



Reconstructing the life appearance of a Pleistocene giant: size, shape, sexual dimorphism and ontogeny of *Palaeoloxodon antiquus* (Proboscidea: Elephantidae) from Neumark-Nord 1 (Germany)

Asier LARRAMENDI, Maria Rita PALOMBO & Federica MARANO

A. Larramendi, EoFauna Scientific Research, Errondo pasalekua 6, 10c. 20010 Donostia, Navarre, Spain; larramendi.asier@eofauna.com
M.R. Palombo, Dipartimento di Scienze della Terra, Università La Sapienza di Roma, P.le A. Moro 5, I-00185 Roma, Italy; IGAG-CNR, Montelibretti, Area della Ricerca di Roma 1- Montelibretti, Via Salaria km 29.300 - I-00015 Monterotondo, Roma, Italy; mariarita.palombo@uniroma1.it
F. Marano, Dipartimento di Scienze della Terra, Università La Sapienza di Roma, P.le A. Moro 5, I-00185 Roma, Italy; federica.marano@uniroma1.it

SUPPLEMENTARY ONLINE MATERIAL 1

Tab. S1 - Measurements of the cranium of *Palaeoloxodon antiquus* 152-E9 and 175-E23B specimens; e: estimated.

Cranium	152-E9	175-E23B
Length from top of cranium to the tip of premaxilla	1340e	1520e
Length from condyles to the tip of premaxilla	1140e	1250e
Distance from skull apex to masticatory molar surface	960e	1100e
Maximum width of the occiput	992e	1100e
Maximum distal width of the right premaxilla side	502	524
Maximum distal width of the premaxilla	970e	1048e
Length of the premaxilla	782	834
Length of the premaxilla along the suture line	750	806
Length of the suture line	790	830
Distance between the middle point of the coanae and lateral edge of the alveolus	780	820
Maximum width of the fan between lacrimals	540	600e
Maximum zygomatic width	810	923
Maximum distance between orbits	730	>790
Maximum width of the nasal opening	458	554
Minimum width of frontal bones	564	660
Maximum diameter of the alveolus	180	194
Maximum width of the occipital condyles	280	-

Tab. S2 - Measurements of the mandible of *Palaeoloxodon antiquus* 152-E9 and 175-E23A specimens; e: estimated.

Mandible	152-E9
Maximum length of the lower jaw (34)	809
Maximum breadth of the jaw (28)	555e
Lower jaw depth (25)	339e
Maximum height of the ascending branch (24)	472
Length from the anterior edge of alveola of molar teeth to end of the branch	597
Maximum breadth of horizontal branches	550e
Distance between horizontal branches (at the level of posterior edge of alveoli)	205
Maximum breadth of horizontal branches (at the level of anterior edge of alveoli)	136
Maximum breadth of horizontal branches	550e

Tab. S3 - Measurements of the teeth M3 and m3 of *Palaeoloxodon antiquus* from Neumark Nord sample.

Molar	M3	m3
Plates number	15 - 20	15 - 19
Maximum length	227 - 335	181 - 330
Maximum width	82 - 118	68 - 109
Maximum height	186 - 225	157 - 180
Enamel thickness	2.1 - 3.1	2.4 - 3.3
Lamellar frequency	4.5 - 6.5	5 - 7

Tab. S4 - Measurements of Atlas vertebrae of *Palaeoloxodon antiquus* 152-E9 and 175-E23A specimens; e: estimated.

Atlas	152-E9	175-E23A
Maximum width	485e	480e
Maximum height	290	290
Length of the corpus	145	155
Maximum width of the cranial articulation	270	266
Maximum height of the cranial articulation	160	152
Maximum width of the caudal articulation	264	260
Maximum width of the caudal articulation	-	136
Maximum width of the neural arch	96	108
Maximum length of the neural arch	138	131

Tab. S5 - Measurements of Axis vertebrae of *Palaeoloxodon antiquus* 152-E9 and 175-E23A specimens.

Axis	152-E9	175-E23A
Maximum width	346	344
Maximum height	356	350
Maximum length (antero-posterior diameter) with apophysis	220	224
Maximum length (antero-posterior diameter) without apophysis	188	-
Maximum dorsal width	174	164
Maximum width of the cranial articulation	-	262
Maximum height of the cranial articulation	-	149
Maximum width of the caudal articulation	176	210
Maximum height of the caudal articulation	222	164

Tab. S6 - Measurements of cervical vertebrae of *Palaeoloxodon antiquus* 152-E9 and 175-E23A specimens.

Cervicals	C3	C4	C5	C6	C7
Maximum width of the vertebrae (152-E9)	395	372	385	-	-
Maximum width of the vertebrae (175-E23A)	-	365	382	-	-
Maximum height of the vertebrae (152-E9)	-	-	-	-	-
Maximum height of the vertebrae (175-E23A)	307	330	-	-	-
Maximum width of the cranial articulation (152-E9)	178	173	180	-	-
Maximum width of the cranial articulation (175-E23A)	163	171	168	165	168
Maximum height of the cranial articulation (152-E9)	181	173	179	-	-
Maximum height of the cranial articulation (175-E23A)	181	169	172	173	186
Maximum width of the caudal articulation (152-E9)	189	191	187	-	-
Maximum width of the caudal articulation (175-E23A)	191	191	188	194	170
Maximum height of the caudal articulation (152-E9)	224	232	226	-	-
Maximum height of the caudal articulation (175-E23A)	213	209	211	212	188

Tab. S7 - Measurements of thoracic vertebrae of *Palaeoloxodon antiquus* 175-E23A specimen; e: estimated.

Thoracics	T1	T2	T3	T4	T5	T9	T11	T12	T13	T14	T15	T16	T18	T19
Maximum width of the vertebrae	395	-	340	390	383	368	275	276	267	269	265	270	255	260
Maximum height of the vertebrae	740	735	595	677e	520e	540e	510e	515e	513e	502e	495e	470e	-	-
Height of the spinosus process	542	585	575e	567e	552	483	365e	345	320e	315e	305e	277	-	-
Maximum width of the cranial articulation	162	-	151	142	136	145	136	138	136	127	127	127	133	136
Maximum height of the cranial articulation	156	156	150	158	149	144	139	139	133	126	124	130	135	143
Maximum width of the caudal articulation	161	-	161	153	156	162	151	138	136	134	140	135	138	152
Maximum height of the caudal articulation	162	156	166	159	149	154	142	145	138	125	136	139	147	-

Tab. S8 - Measurements of lumbar vertebrae of *Palaeoloxodon antiquus* 152-E9 and 175-E23A specimens; e: estimated.

Lumbar	L1	L2	L3	L4	
Maximum width of the vertebrae (152-E9)		307e	350e	335e	302e
Maximum width of the vertebrae (175-E23A)		-	-	394	280
Maximum height of the vertebrae (152-E9)		-	395	370	-
Maximum height of the vertebrae (175-E23A)		-	-	383	321
Height of the spinosus process (152-E9)		-	211	190	-
Height of the spinosus process (175-E23A)		-	-	223	198
Maximum width of the cranial articulation (152-E9)		144	158	-	142
Maximum width of the cranial articulation (175-E23A)		-	-	135	137
Maximum height of the cranial articulation (152-E9)		152	158	-	175
Maximum height of the cranial articulation (175-E23A)		-	-	157	164
Maximum width of the caudal articulation (152-E9)		156	-	153	122
Maximum width of the caudal articulation (175-E23A)		-	-	140	131
Maximum height of the caudal articulation (152-E9)		170	-	199	172
Maximum height of the caudal articulation (175-E23A)		-	-	187	175

Tab. S9 - Measurements of the sacrum vertebrae of *Palaeoloxodon antiquus* 152-E9 and 175-E23A specimens; e: estimated.

Sacrum	152-E9	175-E23A
Maximum width	273	307e
Maximum height	267	272
Maximum length	425	470
Ventral length of the corpus	302	330
Maximum width of the cranial articulation	176	169
Maximum height of the cranial articulation	126	127

Tab. S10 - Measurements of the Scapula of *Palaeoloxodon antiquus* 152-E9, 175-E23B, 176-E24A, 167-E43A male specimens and 151-E8, 161-E22A, 176-E24B female specimens. To estimate the dorsal epiphysis size, a conservative 8% was added to the scapula preserved length; e: estimated; () included the estimated epiphysis length.

Scapula	152-E9	175-E23B	161-E22A	176-E24A	167-E43A	151-E8	176-E24B
Side	L	R	R	L	R	R	R
Maximum length excluding dorsal epiphysis	>1000	>1080	820	1060	1070	-	-
Maximum length including dorsal epiphysis	(>1080)	(>1166)	(886)	(1145)	(1156)	844	886
Articular length excluding dorsal epiphysis	980	1050	794	1030	1020	-	-
Articular length including dorsal epiphysis	(1058)	(1134)	(858)	(1112)	(1102)	750	840
Maximum width	-	>880	-	-	-	-	-
Width of scapular neck	300	326	250e	290	-	227	254
Glenoid articular length	243	244	188	228	-	196	186
Glenoid articular width	157	152	108	144	-	129	123

Tab. S11 - Measurements of the Humerus of *Palaeoloxodon antiquus* 152-E9, 176-E24A, 167-E43A male specimens and 151-E8, 161-E22A female specimen.

Humerus	152-E9	161-E22A	176-E24A	167-E43A	151-E8
Side	L	R	L	R	R
Maximum length	1220	937	1270	-	-
Articular length	1180	924	1226	>1230	>836
Proximal width	380	260	334	350	-
Proximal thickness	330	242	276	-	-
Minimum diaphysis width	-	105	-	154	102
Minimum diaphysis thickness	-	84	152	130	-
Minimum diaphysis circumference	530	348	508	480	-
Distal width	340	275	330	-	-
Distal thickness	214	173	272	-	176
Width of the trochlea	268	223	286	-	210

Tab. S12 - Measurements of the Ulna of *Palaeoloxodon antiquus* 152-E9, E154-E10A male specimens and 151-E8, 161-E22A, 171-E34A female specimen.

Ulna	152-E9	161-E22A	E154-E10A	151-E8	171-E34A
Side	L	R	R	R	L
Maximum length	1030	>735	1108	860	810
Articular length	830	672	896	630	-
Proximal width	375	284	354	300	296
Proximal thickness	335	257	370	287	292
Olecranon width	229	164	220	-	163
Olecranon thickness	215	136	282	205	212
Minimum diaphysis width	146	95	112	91	89
Minimum diaphysis circumference	470	305	474	311	312
Distal width	226	166	-	204	-
Distal thickness	250	168	-	180	-
Distal articular width	148	116	-	95	-
Distal articular thickness	150	93	-	113	-

Tab. S13 - Measurements of the Radius of *Palaeoloxodon antiquus* 152-E9, 176-E24A, 167-E43A, E154-E10A male specimens and 151-E8, 161-E22A, 171-E34A female specimen; e: estimated.

Radius	152-E9	161-E22A	176-E24A	167-E43A	E154-E10A	151-E8	171-E34A
Side	L	L	L	L	R	L	R
Maximum length	882	685	910	934	965	657	760
Articular length	856	650	886	912	950	612	722
Proximal width	138	122	154	-	164	122	125
Proximal thickness	88	67	105	-	-	70	68
Proximal articular width	133	110e	145	-	146	110	112
Proximal articular thickness	84	61	77	-	76	63	56
Minimum diaphysis width	71	50	84	71	-	62	58
Minimum diaphysis circumference	264	170	234	236	-	180	180
Distal width	169	132	218	200	161	123	136
Distal thickness	222	165	164	172	198	162e	-
Distal articular width	126	105	139	-	113	95	83
Distal articular thickness	170	131	163	178	167	128	112

Tab. S14 - Measurements of carpal bones of *Palaeoloxodon antiquus* 152-E9 male.

Individual	152-E9	
Scaphoid		
Side	L	R
Greatest height	159.5	160.4
Greatest thickness	133.5	131.1
Greatest width	69.9	81.5
Lunar		
Side	L	R
Greatest height	96.3	91.1
Greatest thickness	161.8	167.7
Greatest width	172.5	169.6
Pyramide		
Side	L	R
Greatest height	53.9	51.8
Greatest thickness	146.7	149.4
Greatest width	220	217.5
Pisiforme		
Side	L	R
Greatest length	172.3	-
Greatest thickness (proximal)	92	-
Greatest width (distal)	59.5	-
Trapezium		
Side	L	R
Greatest height	103.8	106.3
Greatest thickness	98.4	94.8
Greatest width	60.3	65.8
Trapezoid		
Side	L	R
Greatest height	86	86.1
Greatest thickness	140.9	141.6
Greatest width	82.4	84.1
Magnum		
Side	L	R
Greatest height	125.1	138.9
Greatest thickness	154.7	154.7
Greatest width	118.3	116.7
Unciforme		
Side	L	R
Greatest height	137.2	138.9
Greatest thickness	153.3	143.6
Greatest width	149.7	162.7

Tab. S15 - Measurements of metacarpal bones of *Palaeoloxodon antiquus* 152-E9 male; e: estimated.

Individual	152-E9	
Mc I		
Side	L	R
Greatest length	127.5e	-
Greatest proximal thickness	109	-
Greatest proximal width	65.2	-
Minimum body thickness	56.3	-
Minimum body width	45	-
Greatest distal thickness	-	-
Greatest distal width	67.7	-
Mc II		
Side	L	R
Greatest length	205.1	211.3
Greatest proximal thickness	126.7	127.1
Greatest proximal width	90.7	89.7
Minimum body thickness	68.9	69.2
Minimum body width	86.9	91
Greatest distal thickness	98.3	103.8
Greatest distal width	113.8	118.3
Mc III		
Side	L	R
Greatest length	228.8	216.1
Greatest proximal thickness	123.5	131.5
Greatest proximal width	95.1	96.2
Minimum body thickness	66.8	63.3
Minimum body width	88.2	94.4
Greatest distal thickness	105.5	104.8
Greatest distal width	117.8	121.1
Mc IV		
Side	L	R
Greatest length	207.4	201.1
Greatest proximal thickness	124.2	122.8
Greatest proximal width	110.5	111.2
Minimum body thickness	72.3	71.2
Minimum body width	97.4	104.5
Greatest distal thickness	104.7	104.6
Greatest distal width	124.5	123.6
Mc V		
Side	L	R
Greatest length	200.5	186.1
Greatest proximal thickness	120.2	109.2
Greatest proximal width	123.7	120.1
Minimum body thickness	116.6	76.7
Minimum body width	119.4	107.9
Greatest distal thickness	130.7	113
Greatest distal width	122.5	124.2

Tab. S16 - Measurements of manus phalanges bones of *Palaeoloxodon antiquus* 152-E9 male.

Individual	152-E9	
PP I		
Side	L	R
Greatest length	81.9	-
Greatest proximal thickness	51.1	-
Greatest proximal width	53.7	-
Minimum body thickness	35.1	-
Minimum body width	36.3	-
Greatest distal thickness	36	-
Greatest distal width	34.6	-
PP III		
Side	L	R
Greatest length	-	-
Greatest proximal thickness	97.2	-
Greatest proximal width	-	-
Minimum body thickness	72.8	-
Minimum body width	-	-
Greatest distal thickness	-	-
Greatest distal width	-	-
PP V		
Side	L	R
Greatest length	-	125.5
Greatest proximal thickness	-	97.8
Greatest proximal width	-	92.2
Minimum body thickness	-	61.9
Minimum body width	-	59.6
Greatest distal thickness	-	65.6
Greatest distal width	-	62.9

Tab. S17 - Measurements of the Femur of *Palaeoloxodon antiquus* 152-E9, 167-E43A male specimens and 151-E8, 171-E34A female specimens.

Femur	152-E9	167-E43A	151-E8	171-E34A
Side	R	L	L	L
Maximum length	1320	1398	1040	1070
Proximal width	425	-	-	338
Caput width	205	216	155	146
Caput thickness	210	205	159	159
Minimum diaphysis width	156	-	116	121
Minimum diaphysis thickness	121	-	95	86
Minimum diaphysis circumference	470	-	340	332
Distal width	318	-	229	244
Distal articular width	-	-	-	192

Tab. S18 - Measurements of the Tibia of *Palaeoloxodon antiquus* 152-E9, 167-E43A, E154-E10A male specimens and 151-E8, 161-E22A, 171-E34A female specimens; e: estimated.

Tibia	152-E9	161-E22A	167-E43A	E154-E10A	151-E8	171-E34A
Side	R	L	L	L	R	R
Maximum length	795	638	842	914	576	624
Articular length	775	625	820	794	490	598
Proximal width	278	217	286	312	208	205
Proximal thickness	-	171	234	-	150	143
Proximal articular width	263	210	274	274	188	192
Proximal articular thickness	163	152	183	164e	123	139
Minimum diaphysis width	151	94	140	142	98	89
Minimum diaphysis thickness	136	80	139	-	83	87
Minimum diaphysis circumference	440e	280	430	-	-	288
Distal width	232	183	252	237	170	167
Distal thickness	180	130e	182	-	132	133
Distal articular width	231	169	215e	205	153	145
Distal articular thickness	62	52	67	>63	47	57

Tab. S19 - Measurements of the Fibula of *Palaeoloxodon antiquus* 152-E9, male specimen and 151-E8 female specimen.

Fibula	152-E9	151-E8
Side	R	R
Maximum length	740	570
Articular length	-	570
Proximal width	86	59
Proximal thickness	86	50
Proximal articular width	35	25
Proximal articular height	33	25
Minimum diaphysis thickness	35	20
Minimum diaphysis circumference	158	91
Distal width	148	104
Distal thickness	116	63
Distal articular height	103	93
Distal articular thickness	100	92
Minimum articular width for the astragalus	-	73
Minimum articular height for the astragalus	71	-
Minimum articular thickness for the calcaneus	37	-
Minimum articular height for the calcaneus	33	42

Tab. S20 - Measurements of the Tarsal bones of *Palaeoloxodon antiquus* 152-E9 male.

Individual	152-E9
Calcaneum	
Side	R
Greatest height	250.1
Greatest thickness	192.9
Greatest width	188
Astragalus	
Side	R
Greatest height	168.4
Greatest thickness	114.7
Greatest width	186.4

Tab. S21 - Measurements of metatarsal bones of *Palaeoloxodon antiquus* 151-E8 female; e: estimated.

Individual	151-E8
Mt II	
Side	R
Greatest length	100.4
Greatest proximal thickness	52.2
Greatest proximal width	45.1
Minimum body thickness	36.3
Minimum body width	50.4
Greatest distal thickness	56.1
Greatest distal width	-
Mt III	
Side	R
Greatest length	126
Greatest proximal thickness	64
Greatest proximal width	61.2
Minimum body thickness	37.9
Minimum body width	56.1
Greatest distal thickness	58.2
Greatest distal width	-
Mt IV	
Side	R
Greatest length	123.5
Greatest proximal thickness	64.7
Greatest proximal width	72.5
Minimum body thickness	38.9
Minimum body width	57.6
Greatest distal thickness	63.6
Greatest distal width	-
Mc V	
Side	R
Greatest length	73.7
Greatest proximal thickness	56.5
Greatest proximal width	53.4
Minimum body thickness	56.7
Minimum body width	65.3e
Greatest distal thickness	59.4e
Greatest distal width	-

Tab. S22 - Measurements of the Pes phalanges bones of *Palaeoloxodon antiquus* 151-E8 female; e: estimated.

Individual	151-E8
PP I	
Side	R
Greatest length	48.5
PP III	
Side	R
Greatest length	60.2
Greatest proximal thickness	41.4
Greatest proximal width	53.8
Minimum body thickness	41e
Minimum body width	47.7
Greatest distal thickness	31.5e
Greatest distal width	52.6e
PP IV	
Side	R
Greatest length	60e
Greatest proximal thickness	39.7
Greatest proximal width	57
Minimum body thickness	34
Minimum body width	53.4