maximum width 52.5 mm. The anterior surface is much taller than broad (53 and 41.5 mm), and its lateral edge is longer than the medial one.

Two naviculars have been recovered, and are broader

TABLE 9.

Compared dimensions of the astragalus of *Diceros australis* nov. sp.
ap= anteroposterior; artic= articular; diam= diameter; dist= distal; horiz= horizontal; prox= proximal; tr= transverse.

	Arrisdrift AD 619'94	Arrisdrift PQ AD 1219	*D. gr. pachygnathus/neumayri* n	mean	min.	max.	Stand. dev.	coeff. var.
Transverse diameter	101	100	7	98.57	94	104	3.65	3.70
Height	95	96	6	87.17	84	92	3.55	4.07
ap medial diameter	63.5	64.5	6	63.00	61	65	1.90	3.01
Dist artic tr	75	78	7	81.07	76.5	86	3.10	3.83
Dist artic ap	55	53.5	7	50.86	45	53.5	3.33	6.54
Trochlea width	72	77	6	69.83	61	77.5	5.77	8.26
Distal tr diameter	80.5	85	5	84.90	82	90.5	3.47	4.09

	D. schleiermacheri n	mean	min.	max.	Stand. dev.	coeff. var.	*Brachypotherium snowi* n	mean	min.	max.
Transverse diameter	11	91.45	86.5	99	3.60	3.93	2	108.75	105	112.5
Height	13	85.35	78.5	93	4.72	5.53	1	82.00		
ap medial diameter	12	61.79	55	70	4.13	6.68	2	59.00	58	60
Dist artic tr	8	73.00	62	82	6.65	9.11	2	82.25	80	84.5
Dist artic ap	10	47.95	44.5	55	2.83	5.91				
Trochlea width	12	66.63	61	75	3.73	5.60	1	51.00		
Distal tr diameter	10	79.75	76	86	3.81	4.78	2	92.75	90.5	95

	Aceratheres n	mean	min.	max.	Stand. dev.	coeff. var.	*Chilotheridium pattersoni* n	mean	min.	max.	Stand.. dev.
Transverse diameter	29	79.60	72	88.5	4.35	5.46	3	88.50	85.5	92	3.28
Height	30	70.07	62	81	4.58	6.54	3	70.17	68.5	71	1.44
ap medial diameter	26	52.44	45	59	3.59	6.85	3	53.67	52	55.5	1.76
Dist artic tr	29	64.59	56.5	73	3.88	6.01	3	71.00	64	79	7.55
Dist artic ap	25	39.68	35	47	2.69	6.77	2	40.50	38	43	3.54
Trochlea width	31	52.39	46	65	5.23	9.98	3	55.33	52	58	3.06
Distal tr diameter	28	70.95	65	76.5	3.12	4.40	3	75.33	73	79	3.22

	MSUR n	mean	min.	max.	Stand. dev.	coeff. var.
Transverse diameter	8	80.62	75.5	84	3.41	4.23
Height	7	72.79	69	78.5	3.71	5.09
ap medial diameter	7	52.14	47.5	56	3.16	6.06
Dist artic tr	8	68.00	65	74	3.02	4.45
Dist artic ap	6	38.83	33.5	43.5	3.80	9.79
Trochlea width	7	48.79	45	50	1.89	3.87
Distal tr diameter	8	73.81	70.5	78.5	3.09	4.19

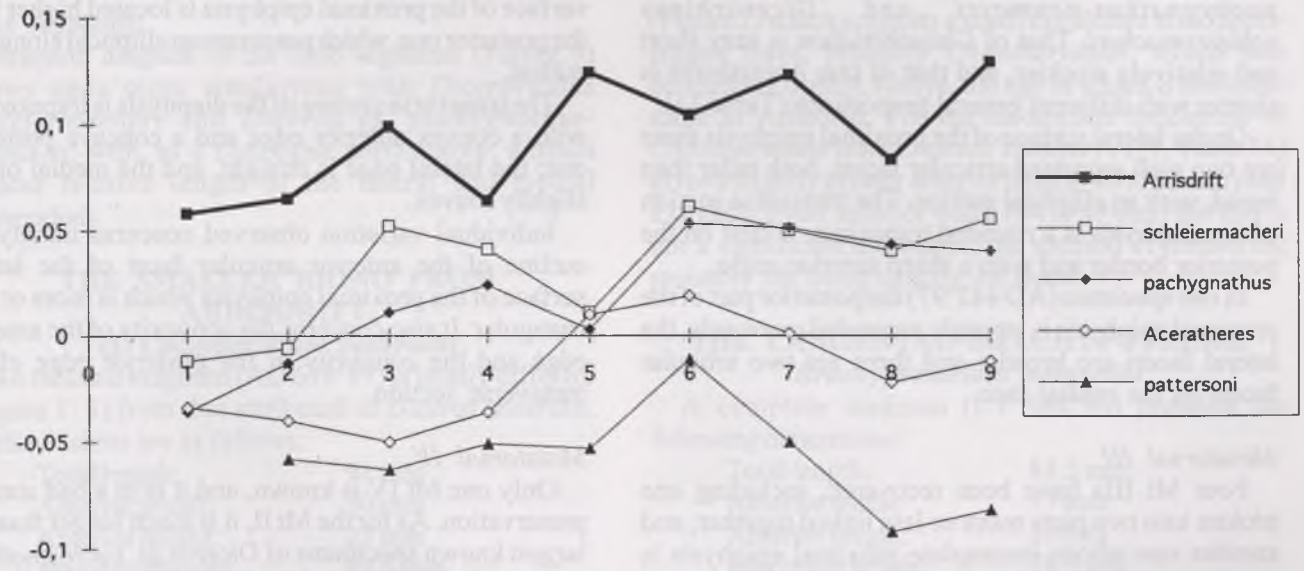

Figure 9. *Diceros australis* nov. sp: Simpson diagram of the limb segments compared with those of other Miocene rhinoceroses. Reference is *Diceros bicornis*. 1: ulna length; 2: radius length; 3: Mc II length; 4: Mc III length; 5: Mc IV length; 6: tibia length; 7: Mt II length; 8: Mt III length; 9: Mt IV length.

TABLE 10.

Compared dimensions of the calcaneum of *Diceros australis* nov. sp.
ap= anteroposterior; artic= articular; diam= diameter; dist= distal; horiz= horizontal; prox= proximal; tr= transverse.

	ARRISDRIFT AD 50'97	ARRISDRIFT PQ AD 601	ARRISDRIFT AD 530'95	*Paradiceros* Kisegi	MSUR
Height	158.5	153	153	92.5	130.5
Head tr	58	55	64	36	52.5
Head ap	77	67		50	54
middle width	41.5	40		33	43
Sustentaculum tr	77.5	79	77	50	81
maximum width	81	81	80	55.5	85.5
maximum ap	84	75.5	about 75		63

	D. gr. pachygnathus/neumayri					*Chilotheridium pattersoni*				
	n	mean	min.	max.	Stand. dev.	coeff. var.	n	mean	min.	max.	Stand. dev.	coeff. var.
Height	7	143.36	132	151.5	6.30	4.39	3	120.83	113	132	9.93	8.22
Head tr	6	58.42	54	63	3.64	6.23	3	44.33	42	48.5	3.62	8.16
Head ap	7	75.07	65	82	5.76	7.68	3	67.67	60	74	7.10	10.48
middle width	2	46.50	45	48	2.12	4.56						
Sustentaculum tr	7	82.07	74	87.5	4.64	5.65	2	70.00	70	70	0.00	0.00
maximum width												
maximum ap	5	77.90	72	83	5.03	6.46	3	59.17	57	62	2.57	4.34

	D. schleiermacheri					Acératheres				
	n	mean	min.	max.	Stand. dev.	coeff. var.	n	mean	min.	max.	Stand. dev.	coeff. var.
Height	5	142.10	134	149	6.71	4.72	20	108.82	98.5	123.5	6.66	6.12
Head tr	6	53.17	50.5	55	1.78	3.35	20	42.97	35	49	3.93	9.13
Head ap	6	72.67	68.5	79.5	5.97	9.01	19	61.03	49.5	79	6.55	10.73
middle width	4	40.13	37	43.5	2.78	6.93	6	33.75	26	41	6.03	17.87
Sustentaculum tr	5	80.90	72.5	88	6.37	7.87	15	70.33	61	78.5	4.14	5.88
maximum width												
maximum ap	6	74.50	69	86	6.72	9.01	20	59.58	51	70	5.10	8.55

than long: respectively 67 x 56.5 mm for a height of 40 mm and 78 x 56.5 mm for a height of 38 mm.

The only big cuneiform preserved is 44.5 mm long, 26 mm wide, and 35.5 mm high.

Metatarsal II

Four Mt IIs were found, of which two are complete or nearly so (during fossilisation they were broken but knitted again into place). They are much longer but more slender than the largest known specimens of *Diceros* gr. *pachygnathus-neumayri* and *Dicerorhinus schleiermacheri*. That of *Chilotheridium* is very short and relatively stockier, and that of true Aceratheres is shorter with different general proportions (Table 11).

On the lateral surface of the proximal epiphysis there are two well separated articular facets, both taller than broad, with an elliptical outline. The transverse section of the diaphysis is a rounded trapezium, widest on the posterior border and with a sharp anterior angle.

In one specimen (AD 442'97) the posterior part of the proximal epiphysis is strongly expanded rearwards, the lateral facets are broader and there are two articular facets on the medial face.

Metatarsal III

Four Mt IIIs have been recovered, including one broken into two parts more or less linked together, and another one whose incomplete proximal epiphysis is partly preserved in gypsum.

The bone (Figure 5: 1-2) is about as long as the largest known specimens of *Diceros* gr. *pachygnathus-neumayri* and has about the same proportions except the sus-articular transverse distal diameter. It is significantly longer than those of *Dicerorhinus schleiermacheri*. *Chilotheridium* is much shorter and relatively stockier. True Aceratheres show different proportions and are smaller (Table 12, Figure 8).

The proximal articulation is very wide, triangular, with a convex anterior edge whose point of bending is laterally offset; the antero-lateral angle is pointed; the medial edge begins with a cant followed by a shallow depression. The anterior articular facet on the lateral surface of the proximal epiphysis is located higher than the posterior one, which possesses an elliptical elongated outline.

The transverse section of the diaphysis is trapezoidal, with a convex anterior edge and a concave posterior one; the lateral edge is straight, and the medial one is slightly convex.

Individual variation observed concerns mainly the outline of the anterior articular facet of the lateral surface of the proximal epiphysis which is more or less triangular. It also concerns the convexity of the anterior edge and the concavity of the posterior edge of the transverse section.

Metatarsal IV

Only one Mt IV is known, and it is in a bad state of preservation. As for the Mt II, it is much longer than the largest known specimens of *Diceros* gr. *pachygnathus-neumayri* and *Dicerorhinus schleiermacheri*, but is not especially slender. That of *Chilotheridium* is very short, and that of true Aceratheres is shorter with different general proportions (Table 13).

TABLE 11.

Compared dimensions of the second metarsal of *Diceros australis* nov. sp.
ap= anteroposterior; artic= articular; diam= diameter; dist= distal; horiz= horizontal; prox= proximal; tr= transverse.

	Arrisdrift AD 744'97	Arrisdrift PQ AD 251	Arrisdrift AD 442'97	Arrisdrift AD 348'95	*Chilotheridium pattersoni* Loperot	Loperot	MSUR Kiboko
Length	182.5	181			129	115	153
prox tr	30	31	32	31	about 36	30	27
prox ap	51	47	57	51		37.5	34.5
diaphysis tr	31	30	31.5			23	19.5
diaphysis ap	30	25.5	29			21	18.5
dist max tr	40.5	39			42	35	29
dist tr artic	38.5	37.5			38.5	32.5	28
dist ap	46	40			43	36.5	30

D. schleiermacheri

	n	mean	min.	max.	Stand. dev.	coeff. var.
Length	3	153.33	150	156	3.06	1.99
prox tr	3	33.83	27	40.5	6.75	19.96
prox ap	3	45.67	43	50.5	4.19	9.18
diaphysis tr	2	27.00	26	28	1.41	5.24
diaphysis ap	2	27.75	27	28.5	1.06	3.82
dist max tr	3	37.17	35.5	39	1.76	4.72
dist tr artic	3	35.00	33	37	2.00	5.71
dist ap	3	39.17	37	40.5	1.89	4.83

D. gr. pachygnathus/neumayri

	n	mean	min.	max.	Stand. dev.	coeff. var.
Length	5	153.70	147.5	157.5	4.04	2.63
prox tr	5	33.60	30.5	37	3.03	9.01
prox ap	5	45.70	42.5	49	2.73	5.97
diaphysis tr	5	34.80	32	37.5	2.08	5.98
diaphysis ap	5	25.20	23.5	27	1.48	5.89
dist max tr	4	43.50	40	45	2.38	5.47
dist tr artic	5	39.30	36.5	41	1.75	4.46
dist ap	5	43.50	39	47	2.96	6.80

Aceratheres

	n	mean	min.	max.	Stand. dev.	coeff. var.
Length	8	137.06	117.5	165.5	14.37	10.49
prox tr	9	28.00	25.5	31	1.70	6.06
prox ap	9	39.17	35	41.5	2.26	5.78
diaphysis tr	7	26.57	23.5	32	2.99	11.26
diaphysis ap	7	21.93	19	25	2.13	9.71
dist max tr	7	36.07	31	40	3.18	8.82
dist tr artic	8	32.88	26	40	4.60	14.00
dist ap	7	36.50	33	40.5	2.80	7.67

Limb segments:

Simpson diagram of the limb segments (Figure 9) shows once more similarities with *Dicerorhinus schleiermacheri* and *Diceros* gr. *pachygnathus-neumayri*, with, as a noticeable particularity, a much greater relative length of the lateral and medial metapodials.

THE SMALLER RHINO FROM ARRISDRIFT, cf. *Chilotheridium pattersoni*

An isolated magnum (AD 618'97) is totally different (Figure 1: 3) from that attributed to *Diceros australis*. Its dimensions are as follows:

Total length:	91 mm
Anterior width:	50 mm
Anterior height:	27 mm
Maximum height:	54.5 mm
Sus-articular height:	52.5 mm

Shallow and very wide, with a flattened and oblique anterior surface, it shows an inverted width/height ratio (Figure 2) which suggests a small to medium sized short-legged form, probably *Chilotheridium*, which was defined at Loperot, Kenya, the age of which is about the same as Arrisdrift. For ten incomplete specimens of *Chilotheridium* from Loperot, Hooijer (1971, Table 14) gives a slightly greater anterior height (30 to 33 mm) and a slightly lesser anterior width (44 to 49 mm) but this is not a significant difference, the method of measuring probably not being exactly the same.

THE LANGENTAL BRACHYPOTHERE, *Brachypotherium heinzelini*

A complete magnum (LT 384'96) presents the following dimensions:

Total length:	84.5 mm
Anterior width:	57 mm
Anterior height:	39 mm
Maximum height:	58.5 mm
Sus-articular height:	57 mm

The Langental magnum (Figure 1: 5) is thus much larger than the smaller specimen from Arrisdrift but

TABLE 12.

Compared dimensions of the third metatarsal of Diceros australis nov. sp. ap= anteroposterior; artic= articular; diam= diameter; dist= distal; horiz= horizontal; prox= proximal; tr= transverse.

	Arrisdrift AD 618'94	Arrisdrift PQ AD 249	Arrisdrift PQ AD 119	Arrisdrift PQ AD 183		*C. pattersoni* Loperot
Length	197.5	197	about 180	about 178		128
prox tr	57.5	61		54		43.5
prox ap	52			49		40
diaphysis tr	50	51.5	52.5	44		36
diaphysis ap	26	25.5		25.5		18.5
dist max tr	61.5	60.5	57.5	55.5		48
dist tr artic	53	57	52.5	51		43
dist ap	46	47.5	42	42		35
	D. schleiermacheri					
	n	mean	min.	max.	Stand. dev.	coeff. var.
Length	2	173.25	171.5	175	2.48	1.43
prox tr	1	48.00				
prox ap	1	40.00				
diaphysis tr	2	45.00	43.5	46.5	2.12	4.71
diaphysis ap	2	23.25	23	23.5	0.35	1.52
dist max tr	2	55.50	53.5	57.5	2.83	5.10
dist tr artic	2	47.75	46	49.5	2.48	5.18
dist ap	2	39.00	33	45	8.49	21.76
	D. gr. pachygnathus/neumayri					
	n	mean	min.	max.	Stand. dev.	coeff. var.
Length	9	174.56	165	194.5	8.56	4.90
prox tr	8	60.06	57	64.5	2.32	3.86
prox ap	8	50.88	45	57.5	4.96	9.74
diaphysis tr	9	53.22	51.5	55	1.23	2.31
diaphysis ap	9	25.33	22.5	28.5	1.97	7.77
dist max tr	7	66.93	60.5	71.5	3.76	5.61
dist tr artic	8	54.50	49.5	60.5	3.65	6.69
dist ap	8	46.50	41.5	49	2.41	5.17
	Aceratheres					
	n	mean	min.	max.	Stand. dev.	coeff. var.
Length	11	150.36	130	166	11.44	7.61
prox tr	10	46.25	40	53.5	4.63	10.00
prox ap	10	41.90	38	46	2.76	6.58
diaphysis tr	11	41.32	37.5	46.5	2.70	6.55
diaphysis ap	10	19.90	16.5	24.5	2.76	13.85
dist max tr	11	52.45	47	60.5	4.12	7.85
dist tr artic	11	45.45	40.5	51.5	3.23	7.10
dist ap	11	37.82	32	42.5	3.47	9.17

presents the same kind of width/height ratio (Figure 2), which is typical of Brachypotheres and Chilotheres. I thus assign it to *Brachypotherium heinzelini*, a large brachypothere whose magnum remains undescribed but the presence of which is already known at the site since the study of K. Heissig (1971).

UNDETERMINED RHINOS FROM FISKUS AND AUCHAS MINE

From Fiskus a very worn and poorly preserved upper right premolar (P 3/ or P 4/) was recovered. Its total length is 42 mm for a collar width of 52 mm. The ectoloph seems flat. Dimensions are compatible with the P 3/ of a Brachypothere or the P 4/ of a large true Acerathere.

From Auchas Mine there is an atlas not completely cleared from the sediment, and a totally encrusted mandibular fragment which was found during the field trip following the 1998 PSSA meeting at Windhoek.

CONCLUSIONS

Four mammal-bearing Miocene sites excavated since 1991 by the Namibia Paleontology Expedition have yielded rhinoceros remains: Langental, Fiskus, Auchas Mine and Arrisdrift, the last three being new.

At Langental a well preserved magnum was found. It probably pertains to *Brachypotherium heinzelini*, a half mandible of which was recovered from the site before the First World War and which was identified by K. Heissig (1971).

From Fiskus there is a very worn upper premolar, perhaps from an Acerathere or a Brachypothere.

An atlas vertebra and a mandibular fragment, both encrusted with sediment and thus specifically undeterminable, have been recovered from Auchas Mine.

A great number of rhino specimens were found at Arrisdrift. All but one of the 81 fossil pieces constitute

TABLE 13.

Compared dimensions of the fourth metatarsal of Diceros australis nov. sp. ap= anteroposterior; artic= articular; diam= diameter; dist= distal; horiz= horizontal; prox= proximal; tr= transverse.

	Arrisdrift PQ AD 253	*Chilotheridium pattersoni* Loperot	Loperot
Length	about 182	111	113
prox tr	44	41	40.5
prox ap	42	40	about 38,5
diaphysis tr	35.5	22.5	22.5
diaphysis ap	22.5	20.5	20
dist max tr	42	33	30.5
dist tr artic	41	34.5	32
dist ap	about 36	35.5	34.5

D. schleiermacheri

	n	mean	min.	max.
Length	2	153.50	152	155
prox tr	2	42.25	37	47.5
prox ap	1	50.00	50	50
diaphysis tr	2	27.75	26.5	29
diaphysis ap	2	29.25	28	30.5
dist max tr	2	36.00	35.5	36.5
dist tr artic	2	36.50	35	38
dist ap	2	42.50	42	43

D. gr. pachygnathus/neumayri

	n	mean	min.	max.	Stand. dev.	coeff. var.
Length	8	148.31	138.5	166.5	9.05	6.10
prox tr	8	48.63	43	53	3.15	6.47
prox ap	8	46.88	42.5	51	2.90	6.19
diaphysis tr	8	32.12	30	35	1.64	5.11
diaphysis ap	8	29.00	24.5	32	2.79	9.62
dist max tr	8	41.12	37	45	2.62	6.36
dist tr artic	8	39.75	35.5	43	2.78	6.99
dist ap	8	42.75	40	45	1.93	4.51

Aceratheres

	n	mean	min.	max.	Stand. dev.	coeff. var.
Length	10	131.40	117.5	144	9.02	6.87
prox tr	11	40.95	37	44.5	2.08	5.08
prox ap	11	38.09	32.5	42.5	3.59	9.43
diaphysis tr	10	26.85	23	30	2.08	7.76
diaphysis ap	10	24.85	21	28	2.21	8.90
dist max tr	9	31.56	29	34.5	1.98	6.26
dist tr artic	8	30.25	27.5	35.5	2.87	9.47
dist ap	10	35.15	31	37.5	2.48	7.07

a homogeneous sample pertaining to a very large species of cursorial rhino. The exception is an isolated magnum which suggests a small to medium sized short-legged form, perhaps *Chilotheridium pattersoni*, a species described from Loperot in Kenya, the age of which is about the same as Arrisdrift, i.e. 17 Ma. The large form from Arrisdrift seems to be the largest of the African Miocene Rhinos; the size and proportions of the metapodials and the other limb bones suggest a strong analogy with *Diceros* gr. *pachygnathus-neumayri* of the Upper Miocene of the Near East; the type of construction of the upper cheek teeth, in particular the fourth premolar, is of Dicerotine type and presents, as do the dimensions, close resemblances with *Diceros douariensis* of the Upper Miocene of North Africa and Italy; the mandible shows analogies with the Dicerotines, especially the apparently short symphysis. This rhino is *Diceros australis* nov. sp., so far the oldest known species of the subfamily.

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REFERENCES

AGUIRRE, E. & GUÉRIN, C. 1974. Première découverte d'un *Iranotheriinae* (Mammalia, Perissodactyla, Rhinocerotidae) en Afrique: *Kenyatherium bishopi* nov. gen. nov. sp. de la formation vallésienne (Miocène supérieur) de Nakali (Kénya). *Estudios geologicos* **30,** 229-233.

GERAADS, D. 1986. Sur les relations phylétiques de *Dicerorhinus primaevus* Arambourg, 1959, rhinocéros du Vallésien d'Algérie. *Comptes rendus hebdomadaires des séances de l'Académie des Sciences de Paris,* II **302** (13), 835-837.

-------- 1989. Vertébrés fossiles du Miocène supérieur du Djebel Krechem el Artsouma (Tunisie centrale). Comparaisons biostratigraphiques. *Geobios* **22** (6), 777-801.

GUÉRIN, C. 1966. *Diceros douariensis* nov. sp., un rhinocéros du Mio-Pliocène de Tunisie du Nord. *Documents du Laboratoire de Géologie de la Faculté des Sciences de Lyon* **16,** 1-50.

-------- 1976. Les restes de rhinocéros du gisement miocène de Béni-Mellal, Maroc. *Géologie méditerranéenne* **3** (2), 105-108.

-------- 1980 a. Les rhinocéros (Mammalia, Perissodactyla) du Miocène terminal au Pléistocène supérieur en Europe occidentale. Comparaison avec les espèces actuelles. *Documents des Laboratoires de Géologie de Lyon* **79** (1-3), 1-1185.

-------- 1980 b. A propos des rhinocéros (Mammalia, Perissodactyla), néogènes et quaternaires d'Afrique: essai de synthèse sur les espèces et sur les gisements. *Proceedings of the 8th. PanAfrican Congress of Prehistory and Quaternary Studies,* Nairobi, September, 1977, *TILLMIAP edit.,* Nairobi, 58-63.

-------- 1989. La famille des Rhinocerotidae (Mammalia, Perissodactyla): systématique, histoire, évolution, paléoécologie. *Cranium* 6 (2), 3-14.

-------- & DEMATHIEU, G. 1993. Empreintes et pistes de Rhinocerotidae (Mammalia, Perissodactyla) du gisement pliocène terminal de Laetoli (Tanzanie). *Geobios* **26** (4), 497-513.

-------- 1994. Les Rhinocéros (Mammalia, Perissodactyla) du Néogène de l'Ouganda, 263-279, **In:** Senut, B. & Pickford, M. Eds, *Geology and Palaeobiology of the Albertine Rift Valley, Uganda-Zaire*, vol. II: Palaeobiology, CIFEG édit, Orléans, occasional publication 1994/29.

HAMILTON, W.R. 1973. North African Lower Miocene Rhinoceroses. *Bulletin of the British Museum (Natural History),* London **24** (6), 351-395.

-------- & VAN COUVERING, J.A. 1977. Lower Miocene Mammals from South West Africa. *Bulletin of the Desert Ecological Research Unit*, **Oct. 1977,** 9-11.

HEINZ, R. 1933. Ein vorzeitlicher Tränkplatz in der Namibwüste bei Lüderitzbucht (Deutsch-Südwestafrika). *Mitteilungen der Geographischen Gesellschaft in Hamburg* **XLIII,** 267-302.

HEISSIG, K. 1971. *Brachypotherium* aus dem Miozän von Südwestafrika. *Mitteilungen der Bayerische Staatssammlung für Paläontologie und historische Geologie*, München **11,** 125-128.

HOOIJER, D.A. 1966. Miocene rhinoceroses of East Africa. *Bulletin of the British Museum (Natural History),* London, **13** (2), 119-190.

-------- 1968. A rhinoceros from the late Miocene of Fort Ternan, Kenya. *Zoologische Mededelingen* **43** (6), 77-92.

-------- 1971. A new rhinoceroses from the late Miocene of Loperot, Turkana District, Kenya. *Bulletin of the Museum of Comparative Zoology.* **42** (3), 339-392.

-------- 1973. Additional Miocene to Pleistocene rhinoceroses of Africa. *Zoologische Mededelingen* **46** (11), 149-178.

-------- 1978. 19: Rhinocerotidae, 371-378, **In:** Maglio V.J. & Cooke H.B.S. Eds, *Evolution of African Mammals*, Cambridge (Mass.), Harvard University Press.

NAKAYA, H., PICKFORD, M., YASUI, K., & NAKANO, Y., 1999 (dated 1987). Additional large mammalian fauna from the Namurungule Formation, Samburu Hills, Northern Kenya. *Afr. Study Monogr. Suppl. Issue* **5,** 79-130.

PICKFORD, M., SENUT, B. & HADOTO, D. 1993. *Geology and palaeobiology of the Albertine Rift Valley, Uganda-Zaire*, vol. I: Geology, CIFEG, Orléans, occasional publication 1993/24, 190 p.

--------, SENUT, B., MEIN, P., MORALES, J., SORIA, D., NIETO, M., WARD, J. & BAMFORD, M. 1995. The discovery of lower and middle Miocene vertebrates at Auchas, southern Namibia. *Comptes rendus hebdomadaires des séances de l'Académie des Sciences de Paris*, II a **322,** 901-906.

--------, SENUT, B., MEIN, P., GOMMERY, D., MORALES, J., SORIA, D., NIETO, M. & WARD, J. 1995. Preliminary results of new excavations at Arrisdrift, middle Miocene of southern Namibia. *Comptes rendus hebdomadaires des séances de l'Académie des Sciences de Paris*, II a **322,** 991-996.

PROTHERO, D.R., GUERIN, C. & MANNIN, G. E. 1989. The History of the Rhinocerotoidea. **In:** Prothero, D.R. & Schoch, R.M., Eds, *The Evolution of Perissodactyls* (IVth Theriological Congress, Edmonton, Alberta, 1985), 321-340. New York, Oxford Univ. Press.

STROMER E. 1926. Reste Land- und Süsswasser-bewohnender Wirbeltiere aus den Diamantfeldern Deutsch-Südwestafrikas. **In:** Kaiser, E. Ed., *Die Diamantenwüste Südwestafrikas*, 107-153 Dietrich Reimer (Ernst Vohsen) A.D. édit., Berlin, Bd. II.