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Taxonomic comparison of Derby eland and common eland (*Taurotragus* sp.)

DIPLOMA THESIS

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Declaration

I declare that I have written my diploma thesis titled „Taxonomic comparison of Derby eland and common eland (*Taurotragus* sp.)“ on my own with a help of my supervisors and literature listed in References. I agree with storing this thesis in the library of CULS Prague and enabling it for study use.

In Prague, 19. 4. 2012

Barbora Lutovská

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Abstract

This master thesis provides a morphological research on antelopes of genus *Taurotragus*. Differences between two species, *Taurotragus oryx* (common eland) and *Taurotragus derbianus* (Derby eland) and their subspecies (subspecies of common eland – *T. o. oryx*, *T. o. livingstonii*, *T. o. pattersonianus*; subspecies of Derby eland – *T. d. gigas* and *T. d. derbianus*), were compared based on photo inspections (exterior characters) and craniometrical measurements of skulls and horns (detailed morphological differences).

Basic exterior comparison of species and subspecies was based on about 260 credible photos. Craniometrical measurements were taken for 149 skulls and horns of adult animals from museums (Museum für Naturkunde in Berlin, Muséum National d´Histoire Naturelle in Paris and Natural History Museum in London), four skulls of common elands from CULS Farm Estate in Lány, one skull and 3 horn samples of Derby elands from reserves Bandia and Fathala in Senegal and 6 horn measurements provided during transfers of Derby elands.

Considering the photo inspection, visible differences were found between species. In common eland, clear differences were found also between *T. o. oryx* and *T. o. livingstonii* and between *T. o. oryx* and *T. o. pattersonianus*, but not very clear between *T. o. livingstonii* and *T. o. pattersonianus*. In Derby eland, no exterior differences were found. In craniometrical (skulls + horns) parameters, differences were found between species and also between subspecies. Species were different in three parameters under the 100 % rule of difference. In common eland, subspecies *T. o. oryx* and *T. o. pattersonianus* were different in 3 parameters under the 75% rule of difference and in 2 parameters under the 100% rule of difference. Subspecies *T. o. livingstonii* and *T. o. pattersonianus* were different in three parameters under the 75% rule of difference. *T. o. oryx* and *T. o. livingstonii* were not different under the 75% rule of difference, but they were different in one parameter close to the subspecies boundary. In Derby eland, subspecies were different in one parameter of horns under the 75% rule of difference after an elimination of one probably atypical individual and in one parameter of skull close to 75% rule of difference.

Key words: *Taurotragus*, common eland, Derby eland, taxonomic comparison, craniometry

Abstrakt

V této diplomové práci byly zkoumány morfologické rozdíly antilop rodu *Taurotragus*. Rozdíly mezi dvěma druhy, *Taurotragus oryx* (antilopa losí) a *Taurotragus derbianus* (antilopa Derbyho) a jejich poddruhy (poddruhy antilopy losí – *T. o. oryx, T. o. livingstonii, T. o. pattersonianus*; poddruhy antilopy Derbyho – *T. d. gigas* a *T. d. derbianus*) byly zjišťovány na základě exteriéru a kraniometrického měření lebek a rohů.

Exteriér druhů a poddruhů byl porovnáván na základě 260 fotografií a měření byla provedena na ca. 150 lebkách a trofejích dospělých jedinců z muzejních sbírek (Museum für Naturkunde v Berlíně, Muséum National d´Histoire Naturelle v Paříži a v londýnském Natural History Museum), na čtyřech lebkách antilop losích ze Školního zemědělského podniku v Lánech (ČZU), jedna lebka a tři páry rohů antilop Derbyho byly změřeny v rezervacích Bandia a Fathala v Senegalu a šest měření rohů bylo provedeno během transportů antilop Derbyho.

Na základě fotografií byly nalezeny viditelné rozdíly mezi druhy. Mezi poddruhy antilopy losí byly zřetelné rozdíly mezi poddruhem *T. o. oryx* a *T. o. livingstonii* a mezi *T. o. oryx* a *T. o. pattersonianus*, nikoli však mezi poddruhy *T. o. livingstonii* a *T. o. pattersonianus*. V exteriéru antilop Derbyho nebyly rozdíly nalezeny žádné.

V kraniometrických (lebka + rohy) rozměrech byly nalezeny rozdíly mezi druhy i poddruhy. Druhy se podle konvenční míry druhové odlišnosti (100 %) lišily ve třech parametrech. Mezi poddruhy antilopy losí byly nalezeny rozdíly mezi *T. o. oryx* a *T. o. patterosonianus* ve třech znacích podle konvenční míry poddruhové odlišnosti (75 %) a dokonce ve dvou znacích podle konvenční míry odlišnosti druhů (100 %). Poddruhy *T. o. livingstonii* a *T. o. pattersonianus* byly odlišné ve třech znacích. Pro poddruhy *T. o. livingstonii* a *T. o. oryx* nebyl nalezen žádný rozdíl podle konvenční míry, nicméně rozdíl v jednom znaku byl hranici 75 % velmi blízko. Poddruhová odlišnost byla prokázána i u poddruhů antilopy Derbyho, s pomocí jednoho parametru rohů (po eliminaci zřejmě atypického jedince) a jednoho parametru lebky, jehož odlišnost se blížila k 75 %.

Klíčová slova: Taurotragus, antilopa losí, antilopa Derbyho, taxonomické srovnání, kraniometrie

CONTENTS

1 Introduction

Antelopes of the genus *Taurotragus*, are largest antelopes of the world (Dollman, 1936), which inhabit savannas throughout the whole sub-Saharan Africa (Lorenzen et al., 2010).

Species *Taurotragus oryx,* common eland, is distributed in southern and East Africa in practically continuous range (Kindgon, 1982). Populations of all subspecies, *T. o. oryx*, *T. o. livingstonii* and *T. o. pattersonianus* are considered as relatively stable in terms of conservation status (IUCN 2010). Thanks to its body size, water-independency (Skinner and Chimimba, 2005), high reproductive rate, high nutrition value of milk and the fact, that it can be easily tamed, common eland is often bred on farms and ranches (Dobroruka, 1973).

First domestication attempts are known from 19th century from South Africa. First domesticated herd in Europe was in Askania Nova in Ukraine in the end of 19th century (Hemmer, 1990).

Species *Taurotragus derbianus*, Derby eland, has disjunctive areal in central and in western Africa (Gentry, 1971). Population of subspecies *T. d. gigas*, albeit it was exterminated in Chad (East, 1990), is considered as relatively stable (IUCN 2008). It is a favourite and highly valuable trophy animal, often described by hunters as „the holy grail of hunting“ (Heath, 2010).

Its western subspecies, *T. d. derbianus*, is critically endangered by extinction. It is distributed only in Senegal (Niokolo Koba National Park), and probably also in few surviving populations in adjacent countries (Mali and Guinea) (Darroze, 2004). Total population in NKNP is up to 200 indiviaduals only (Koláčková et al., 2011).

Semi-captive populations, controlled by Western Derby eland Conservation Programme, were established in 2000 from individuals transported from NKNP to natural reserves Bandia and Fathala. Western Derby Eland Conservation Programme is organized by Society for the Protection of Environment and Fauna of Senegal (SPEFS), in cooperation with Derbianus Czech Society for African Wildlife and Czech University of Life Sciences Prague (Koláčková et al., 2011).

Although all of mentioned subspecies are identified by standart taxonomical reviews, conclusions from Ungulate taxonomy (2011, by Groves and Grubb) distinguished only 2 subspecies of *T. oryx* and none of *T. derbianus* (albeit the number of specimen of *T. derbianus* was very low). Of course, this extrapolation could have a marked conservation consequences and considering their small samples size, it is necessary to try to establish conclusions based on larger samples size. As noted Colin Groves and Peter Grubb (2011), their book is not a finished proposition, it should rather to stimulate more taxonomic research.

1.1 *Aim*

The aim of this thesis is a comparison of some exterior and especially all cranial differences between two species of elands – Derby eland (*Taurotragus derbianus*) and common eland (*Taurotragus oryx*) and their subspecies.

1.2 *Assumptions*

1) Derby and common eland are morphologicaly different (they meet with a conventional 100% rule of differences for at least one parameter);
2) Subspecies of common eland are morpologicaly different, but less than species (i.e. they meet with a conventional 75% rule of differences for at least one parameter);
3) Subspecies of Derby eland are morpologicaly different, but less than species (i.e. they meet with a conventional 75% rule of differences for at least one parameter). The difference could be more than subspecies of common eland due to their disjunctive range in western and central Africa.

2 Bibliographic research

2.1 Taxonomy

This taxonomic arrangement follows the widely used taxonomical review made by Grubb (2005 in Wilson and Reeder, 2005); I tend to use it below for comparing and discussing purposes.

Grandorder: Ungulata (Linnaeus, 1766)
Order: Artiodactyla (Owen 1848)
Family: Bovidae (Gray 1821)
Subfamily: Bovinae (Gray 1821)
Tribe: Tragelaphini (Jerdon, 1874)
Genus: *Taurotragus* (Wagner, 1855, *in* Schreber)
Species: *Taurotragus oryx* (Pallas, 1766), below specified as „common eland“
    Subspecies: *Taurotragus oryx oryx* (Pallas, 1766)
        Taurotragus oryx livingstonii (Sclater, 1864)
        Taurotragus oryx pattersonianus (Lydekker, 1906)
  Taurotragus derbianus (Gray, 1847), below specified as „Derby eland“
    Subspecies: *Taurotragus derbianus gigas* (Heuglin, 1863), below as „Eastern Derby“ or „Eastern subspecies“
        Taurotragus derbianus derbianus (Gray, 1847), below as „Western Derby“ or „Western subspecies“

Additional notes:

Genus *Taurotragus* belongs to tribe *Tragelaphini* together with genus *Tragelaphus* (Grubb 2005). Sometimes (e.g. Estes, 1991; Van Gelder, 1977, IUCN 2008), genus *Taurotragus* has been incorporated in the genus *Tragelaphus*. Van Gelder (1977) mentioned another opinion on the taxonomy of genus *Tragelaphus* – in some cases, genus *Taurotragus* is integrated together with genus *Boocercus* as subgenus *Taurotragus* into genus *Tragelaphus*. This opinion is based on possible hybridization between Eland and Kudu (Van Gelder, 1977), specifically based on the documented hybridization between East African Eland (*Taurotragus oryx pattersonianus*) and Greater Kudu (*Tragelaphus strepsiceros*) in San Diego Wild Animal Park (Jorge et al., 1976). In general, *Taurotragus* is predominantly recognized as separate genus. It could be mentioned in this occasion, that breeding under the human control (zoos, reserves with unnatural sex ratios etc.) is not much informative (see Groves and Robovský, 2011). In general, captive breeding could cause unnatural hybridizations – from this point of view, it could be interesting that common and Derby elands did not produce hybrids despite several occasions under the human control (Estes, 1991).

Haltenorth (1963) reported descriptions of new subspecies without taking the variability in consideration. No wonder, that many subspecies (or so called races), are mentioned in literature, but more often they are considered as synonyms for one of the five mentioned subspecies. Those synonyms are mentioned e. g. by Grubb (2005) and Haltenorth (1963) – e. g. *billingae*, *kaufmanni* and *selousi* as synonyms for subspecies of common eland, *typicus*, *cameroonensis*, *congolanus* and *derbii* for subspecies of Derby eland.

The most recent taxonomical work, Ungulate taxonomy (Groves & Grubb, 2011), also recognized two species with *Taurotragus*, but no subspecies of Derby eland, albeit on very limited sample size, and only two subspecies of common eland (*oryx*, *livingstonii*).

2.2 Distribution and Conservation

2.2.3 Common eland

Kingdon (1982) and later Grubb (2005) recognized three subspecies of Common Eland – *Taurotragus oryx oryx*, *T. o. livingstonii* and *T. o. pattersoni (pattersonianus* – Grubb 2005*).*

Original range of *Taurotragus oryx* can be traced back to Pleistocene – refugium in southern Africa and also a mosaic of refugia in East Africa were indicated by Lorenzen et al. (2010), based on genetic data sets. In closer periods of time, the common eland was formerly widespread in Southern Savanna and adjoining parts of arid zones and in small parts in Northern Savanna in East Africa (Bigalke, 1968). It was distributed in Botswana, Congo, Kenya, Burundi, Lesotho, Ethiopia, Malawi, Mozambique, Namibia, Rwanda, South African Republic, Sudan, Swaziland, Tanzania, Uganda, Zambia and Zimbabwe (IUCN SSC Antelope Specialist Group, 2008). Dollman (1936) considered this species as extinct in the Cape Province, also it is possibly extinct in Burundi and Angola. It was already mentioned, that huge extinction in Kalahari was caused in 1980th by drought, but according to Dunham (1994), population increased again in 1988.

IUCN (2008) do not distinguish those three subspecies, because ranges and characteristics are poorly defined. Common eland is not endangered as Western Derby eland, but it´s original range of distribution has been also eliminated at least to half (IUCN SSC Antelope Specialist Group, 2008).

Common eland has a wide habitat tolerance and thanks to that fact, it can be found in large areas throughout East and South of Africa (Lorenzen et al., 2010). Kingdon (1982) states *T. o. oryx* in Southern and South-Western Africa, *T. o. livingstonii* in central woodlands and *T. o. pattersonianus* in East Africa. According to IUCN, population of common eland is stable and it is considered as Least Concern.

2.2.3.1 *T. o. oryx*

Cape Eland occurs in the southest range of *T. oryx* species. That includes Botswana, South African Republic and the adjacent part of Mozambique (Gentry, 1971).

2.2.3.2 *T. o. livingstonii*

Range of Livingstone´s Eland (Harper, 1945) includes Angola, Zambia, southern Congo, Malawi and Rhodesia (Zimbabwe), also can be seen in southwestern Tanzania (Dorst and Dandelot, 1970).

2.1.3.3 T. o. pattersonianus

This subspecies occurs north of *T. o. livingstonii* range, from central Tanzania through Kenya, westwards to Rwanda and Uganda (Dorst and Dandelot, 1970). Both „*livingstonii*“ and „*pattersonianus*“ are distributed in Mozambique (Gentry, 1971).

2.2.4 Derby eland

Derby eland is Northern Savanna species (Bigalke, 1968). Dollman, 1936, mentioned range of distribution of the whole species from Lado in the Sudan (East) to Senegambia (West). There is possibility, that the species recently occured at all of mentioned range, but had been reduced to limited distribution at two separated ranges (Gentry, 1971).

Two subspecies are now distributed in these reduced ranges, *T. d. gigas* and *T. d. derbianus*.

2.2.4.1 *T. d. gigas*

This subspecies was formerly distributed in the southwestern part of zone of savanna woodland (East, 1998).

The Eastern border of original range of *T. d. gigas* is in Nigeria – extreme eastern limit is the White Nile. On the North, *T. d. gigas* occured in part of Chad beyond 11°N, in Sudan it´s distribution did not exceed Bahrel-Arab (9°N). Southest occurence was in northern Congo and South-western Uganda (Gentry, 1971). The distribution can be summarized in Cameroon, Central African Republic, Chad, Nigeria, Sudan, Uganda and Democratic Republic of Congo. Over 50% of population died during riderpest outbreak in 1982 – 1983 (East, 1998).

Chad population was about few thousands in 1950th. In 1986, according to observations and the fact, that no Derby eland was observed for several years, it was considered as extinct in this area. East (1998), mentioned whole number of individuals of this subspecies – up to 10 000.

Today, Eastern Derby Eland´s range includes Cameroon, Central African Republic, Sudan and Democratic republic of Congo – the Garamba National Park. Over last 20 years, population seem stable or increasing (Bouché et al., 2009). According to IUCN, *T. d. gigas* is considered as Least Concern and its population is estimated about 15 000 individuals (IUCN 2008).

2.2.4.2 *T. d. derbianus*

The Western subspecies of Derby eland, *Taurotragus derbianus derbianus*, was distributed from Senegal to Northern Nigeria (Dorst and Dandelot, 1970), west from southwestern Mali (Gentry, 1971). Formerly in was ranged through Senegal, Gambia, Guinea-Bissau (Portuguese Guinea), Guinea, Mali and North Ivory Coast (Prince Philip and Fisher, 1970). Dollman (1936) recognized *T. d. derbianus* to be endangered.

In 1970, Prince Philip and Fisher stated *T. d. derbianus* practically extinct in Gambia, in great danger caused by hunting pressure in Mali. Animals, which were seen in Guinea-Bissau in 70th were probably only wandered from Senegal and the populations in Guinea-Bissau and Guinea were considered as extinct. In Ivory Coast was *T. d. derbianus* noted as absent in 1962 (Gentry, 1971). The population in Senegal was of the order of 180, large in Niokolo Koba National Park. Few surviving populations have been lately identified in region of Haut-Bafing and Bakoy on the Senegal/Mali/Guinea border (Prince Philip and Fisher, 1970). Gentry (1971) reported range of *T. d. derbianus* to west from southwestern Mali.

According to Nowak and Paradiso (1983), *T. d. derbianus* was considered as Endangered in 1976.

According to East (1998), in 90th was *T. d. derbianus* distributed in Niokolo Koba National Park, located in South-eastern Senegal (area about 8 113 km^2 - Darroze, 2004), in Falema (Falémé) river area (across Mali/Guinea border) and between Casamance and Gambia River. Total population of this subspecies was about 1,000 individuals, 700 - 800 of them in NKNP.

East (1998) also reported *T. d. derbianus* as rare, but not endangered species, because it´s population in NKNP increased in last 20 years (from 1970th to 1990th). However, population in Falema area was by the same author considered as declining and threatened with extinction (East, 1998).

In 2004, other possible occurence was mentioned by Darroze (2004) in Falema River area (between rivers Falémé and Bafing). According tohis research, Western Derby eland was well-known by local populations and meat and tails still used for traditional ceremonies. Several reports were appeared - few animals were killed by hunters in North-eastern Guinea in Nabour area (about 20 km from Guinea/Mali border) in 2001, year later, young bull was shot in Mali near Bafing reserve (now Parc National du Bafing) and two other animals were killed in North-eastern Guinea.

Today, only viable population of wild Western Derby Eland can be found in Niokolo Koba National Park in Senegal (Koláčková et al., 2011). It is listed in IUCN as Critically Endangered (IUCN 2008).

2.3 Habitat

In general, elands are most adaptable ruminants (Estes 1993). They tolerate high solar radiation and high seasonal air temperatures (Maloiy, 1973), inhabiting subdeserts, miombo woodlands, acacia savannas, grasslands and also mountain habitats. Only habitat types they avoid are deserts, swamps and forests (Estes, 1991).

Elands are primarily savanna ungulates, often mentioned as open habitat antelopes (Scott, 1985). However, they are highly migratory (Kinyua, 1998) and according to Boshoff et al. (2002), elands can be found on plenty of types of habitat – depends on seasonal migration, elands occur from thicket savannas trough bushlands to riverine woodlands.

During wet season, elands occur frequently in short grass savannna areas, during dry season, elands prefer areas with tall grass and they are even noticebly avoiding of savannas (Van der Walt et al., 1984).

Derby eland is more often distributed in woodland and forest savannas, which are interspersed with stones (Dorst and Dandelot, 1970). Kingdon (1982) mentioned Derby eland as species tied to the woodland habitat. Common eland occurs in open plain areas and savannas, according to Lamprey et al. (1963), they choose the most open area. Common eland also prefers montane grasslands, light forests and highland forests. Dorst and Dandelot (1970) stated average altitude up to 4,200 m (14,000 feet). Guest and Leedal (1945) mentioned common eland (subspecies *Taurotragus oryx patterosonianus*) as one of the most widely distributed and most abundant animals on higher parts of Kilimanjaro – they were recorded in altitude 4,900 m (16,000 feet).

In summary, differences can be found between species, but there are not any differences known between subspecies.

2.4. Food

As a typical bovids, both elands (Derby eland and common eland) are herbivors. Hofmann and Stewart (1972) classified them as intermediate feeders, more often they are classified as grazing-adapted browsers (Watson and Owen-Smith, 2001). Feeding on grass mainly occurs during the rainy season (Dorst and Dandelot, 1970), when grasses are plentiful (Pappas, 2002), especially in montane habitat (Dorst and Dandelot, 1970). During rains, their diet consists of 50 – 80% of green grass (Estes, 1993). In semi-arid shrubland, ratio in annual diet has been discovered as 96% of browsing and 4% of grazing (Watson and Owen-Smith, 2001). Generally, they eat mostly leaves (even the oily mopane leaves – Dorst and Dandelot, 1970) and shootes and they select browse on low fibre content (Watson and Owen-Smith, 2001).

They feed also on seeds, seedspots (Estes, 1993) and certain fruits, even wild melon. Sometimes they dig with hooves for tuberous roots (Gentry, 1971). They also use horns to facilitate browsing – when branches are too high for comfort feeding, elands can catch them between horns and break (Burton, 1970).

Unlike other antelopes, elands do not congregate around water sources (Kingdon, 1988). They are water – independent animals, but in case when it is plentiful, they drinking regularly (Dorst and Dandelot, 1970). Also in dry conditions, the water intake is relatively low and elands are able to survive practically without drinking – they obtain most of water from their diet (Skinner and Chimimba, 2005). They also can excrete concentrated urine and dry feces (Mares, 1999). In use water-conservation measures by letting their body temperature rise for 7°C (Skinner and Chimimba, 2005).

Differences in diet between species and subspecies are not known.

2.5 Behaviour

Activity of elands is extremely variable, depends mainly on local conditions (Estes, 1993) and forage of food. Elands occur in cool climate eat and ruminate for all day and continue at night until ca. 2:00 am. Then they relaxing for about 4 hours, starting their daily actvity in early morning (Estes, 1991).

In contrast in a hot climate, during dry season, elands spend most of the day in shelter and feed the whole night (Estes, 1991). In mean conditions, they are active mostly in the morning and late evening. Rest of the day they spend in shade, avoiding day heat (Dorst and Dandelot, 1970). E. g. common eland in South Africa shows 4 phases of daily activities. First, they feed, ruminant and walk in early morning, then in the afternoon they feed and ruminant for 2 hours and after that they walking and browsing. This period is followed by long inactivity includes lying. Fourth phase of the day is walking back the way they came (Estes, 1991).

Theodore Roosevelt described elands as „the easiest of big game to ride down on horse back“, liken to Texas cattle. Elands are often considered as the slowest antelopes, they galop only when they are frightened (Estes, 1991). According to Estes (1993), their speed is up to 40 kmh and they get tired very quickly, but Nowak and Paradiso (1983) reported maximum speed at least 70 kmh.

Elands are good high-jumpers (Estes, 1991). They have incredible power of leaping – from almost a standing start, they can jump over another individual (Dorst and Dandelot, 1970) as a display of their prowess (Estes, 1993). Also youngsters can jump over 3 m fence (Estes, 1991).

Elands are animals with rarely display of agressiveness. For advertising dominance, males ground-horning in soil, mud, vegetation and various smelly substances (Estes, 1993). Most important and common is horning in urine – especially in their own, or in urine of other antelope or other species (e. g. elephant) (Kingdon 1982). Dominant animals also exhibit their social position by clicking sound. This castanets-like sound is produced in foreleg joints or tendons (Estes, 1993) and in still night it can be heard for hundreds meters (Estes, 1991). According to Bro-Jørgensen and Dabelsteen (2008), the dominant frequency of clicking is indicated by body size, as a main determinant of ability to fight. Bro-Jørgensen and Dabelsteen (2008) also reported, that darkness of facial mask and size of frontal tuft can be presumed as indicators of androgen-related agression.

Fights, which occurs in connection with mating can be rather ritual (Burton, 1970). But also fights happen between low-ranked males or in case of disturbance of other male´s home range. Hierarchy was observed not only in males, but also in all-females herds. Kingdon (1982) reported, that in case when herd was attacked by cheetah, low-ranked female was forced on the periphery of group.

Elands are quite shy (Bouché et al., 2009) and they are rather silent (Dorst and Dandelot, 1970). Some sound-displays occurs in mother – calf communication – Estes (1991) liken this sound to the sound of slowly opened squeaking doors. Also alarm sound, typical for Tragelaphini, can be heard (Estes**,** 1991). Estes (1993) defined it as loud, gruff bark.

Sense of sight seems poor, contrary to excellent hearing and smell (Dorst and Dandelot, 1970). Last mentioned sense is probably important not only in displaying of dominance by male, or in oestrus of female, but according to Kingdon (1982), skin on forehead may secrete scent, produced by glandular activity. That may help to familiarized calves with their mother´s odure.

The behaviour seems to be identical or very similar for both species and their subspecies (Estes, 1991; Kingdon, 1982).

2.5.1 Social systems

Elands are gregarious animals. They live in large herds, number of individuals is affected by local conditions and distribution. Derby elands occur usually in herd of 15 – 25 heads (Lydekker, 1908), up to 60. Common elands can be seen in herds of few individuals (Dorst and Dandelot, 1970) up to 500 (Estes, 1993), occasionaly in larger herds – especially during period of severe drought or during migration (Dorst and Dandelot, 1970). They also may be assemble with zebra, roan antelope, gemsbok (Gentry, 1971), rarely with giraffe (Harrison, 1936).

Largest groups of elands always contain calves and juveniles, in small groups are only adults. Count of animals in group is also affected by season – in open grasslands in wet season can be seen largest herds of several hundred antelopes, in dry season in forest they occur in small groups (Hillman, 1975).

Males live solitary or in small groups, females and juveniles create large agregations (Nowak and Paradiso, 1983). Size of the home range vary with sex – male elands often have limited home ranges, while females and subadults perform extensive seasonal movements between open habitats and bushed areas (Hillman, 1975).

Home ranges of females and subadults are large, e.g. on the area of Athi Plains from 174 km^2 to 422 km^2, bulls ranges from 13 to 60 km^2 (Estes, 1993), according to Nowak and Paradiso (1983) 6 – 71 km^2.

Young calves stay together, never far from adults. Distance increases with age and horn developement. Thanks to attraction between calves, the largest herds are created – calves mix, forming the nucleus which is rounded by mothers and the rest of herd (Estes 1993).

In summary, the social systems are also very similar, maybe except for smaller group size in Derby eland.

2.5.2 Reproduction and ontogeny

Eland females reach sexual maturity in 2,5 years of age, males in 4 years (Pappas, 2002). Females regularly mate for the first time at the age of 3 (Burton, 1970). Estrus lasts 3 days (Estes, 1993) and occurs at 21 – 26 days intervals (Posselt, 1963).

They have non-territorial mating system. Courtship displays involve following the female, licking and tries to rest chin to female´s rump. During this activity, the dewlap comes to direct contact with root of female´s tail or even with vulva. According to this, Kingdon (1982) suppose tactile importance of dewlap.

In spite of the fact, that elands can reproduce any time during the year (Pappas, 2002), mating and calving occur with definite peaks (Estes, 1991). Majority of births happens during wet season, from May to November (Kingdon, 1982). According to Pappas (2002), peak calving months are from August to November, Kingdon (1982) stated peak between July and September. Also there is a case from 1955 from area of Kidepo (North of Equator), where calves were born in January and February (Kingdon, 1982).

Female gives birth to usually 1 calf, rarely can have 2. Parturition commonly takes place during the night (Shorrock, 2007).

Oestrus of some females comes very soon after calving, but according to Pappas (2002) only 1 of 8 females conceived in this short period. The shortest calving interval can be 10 months. Generally 83% of females calved each year. New-born calf weighs 22 – 30kg and it stands shortly after the birth (Kingdon, 1982). Calf remains hidden in bush cover for two weeks, always close to his mother (Shorrock, 2007). In age of two weeks it joins the nursery. It is weaned usually twice a day, suckling takes about 3 minutes (Kingdon, 1982). Calf is feed by his mother usually for 6 months (Underwood, 1979).

Calves grow very fast, in the age of 1 year, male can weigh more than 450 kg. Horns also grow rapidly, but up to 6 month they are soft and easily deformed. Mortality of young elands is very high, it is cause not only by predators, but also by diseases and accidents (Kingdon, 1982).

Reproduction and ontogeny seems similar for both species, although more informations are known about Common eland. No differences are reported in reproduction and ontogeny between subspecies of Common or Derby eland.

Differences in suckling behaviour of Derby elands under semi-captive conditions and common elands under farm conditions were researched and compared by Hejcmanová et al. (2010). In observed differences (Derby elands had longer suckling bouts in male than female calves and shorter suckling bouts in primiparous mothers than multiparous ones; no differences were found in farmed Common elands) there is, unfortunately, known a portion of captive and inherited factors.

2.6 Morphology

2.6.1 Basic description of elands

The whole subfamily Bovinae can be characterised by horns longer than the face and spiraly twisted (Sclater and Thomas, 1899). Elands are large spiral-horned antelopes, often considered as the biggest antelopes of the world (Dollman, 1936).

According to Roosevelt (1911), coloration of body is countershaded, but not very protective. Especially when elands occur in open habitat, they can be seen for at least a mile away (Roosevelt, 1911).

General colour of short and smooth coat (Haltenorth and Diller, 1980) of elands in not very variable – usually, they have brown fawn colour, with greyish tint on the forequarters (Haltenorth, 1963). Body of subspecies of Derby and Common eland are marked with varying numbers of white transverse stripes, except Cape Eland (*T. o. oryx*) (Haltenorth, 1963). Number of stripes in genus *Taurotragus* is between 2 and 15 (Haltenorth and Diller, 1980). The stripe pattern can be different on each side of the body and it is unique for each animal (Hillman, 1975).

Elands show common signs of modification by the large body size. They have short and robust neck, also their legs are shorter. Those signs give them the typical bovine look. In comparison to other bovine species, e.g. cows or buffalos, they are taller and more agile (Kingdon, 1982). In most of subspecies of both species, black patch under the knee can be found (Harper, 1945).

The thing that reliably separate genus *Taurotragus* from other relative genera, with the exception of the bongo (Dollman, 1936), is fact that horns, clearly visible at birth (Skinner and Chimimba, 2005), are presented in both sexes (Sclater and Thomas, 1899).

Colour of horns is grey, almost black (Haltenorth, 1963), cores are twisted and spiraled (but less spiraled than in genus *Tragelaphus*) (Gentry, 1971) mostly in basal half (Sclatter and Thomas, 1899). They are directed upward and outward (Ward, 1910).

Another simple sign is a flap of loose skin or dewlap on their necks (Sclater and Thomas, 1899). Haltenorth and Diller (1980) characterized genus *Taurotragus* as ox-size antelopes with small hump on withers.

A short dark mane is presented on the neck and on the withers. On the back, from withers to the tail, is a narrow black spinal stripe (Haltenorth, 1963; Dorst and Dandelot, 1970). Tail is long, reaching to the hocks (Haltenorth, 1963; Dorst and Dandelot, 1970), covered with short hair and tufted in the end (Sclater and Thomas, 1899). As typical bovids, elands have shorter legs, with large lateral hooves. Hinder pair of hooves has glandural hair pad on the inner side (Haltenorth, 1963). Kingdon (1982) explained bigger size of forehooves by concentration of weight on forequarters.

As a disproportion to the great body size is the size of mouth and muzzle – it is small and pointed. Also the teeth and jaw muscles are smaller than in other bovine species like e. g. cattle or buffalo (Kingdon, 1982).

2.6.1.1 Sexual dimorphism

Sexual dimorphism is settled by massiveness in males (Sclater and Thomas, 1899). Females are noticebly smaller and lightly built, with lighter horns, which can be shorter or longer in particular species (see below) (Dorst and Dandelot, 1970). Dewlap in the neck area is presented in both species and in both sexes – usually it is more distinct in males, especially in older indiviaduals (Haltenorth and Diller, 1980). Dewlap in female common elands is smaller and placed further the neck (Kingdon, 1982).

Males can achieve weight almost twice as big as females. Males continue increasing their weight for a very long time. In adulthood, neck and shoulders of male get dark and more robust and also the horns are growing and become more massive (Kingdon, 1982).

Dominant males, as mentioned before, can be distinguished by clicking sound (Estes, 1991; Estes, 1993; Bro-Jørgensen and Dabelsteen, 2008).

In males of common eland, forehead is covered by mat of long hairs (Dorst and Dandelot, 1970).

2.6.2 Differences between species

Kingdon (1982) considered Derby eland as possible directly ancestral animal, or at least derived from more primitive type than common eland, albeit without any additonal arguments.

General colour of Derby eland is more reddish (Haltenorth, 1963) - chestnut or ruddy fawn, with age turning to bluish grey. Colour of common eland is fawn or sandy, also turning to grey with age as in Derby Eland (Haltenorth and Diller, 1980; Caro, 2005). Skinner and Chimimba (2005) gave reason for changing the colour in old animals as consequence of loosing hair and showing the dark skin throught the coat. In both species, lower parts are nearly white, with black stripe in the middle of belly in Derby Eland (Harper, 1945).

Derby Eland is also characterised by the presence of numerous white stripes than common eland. Also in common eland, the stripes are less conspicuous (Dorst and Dandelot, 1970). Number of stripes in common eland up to 10 (Dorst and Dandelot, 1970) or from 2 to 15 (Haltenorth and Diller, 1980). The average number in Derby eland is 14 or 15 (Ward, 1910; Dorst and Dandelot, 1970).

According to Gentry (1971), horns in *T. oryx* are shorter (less than twice head lenght) and slightly diverging. Kingdon (1982) stated, that horns of common eland male show strenght, which is tested directly in twisting and pushing during fights. In comparison, horns of *T. derbianus* are longer (up to about twice head lenght), distinctively more diverging and more massive (Dorst and Dandelot, 1970). Horns of Derby eland females are shorter and more slender than male horns, in comparison to horns of females of common eland, they are more strongly twisted and crested (Sclater and Thomas, 1899).

As mentioned before, horns are presented in both sexes, horns of females in common eland are usually longer and lighter. Short, massive horns of male common eland measure about 54 cm, horns of females 60,5 cm (Estes, 1991). According to Kingdon (1982), proportions of horns of common eland are from 60 to 102 cm. Lenght of horns of Derby eland is specified e.g. by Estes (1991) – the average lenght is about 100 cm, but it can reach around 120 cm. According to Harper (1945), average lenght of horns of Derby eland is around 920 cm (361 in). Kingdon (1982) mentioned the horns lenght from 80 to 123 cm.

Groves and Grubb (2011) recognized the horns of the Derby eland to be very much larger – thicker at the base, longer (absolutely so in the case of the males) and more divergent in the Derby eland, and mentioned also differences in size of skulls. Males of common eland are very slightly larger than males of Derby eland. On the contrary, females are slightly larger in Derby eland.

Nose of Derby Eland is black, sides of head are dusky brown. In front of each eye is whitish stripe and lips and chin are also white (Harper, 1945). In the common eland, no white spot on cheeks is present (except for *T. o. pattersonianus* – see below), in Derby eland, large white spot on each cheek can be found (Haltenorth, 1963).

Males of common eland have mat of hairs on the forehead. Hair on the forehead of Derby eland has moderately different colour than the rest of head, but never create a dense mut as in common eland (Kingdon, 1982). The hair on the forehead and nose of common eland from time to time change lenght and colour from sandy short hair to long chestnut or even black hair (Kingdon, 1982). Mat of hair is often matted and, owing to secretion of glandular region in the skin on the base of the mat, it often has a strong smell (Skinner and Chimimba, 2005).

In Derby eland, a short dark mane on neck and withers is darker than in common eland (Dorst and Dandelot 1970). According to Lafleur et al. (2003), the hump on whithers lay more backwards in common eland.

Ears of common eland are narrow and pointed (Ward, 1910), dark bar on the inside is missing (Gentry, 1971). Ears of Derby eland are large (Harper, 1945), rounded and broader

(Dorst and Dandelot, 1970; Gentry, 1971; Ward, 1910), with more black on the back (Lydekker, 1908), marked with white and brownish (Harper, 1945).

Colour of the neck of *T. oryx* is similar to coloration of animal´s body, coloration of Derby eland´s neck is darker on sides (Gentry, 1971), separated from body by white collar at its lower part (Dorst and Dandelot, 1970).

Dewlap in common eland is commercing on the throat (Gentry, 1971) and it is present only along the throat (Dorst and Dandelot, 1970). In Derby elands, dewlap commencing farther forward – just behind the chin (Dorst and Dandelot, 1970). There are two tufted points on dewlap of Derby eland, one just behind the jaw and the second one at the chest level (Kingdon, 1982).

2.6.2.1 Height and weight

Height in withers of Derby eland is, according to Dorst and Dandelot (1970), 175 cm (69 in), according to Kingdon (1982) from 150 to 176 cm in males and approximately 150 cm in females. Common elands are according to Dorst and Dandelot (1970) moderately bigger – about 178 cm (70 in). Shorrocks (2007) mentioned height of common eland up to 170 cm in males and 150 cm in females, according to Estes (1991), the average height of males is 160 cm (151 – 183 cm), height of females is 142 cm (125 – 153 cm).

Kingdon (1982) mentioned the tail lenght of both species - Derby Eland: 55 – 78 cm, and Common Eland: 54 – 75 cm. According to Kingdon (1982), average body lenghts of elands are: 290 cm in males and 220 in females of Derby Eland, 250 – 340 in males and 200 – 280 in females of common eland.

Derby Eland is also known as Giant eland. This common name used to be misunderstood – the world „giant“ did not advert to whole body size – Derby Eland does not exceeds common eland in size or weight (Bigalke, 1968). Derby elands are characterised not so much by the great body size, as by the size of horns (Dollman, 1936; Estes, 1991; Groves and Grubb, 2011).

Weight of elands varies greatly – it depends on genetic make-up and also on grazing and browsing conditions (Keep, 1972). Kingdon (1982) mentioned approximate weight of female Derby eland about 440 kg and weight of males from 450 to 907 kg. Weight of common Eland varies from 700 to 900 kg in males, females weight is about 450 kg (Shorrocks, 2007). Kingdon (1982) stated approximate weight of common eland males from 400 to 942 kg and weight of females from 390 to 495 kg. The mean weight of domesticated males of the common eland, measured by Keep (1972), was 442 kg and the mean weight of females 265 kg. Wilson (1969) measured weight of *T. o. livingstonii* – average weight of bull was 604 kg (504 – 690 kg) average weight of female was approximately 445 kg (390 – 470 kg).

2.6.3 Differences between subspecies

2.6.3.1 *T. oryx* subspecies

According to Gentry (1971), three subspecies of common eland can be differenciated, also Kingdon (1997) mentioned three subspecies, distinguished by coat colour and number of stripes. Also fourth subspecies, *T. oryx selousi* is mentioned by Ward (1910), and Lyddeker (1914), described it based on an incomplete white chevron below the eyes with well developed frontal tuft in adult males. Gentry (1971) stated this subspecies distinguished only by presence of facial chevron, which seemed to be appearing individualy and possibly seasonaly.

Groves and Grubb (2011) reported only two subspecies of common eland – *T. o. livingstonii* and *T. o. oryx* based on the exterior and skull measurements.

T. o. oryx, the Cape Eland, was described by Ward (1910) as the largest subspecies. It can be easily recognized by absence of white stripes in adults and lighter colour of body (Dorst and Dandelot, 1970). According to Roosevelt and Heller (1914) offsprings of this subspecies are showing ancestral stripes. Another recognition sign is absence of black patch on the back of forelegs (Skinner and Chimimba, 2005).

Skinner and Chimimba (2005) specified for *T. o. oryx* body colour as dull fawn, Harper (1945) as rusty sienna-yellow with under-parts pale cream-yellow, forehead yellowish brown and brownish red in the middle of cheek under the eyes. Sides of the head are according to Harper (1945) creamy white and also the mane is lighter than in other subspecies – it is thin and brownish yellow.

T. o. livingstonii, named after Irish doctor and missionary David Livingstone (Beolens et al., 2009), possesses stripes which varies from 6 to 12 in number (8 – Lyddeker, 1914). Its body colour is deeper than in Cape Eland (Dorst and Dandelot, 1970). Hill (1942) recognized colour of the body as variable between greyish sayal brown and bright cinnamon. According to Skinner and Chimimba (2005), this subspecies is dun-coloured and number of stripes varies with the area of occurence – in Botswana, individuals with 1 or 2 stripes can be found and further North, in Zambia, the number of stripes is approximately 7. Hill (1942) reported, that stripes were missing in some observed animals.

Black mark on legs is mostly absent, or indistinct (Skinner and Chimimba, 2005). According to Hill (1942), the mane in some individuals is just slightly darker than the neck, but in some cases it could be even fuscous. The tuft on the forehead has slightly greyish colour than the rest of the body (Hill, 1942). Two individuals with white mark in front of the eye have been observed by Hill (1942).

In both above mentioned subspecies, no white suborbital streak is presented (Harper, 1945). According to Groves and Grubb (2011), both subspecies have larger teeth. Skull of *T. o. oryx* is larger than skull of *T. o. livingstonii*, which has, on the other hand, longer and more diverging horns.

T. o. pattersonianus possesses also stripes and its coat colour is more rufous than in other subspecies and incomplete white chevron is presented on the forehead of males (Dorst and Dandelot, 1970). East African eland, also known as Patterson´s eland, was discovered by Colonel J. H. Patterson (Patterson, 1907). Lydekker (1914) described this subspecies as pale rufous fawn. Number of stripes on each body side is from 3 to 5 (Lydekker, 1914) in southern part of its range and up to 15 in northern part (Haltenorth and Diller, 1980). Frontal tuft is according to Lydekker (1914) fully developed and on the forehead of adult males can be found a narrow median brown stripe above the eye. The black patch on forelegs is presented in this subspecies (Harper, 1945) and neck is noticebly more rufous than body (Lydekker, 1914).

Groves and Grubb (2011) mentioned skull of East African eland sligtly smaller in teeth and shorter in horns of females.

This subspecies is very interesting, because it possesses some characters somewhat intermediate between common and Derby eland or even much closer to the Derby eland (Patterson 1907). Specifically these charactes exhibit this pattern: a) an incomplete white stripe ran from the lower corner of each eye – altough it is smaller, it is similar to those in Derby eland (Patterson, 1907); b) black patch on the forelegs (Patterson, 1907); c) white spot on cheak (less distinct than in Derby eland) (Haltenorth, 1963).

Otherwise, its head coloration (sides of head are reddish, brown patch on the lower part of the face) is larger than in other subspecies of the common eland - Patterson, 1907) and e.g. mat of hairs in the forehead connects this subspecies with other common eland subspecies (Harper, 1945; Lydekker, 1914).

2.6.3.2 *T. derbianus* subspecies

Two subspecies of Derby eland are usually recognized (e. g. Grubb, 2005). Groves and Grubb (2011) reported no difference between both subspecies and according to them, all Derby eland would be taxonomically the same, albeit their samples were very small.

Dollman (1936) and Dorst and Dandelot (1970), also recognized third subspecies of Derby Eland – *Taurotragus derbianus congolanus*. Dorst and Dandelot (1970) described this subspecies as the biggest one, with horns even longer than *T. d. gigas* (record 441 in – 1,120 cm). Harper (1945) defined the coat of „Congo race“ as lighter than in other subspecies. But more authors and based on all acumulated new evidence tend to consider *T. d. congolanus* as conspecific with *T. d. gigas* (Grubb, 2005).

According to Dorst and Dandelot (1970), subspecies of Derby Eland can be distinguished by coat coloration – coat of Western Derby eland is deep chestnut or rufous with about 15 white stripes (Lydekker, 1914; Kingdon, 1997). Coat of Eastern subspecies is paler (Lydekker, 1914) – it has sandy ground colour (Dorst and Dandelot, 1970; Kingdon, 1997) and number of stripes is lower – from 9 to 12 (Kingdon, 1997). Lydekker (1914) described adult male of *T. d. gigas* as eland with sides of head from light grey to pale fawn. According to Lydekker (1914) and Haltenorth (1963), white spot on cheek is round in *T. d. gigas* and elongated in *T. d. derbianus*. Sides of head of *T. d. derbianus* are according to Lydekker (1914) dusky brown.

Horns of Eastern subspecies are (according to Dollman, 1936) longer than horns of Western subspecies. According to Lydekker (1914), lenght of horns in *T. d. derbianus* is from 76 cm (30 in) to 107 cm (42 in), the span from 38 cm (15 in) to 74 cm (29 in) and the basal circumference from 23 cm (9 in) to 36 cm (14 in). Lydekker (1914) measured average lenght of *T. d. gigas* from 89 cm (35 in) to 105 cm (41 in), Dollman (1936) mentioned lenght of this subspecies up to 112 cm (44 in). The basal circumference ranges from 30,5 cm (12 in) to 35,6 cm (14 in) with the span from 48 cm (19 in) to 84 cm (33 in) (Lydekker 1914).

Lenght, circumference and tip-to-tip measurement of trophy horns of Western (N=15) and Eastern (N=137) subspecies were also measured by Ward (1910). Lenght of horns was 81.92-94.94 cm in Western and from 96.52-123.8 cm in Eastern subspecies, circumference 33.02-35.88 cm in Western and 32.07-34.93 cm in Eastern and tip to tip 59.06-71.12 in Western and 72.08-88.27 cm in Eastern subspecies. So, lengths of horns and tip to tip indicate differences at the species level, because their spectra do not meet for obtained values.

For photos of all subspecies, see Appendices (Appendix I).

3 Material and Methods

3.1 Material

Measurements were taken mostly in museum collections. Specifically, I visited three large European museums – Berlin, London and Paris.

In Museum für Naturkunde (Berlin), 88 specimen (7 of *T. derbianus* and 81 of *T. oryx*), were examined. In few specimens, subspecies were already settled, in others (where it was possible), subspecies were identified according to specific location. In some specimens, it was impossible to settle up the subspecies (unknown location, or located in area, where more subspecies were found).

In Muséum National d´Histoire Naturelle (Paris), 16 skulls of *T. oryx* with unidentified location and one complete skull of *T. derbianus* (also with unidentified location or subspecies) were measured and just few possible measurements were taken on practically destroyed fragments of skull of *T. d. derbianus* (identification of subspecies was based on location – Senegambia).

In Natural History Museum (London), measurements were done for 45 specimens. 34 of them were skulls of of *Taurotragus oryx*, 8 skulls of *T. d. gigas* and 1 skull of *T. d. derbianus*. Also measurements were provided on head of *T. d. derbianus*. This specimen has skin and ears and because of that, measures were taken only from horns and few parts of exposed bones (occipital condyles and teeth).

6 pairs of horns were measured in Senegal during transfer of Derby Elands from one reserve to another (in pursuace of Conservation Programme of Western Derby Elands). Those data were measured on adult animals in years 2006 and 2007.

One skull of the male of *T. d. derbianus* was measured in Fathala Reserve in Senegal and 4 skulls of *Taurotragus oryx* were measured in CULS (CULS Farm Estate in Lány).

Inventory numbers of analyzed specimens are mentioned in Appendices (Appendix II).

3.2 Methods

My thesis deals with skull measurements based on my previous literature survey.
Measurements of skull are based on the monography by von Driesch (1976). This classical monograph „A guide for measurement of animal bones from archeological sites“ provides many standard measurements for archaeozoological and zoological studies and it is probably the best solution. Measurements of horns were taken according to the Lister and Bastos-Silviera (2007) and the second way for horn measurements followed horn measurements provided for 10 years in Senegal during transports of Derby Elands.

List of measurements (see also pictures below):

Splanchrocranium:

1.Total length = profile length: akrokranion -> prosthion
2.Condylobasal length: aboral border of the occipital condyles -> prosthion
3. Basal length: basion -> prosthion
4. Premolare -> prosthion
5. Viscerocranium length: nasion -> prosthion
6. Median frontal length: akrokranion -> Nasionnasion
7. Breadth across the premaxillae on the oral protuberances
8. Lateral facial length: ectorbital -> prosthion
9. Prosthion -> infraorbitale
10. Dental length: postdentale -> prosthion
11.a Greatest inner length of the orbit Ect -> Ent, 11b = vertical length of the orbit
12. Greatest breadth between external auditory meatus
13. Greatest breadth of occipital condyles
14. Greatest breadth of paraoccipital condyles
15. Less frontal breadth (between horns)
16. Breadth between orbits, 16a= greatest breadth, ectorbital -> ectorbital, 16b= smallest, entorbital -> entorbital
17. Facial breadth
18. Cranium height
19. Lenght of cheektooth row (along alveoli)

20. Lenght of premolares
21. Lenght of molares
22. Greatest and smallest height of M1 (attrition)
23. From the aboral order of occipital condyle to of the same side
24. Least occipital breadth: the distance between the most media points of the temporal grooves
25. Greatest breadth between cheekrows
26. Staphylion -> prosthion
27. Otion -> otion
28. Zygomatic breadth: zygion -> zygion
29. Greatest breadth across the nasals
41. Staphylion -> occipital condyles

Mandibula:

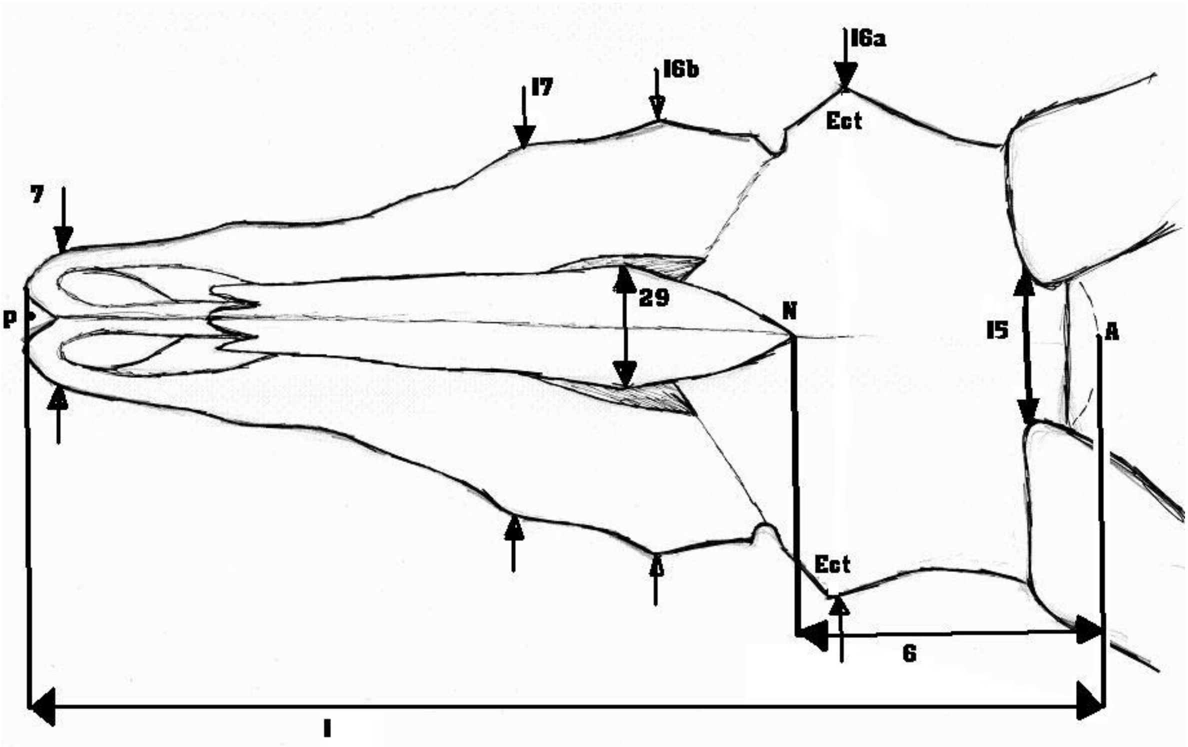
30. Height (greatest)
31. Height (smallest)
32. Lenght of cheektooth row
33. Lenght of molares
34. Lenght of premolares
35. Total lenght
36. Lenght of diastema

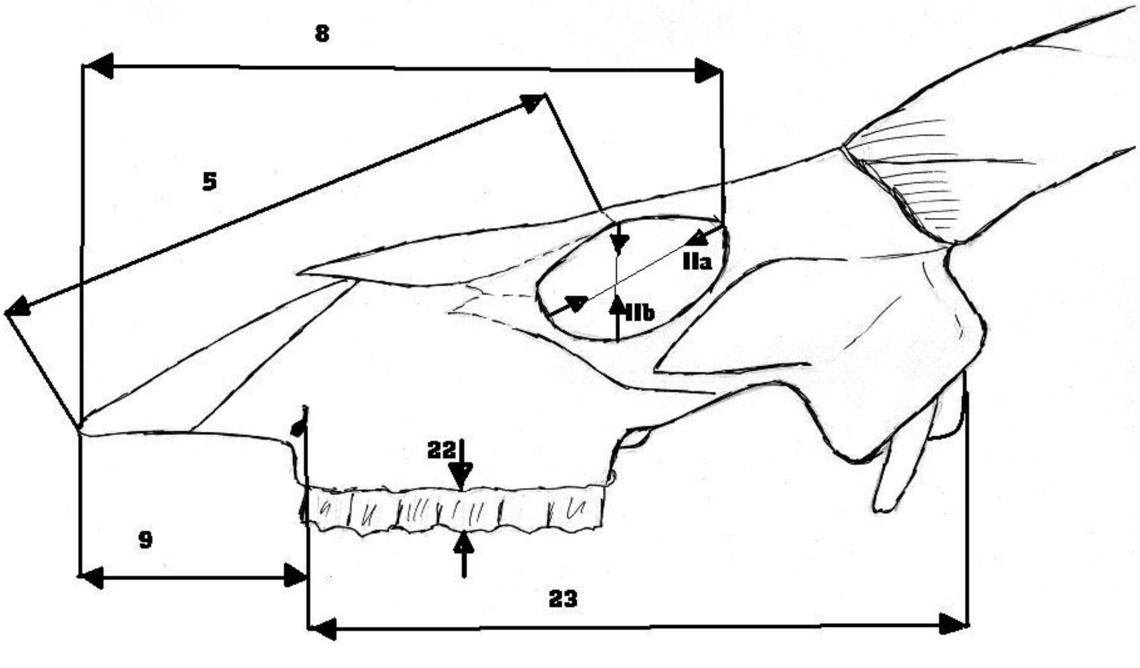
Horns:

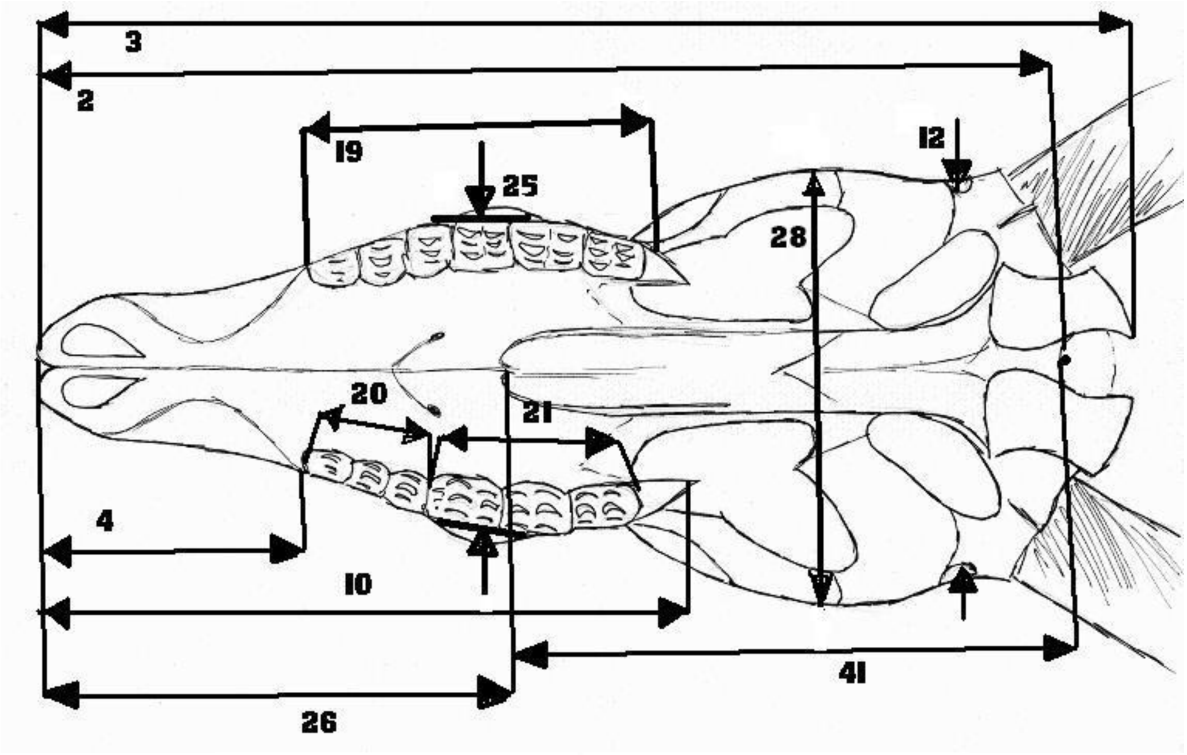
37. Total lenght
38. Lenght – along first spiral
39. Tip-to-tip (span)

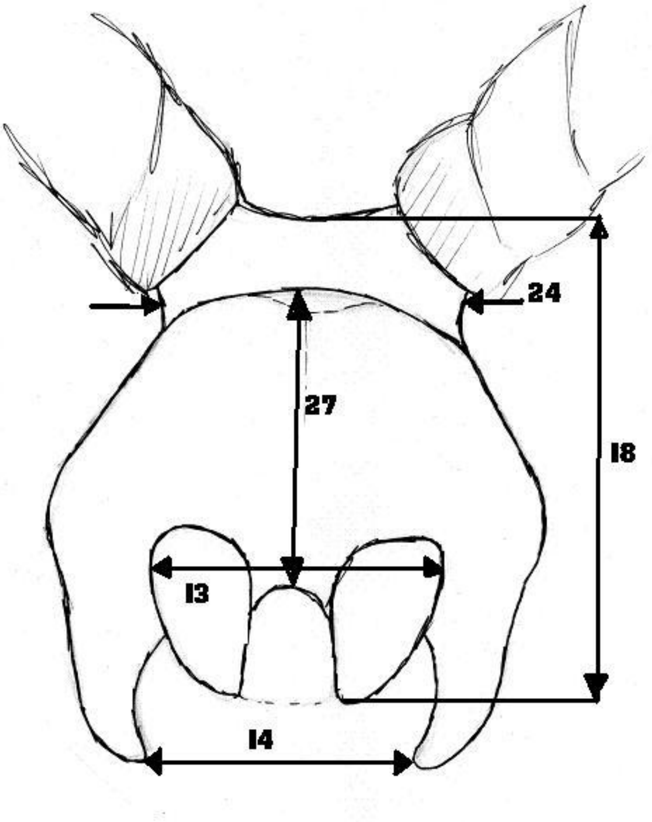
40a. = circumference without contour, 40b = circumference with (along) contour

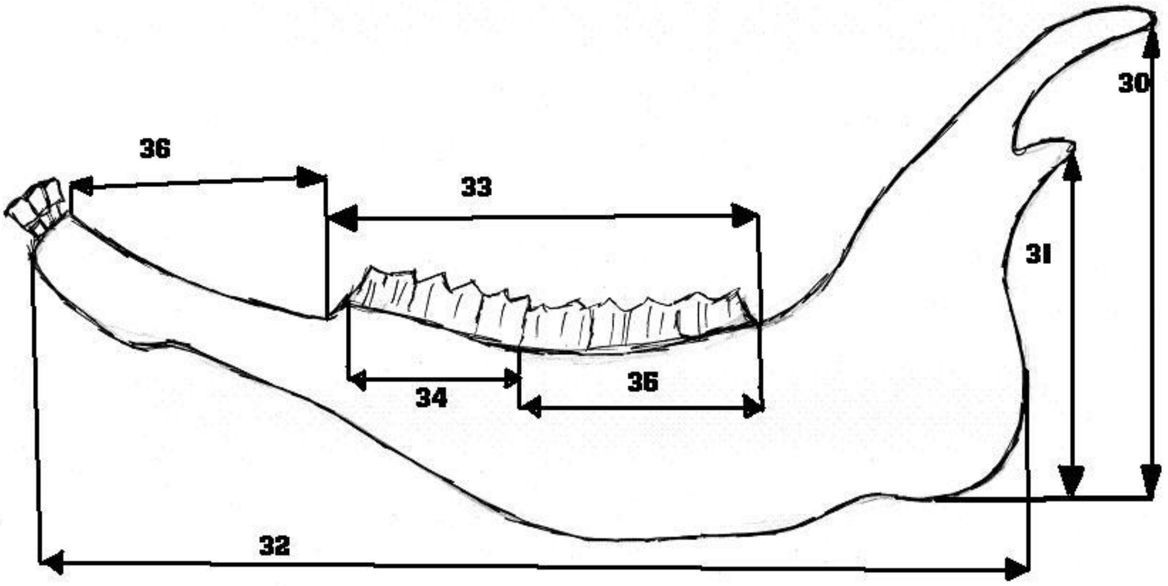
42. Diameter of circumference (on the base of horn)

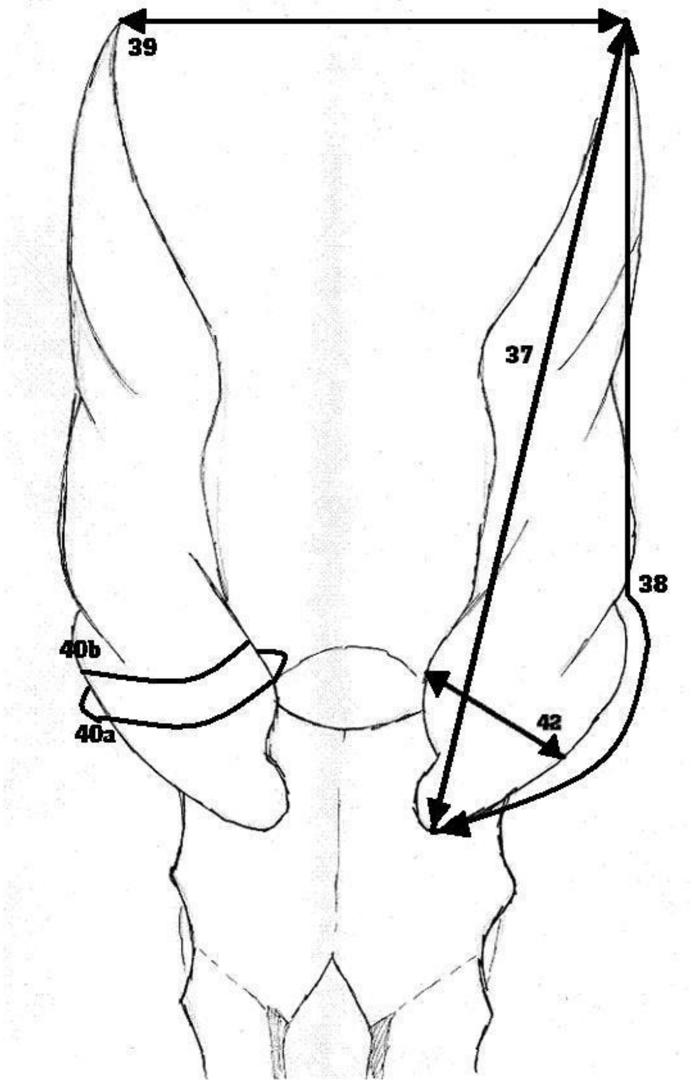

16a
16b
17
Ect
7
P
29
N
15
A
Ect
6
1


8
5
11a
11b
22
9
23


3
2
19
25
12
28
20
21
4
10
41
26


24
27
18
13
14


36
33
30
31
34
36
32


39
37
38
40b
42
40a

In summary, 30 measurements were distributed on *splanchrocranium*, 7 on the lower jaw and 4 on horns. At first, only 29 measurements provided on *splanchrocranium* were established, but during measuring the first specimens in Paris, 30th measurement (number 41) was added. 42nd measurement was added after finding out, that Colin Groves in book Ungulate Taxonomy (2011) used besides of classic measurements (Zygomatic breadth, Condylobasal length, Horn Lenght, Span, Teeth row) also measuring of the diameter of horns circumference on the base of horn. This measurement was taken in all subsequent measuring procedures – specifically on 46 specimens in Natural History Museum in London, and on 3 of horn trophies and one skull measured in Senegal.

Sometimes, measuring was impossible because skulls were fixed to wooden boards, sometimes they were more or less damaged. Some other obstacles occured – mandibles were absent in many skulls, nasal bones and premaxilla were often destroyed, also occipital condyles and teeth were missing in lots of skulls. Very often, measurement number 18 (cranium height) was not applicable due to the fragility of nasal bones.

Skulls were measured with digital caliper, for measuring horns were used iron tape measures. Also curved caliper with accurate steel ruler was used in cases, when specimens were fixed to wooden boards and access to some parts of skull was impossible with normal caliper, or when mandibula was fixed to the rest of skull and lower parts of upper jaw were blocked.

3.2.1 Age determination

All measurements were done only on skulls of adult animals – this procedure is a rule for all taxonomic studies, because young individuals does not finish their growth. Age determination of adult status was based on presence of fully eupted M3 (upper third molar), again it is the standard procedure. According to Kerr and Roth (1970), teeth in elands are fully developed in third or fourth year of life. Of course, in all or nearly all individuals there was a lack of information of their absolute age, but I tried to establish several relative age criteria for detailed comparison of all individuals. Only this approach allows me to compare all studied species and subspecies properly, because I compare „comparable“ (probably individuals of the similar age).

Skulls were divided into 3 age groups based on spirality and massiveness of horns and height of teeth. In some cases, age determination based on teeth was impossible due to the missing teeth. More in detail, age determination used in statistic analysis was based both on teeth height (first molar M1) and on degree of total attrition and on proportions of horns. Three age classes (A, B and C) were recognized. Class A was stated as young animals, class C as visibly old animals.

In horns, relative age determination was based on massiveness and number of spirals on horns, primary established also for the eland (Kerr and Roth, 1970; Jeffery and Hanks, 1981). Similarly to some skull with missing teeth, determination of age by horns spirality cannot be decided very precisely, mostly in females of *Taurotragus oryx*.

3.2.2 Sex determination

Other task was also recognize, which specimens are males and which are females. This analysis was based on size of horns. Horns of males are noticeably more massive than female horns. Also horns of females are longer and lighter. According to Kerr and Roth (1970), there is a possibility, that horns in female elands grow longer than horns of males – Kerr and Roth (1970) stated this hypothesis on fact, that horns of older males have rounded tips.

Final division of skulls according to sex was supported by fact, that skulls of females are perceptibly lighter and slighter than skulls of males.

3.2.3 Analyses

I used univariate, bivariate and multivariate (discriminant) analyses for comparisons of both *Taurotragus* species and their subspecies. I followed recommendations made by Groves and Grubb in Ungulate taxonomy (2011), for example, in bivariate analysis can be compared measurements, which are dependent and independent on age, in multivariate analysis should be compared only measurements of the same kind.

Measurements dependent and independent on sex and age class were analysed by t-test and ANOVA and some of them were significantly recognized as dependent according to $p < 0,05$ or independent according to $p > 0,05$.

Species are considered as morphologicaly identifiable, when the difference is 100% in at least one pattern (= an existence of at least one diagnostic character). Existence of subspecies is proved, when they are different in at least 75% of one pattern (Groves and Grubb, 2011).

Patterns (measurements), which can indicate an existence of species and subspecies, were calculated with Coefficient of difference (C.D.). Boundary for distinguish subspecies is a value of 1.28 (= 75%) and higher. Values around 3 - 4 support the difference at the species level (Mayr et al., 1953).

In summary, measurement of animals were analyzed for skull measurements and horns measurements separately or together according to used statistic methods. In any cases, specimens were divided into 6 groups, according to the relative age and sex:

1. Males of all subspecies, age A
2. Females of all subspecies, age A
3. Males of all subspecies, age B
4. Females of all subspecies, age B
5. Males of all subspecies, age C
6. Females of all subspecies, age C

Statistic analyses were computed using STATISTICA by StatSoft (version 10).

Also inspection of photos was provided and compared with informations from literature.

I surveyed all available credible photos from the wild or zoos (where subspecific character of eland was credibly guaranteed).

About 40 photos of each subspecies of *T. oryx* were examined. They originated mostly from hunters and safaris (e. g. *T. o. oryx* and *T. o. livingstonii* from Kugestwa safaris in SAR).

About 70 photos of each subspecies of *T. derbianus* were examined, photos of *T. d. gigas* originate mostly from zoos and from hunters, photos of *T. d. derbianus* originate from natural reserves Fathala and Bandia in Senegal.

Detailed inspection of coloration and stripes numbers will be provided by my coleague, Bc. Zuzana Böhmová, in her master thesis „Coat pattern of Western Derby Eland – an evidence for herritability?“.

4 Results

4.1 Inspection of photos

Tables for each species were created based on photo inspection for characters mentioned in literature.

4.1.1 Species

Species	**Parameter**			
	colour	stripes	dewlap	spots on cheeks
T. oryx	variable – from creamy white to rufous	0-15	commencing on throat, only along the neck,1 tufted point	no
T. derbianus	variable – from pale to rufous	10-15	commencing behind chin, 2 tufted points	yes

Species	**Parameter**			
	black stripe in the middle of belly	mat of hairs on the forehead	ears	neck colour
T. oryx	sometimes	yes	narrow and pointed	similar to body colour
T. derbianus	yes	no	round and broaded	darker on sides

4.1.2 Subspecies of *T. oryx*

Subspecies	**Parameter**				
	colour	stripes	black patch on forelegs	white stripe from eye corner	black stripe in the middle of belly
T. o. oryx	creamy white/pale yellow	no	no	no	no
T. o. livinstonii	variable – from dun to lighter chestnut/rufous	1 - 9	sometimes	no	sometimes
T. o. pattersonianus	variable, from fawn to rufous	2 - 15	yes	yes	yes

4.1.3 Subspecies of *T. derbianus*

Subspecies	**Parameter**		
	Colour	Stripes	Cheekspot shape
T. d. gigas	variable, mostly pale, but often chestnut/rufous	10 - 14	variable
T. d. derbianus	chestnut/rufous	11 - 15	variable

4.2 Measurings of skulls and horns

Because of condition of skulls, lot of measurements are unfortunately missing (due to the objective condition of collection material) and also because of lack of skulls and horns of subspecies *T. d. derbianus* and *T. o. oryx* (of the specific sexes or age classes - see Appendix II), coefficient of difference could not be calculated for all cases. Despite these limitations, a high morphological similarity of genus *Taurotragus* is an additional limitation factor (see also Discussion). In spite of all these limiting factors, I obtained a lot of intersting results.

4.2.1 Differences between sexes

My analysis computed by t-test shows, that both species do exhibit a marked sexual dimorphism in most of measurements. Considering this result, I had to compute further analyses of differences among taxa separately for males and females.

From all 42 measurements (see chapter Material and methods), only 3 were significantly independent on sex ($p > 0,05$):

No. 4 – premolare -> prosthion

No. 9 – prosthion -> infraorbitale

No. 14 – greatest breadth of paraoccipital condyles

4.2.2 Differences among age classes

My analysis computed by ANOVA shows, that adults of both species do exhibit differences among age classes in some measurements.

Considering this result, I had to compute further analyses of differences among taxa separately for age class A, B and C.

From all 42 measurements (see chapter Material and methods), 18 were independent on age (p > 0,05):

No. 5 - viscerocranium length
No. 7 - breadth across the premaxillae on the oral protuberances
No. 9 - prosthion -> infraorbitale
No. 11a - greatest inner length of the orbit
No. 11b - vertical lenght of the orbit
No. 14 - greatest breadth of paraoccipital condyles
No. 18 - cranium height
No. 19 - lenght of cheektooth row (along alveoli)
No. 20 - lenght of premolares
No. 21 - lenght of molares
No. 23 - from the aboral order of occipital condyle to of the same side
No. 29 - greatest breadth across the nasals
No. 30 - greatest height of mandibula
No. 31 - smallest height of mandibula
No. 32 - lenght of cheektooth row in mandibula
No. 33 - lenght of premolar row in mandibula
No. 34 - lenght of molar row in mandibula
No. 36 - lenght of diastema

4.2.3 Differences between species or subspecies

4.2.3.1 Univariate analysis

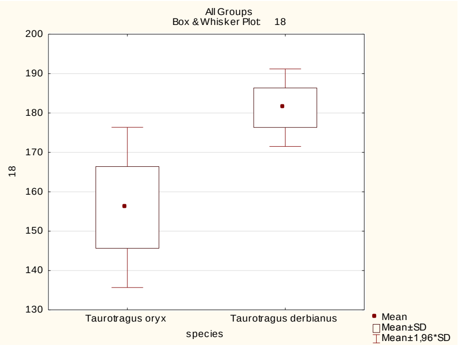
From almost 400 calculations of Coefficient of difference (C.D.), only few showing significant results. I therefore specify the only comparisons, where C.D. values were 1.28 (= 75% taxon A from 97% per cent taxon B = joint nonoverlap, 90% = conventional level of subspecific difference – see Mayr et al., 1953) and bigger, or at least close to this level, because this level could be at least indicative of some inherited morphological differences. Mean, sample size (N), standard deviation, minimum and maximum values and computed coefficients of difference (C.D.) are specified in Tables, these values are presented in the associated Box and Whisker plot graphs.

4.2.3.1.1 Differences between species:

In summary, some differences between species can be found. Cranium height is slightly bigger in females of *T. derbianus*. Also the circumference of horns showing differences – circumference is slightly bigger in both sexes of Derby eland. The spirality of horns at the base and total horn spirality is significantly higher in females of Derby eland. Horns of Derby eland are longer than horns of Common eland in males.

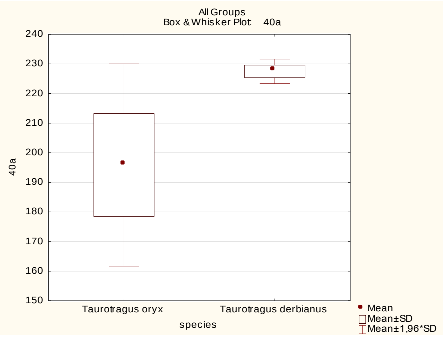
a) <u>Measurement no. 18 (cranium height) – all females (independent on age)</u>

	T. oryx	*T. derbianus*
Mean	156.032	181.35
N	19	2
Std dev	10.376	5.020
Min	139.1	177.8
Max	181.1	184.9
C.D. = 1.644		
Diagnosis: well supported subspecies		



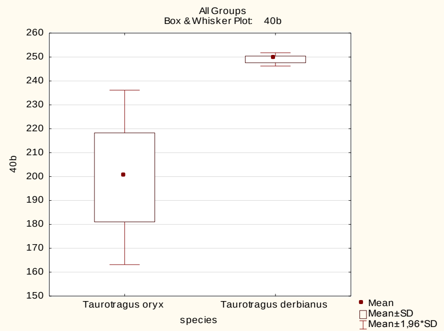
b) <u>Measurement no. 40a (circumference of horns without contour) – females of the age A</u>

	T. oryx	*T. derbianus*
Mean	195.857	227.5
N	14	2
Std dev	17.422	2.121
Min	178.0	226.0
Max	234.0	229.0
C.D. = 1.619		
Diagnosis: well supported subspecies		



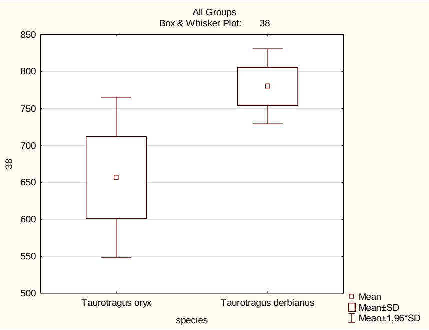
c) Measurement no. 40b (circumference along contour) – females of the age class A

	T. oryx	*T. derbianus*
Mean	199.643	249.0
N	14	2
Std dev	18.620	1.414
Min	180.0	248.0
Max	243.0	250.0
C.D. = 2.464		
Diagnosis: separate species		



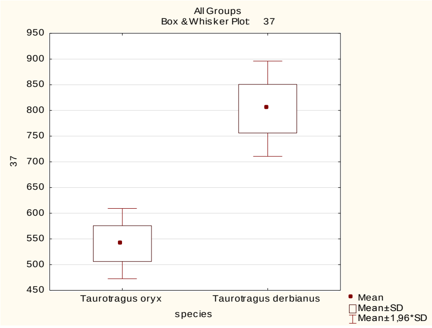
d) Measurement no. 38 (lenght of horn along first spiral) – females of the age class B

	T. oryx	*T. derbianus*
Mean	656.688	780.0
N	16	3
Std dev	55.381	25.865
Min	591.0	752.0
Max	775.0	803.0
C.D. = 1.518		
Diagnosis: well supported subspecies		



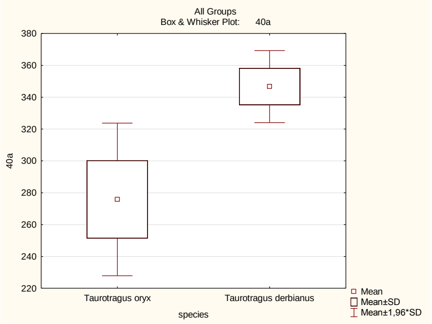
e) Measurement no. 37 (horn lenght) – males of the age class A

	T. oryx	*T. derbianus*
Mean	541.0	803.333
N	6	3
Std dev	34.888	47.258
Min	503.0	750.0
Max	596.0	840.0
C.D. = 3.193		
Diagnosis: separate species		



f) Measurement no. 40a (circumference of horn without contour) – males of the age class A

	T. oryx	*T. derbianus*
Mean	275.833	346.667
N	6	3
Std dev	24.474	11.547
Min	232.0	340.0
Max	298.0	360.0
C.D. = 1.966		
Diagnosis: separate species		



4.2.3.1.2 Differences between subspecies of T. oryx

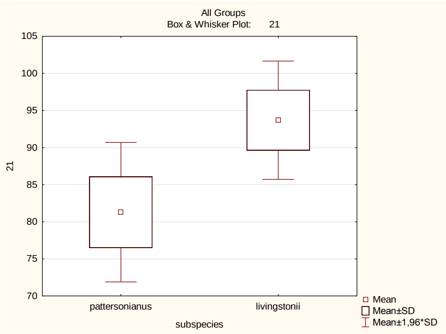
Differences between *T. o. livingstonii* and *T. o. pattersonianus* can be found in lenght of molar row, which is longer in *T. o. livingstonii*. Higher differences are showed by circumference of horns in males – circumference is significantly larger in *T. o. livingstonii*. Another difference found in males is in basal lenght, which is also longer in *T. o. livingstonii*. Dental lenght shows differences between subspecies *T. o. pattersonianus* and *T. o. oryx* – it is longer in *T. o. oryx*. Also lenght of cheektooth row is longer in *T. o. oryx*. It is interesting that both taxa do not overlap for these lengths, so they could be even classify as separate species. *T. o. oryx* has also bigger circumference of horns in females. Moderately different is also spirality of horns at the base, which is also larger in females of *T. oryx*.

The only cranial difference between subspecies *T. o. livingstonii* and *T. o. oryx* is slightly longer dental lenght in *T. o. oryx*.

1) ***T. o. livingstonii* was distinguished from *T. o. pattersonianus* based on those measurements**:

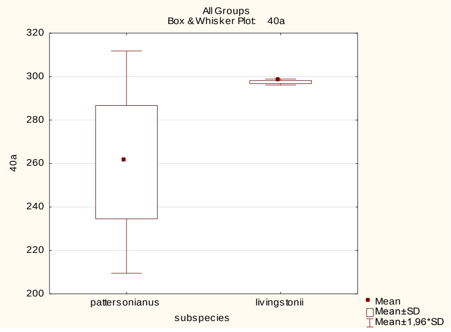
a) Measurement no 21 (molar row lenght) – all females (independent on age)

	T. o. livingstonii	*T. o. pattersonianus*
Mean	93.7	81.292
N	6	13
Std dev	4.067	4.794
Min	88.7	67.8
Max	100.0	87.6
C.D. = 1.400		
Diagnosis: well supported subspecies		



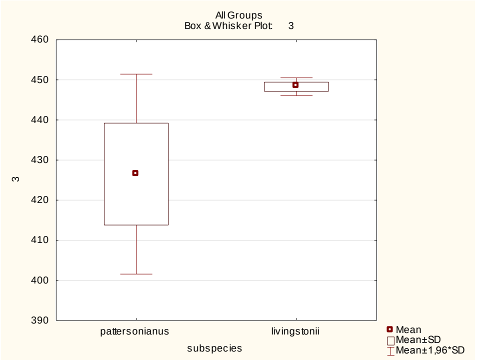
b) Measurement no. 40a (circumference of horn without contour) – males of the age class A

	T. o. livingstonii	*T. o. pattersonianus*
Mean	297.5	260.667
N	2	3
Std dev	0.707	26.083
Min	297.0	232.0
Max	298.0	283.0
C.D. = 1.375		
Diagnosis: well supported subspecies		



c) Measurement no. 3 (basal lenght) – males of the age class B:

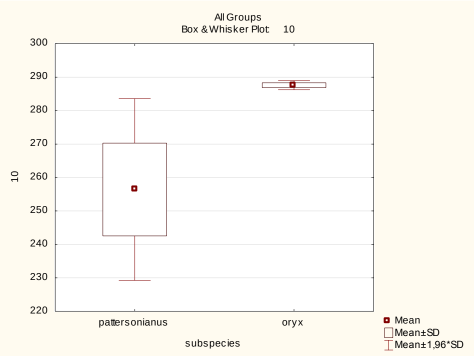
	T. o. livingstonii	*T. o. pattersonianus*
Mean	448.3	426.5
N	2	9
Std dev	1.131	12.728
Min	447.5	410.3
Max	449.1	447.2
C.D. = 1.573		
Diagnosis: well supported subspecies		



2) ***T. o. pattersonianus* was distinguished from *T. o. oryx* in those measurements:**

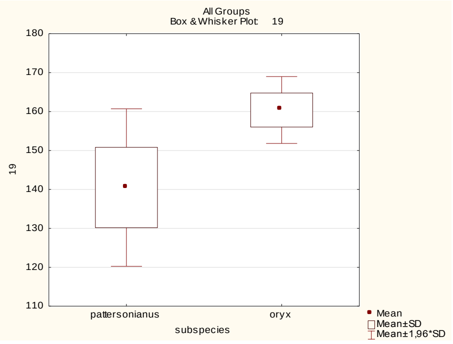
a) Measurement no. 10 (dental lenght) – females of the age class B

	T. o. oryx	*T. o. pattersonianus*
Mean	287.1	256,42
N	2	5
Std dev	0.707	13.867
Min	287.1	235.4
Max	288.1	274.2
C.D. = 2.105		
Diagnosis: separate species		



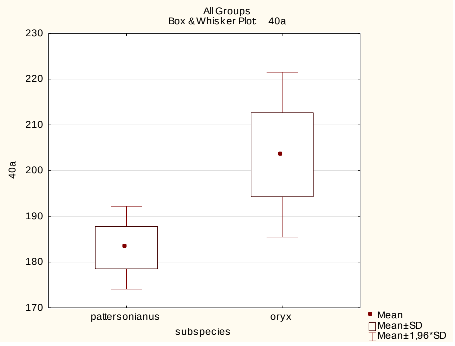
b) Measurement no. 19 (cheektooth row) – all females (independent on age)

	T. o. oryx	*T. o. pattersonianus*
Mean	160.4	140.487
N	2	16
Std dev	4.384	10.317
Min	157.3	115.0
Max	163.5	156.2
C.D. = 1.355		
Diagnosis: subspecies boundary		



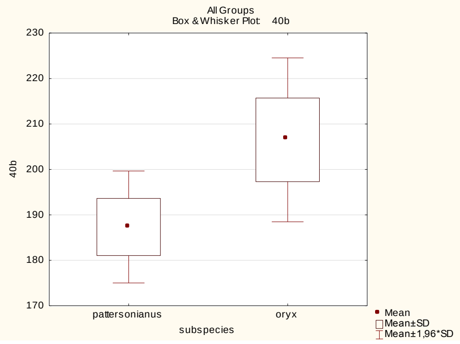
c) Measurement no. 40a (circumference of horn without contour) – females of the age class A

	T. o. oryx	*T. o. pattersonianus*
Mean	203.5	183.167
N	2	6
Std dev	9.192	4.622
Min	197.0	178.0
Max	210.0	190.0
C.D. = 1.472		
Diagnosis: well supported subspecies		



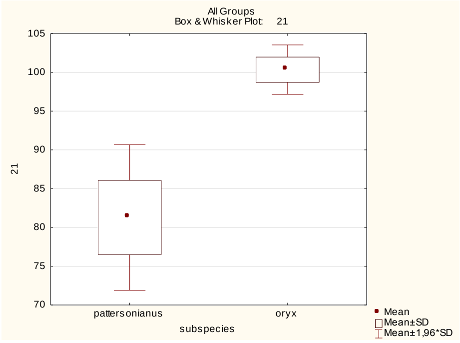
d) Measurement no. 40b (circumference of horn along contour) – females of the age class A

	T. o. oryx	*T. o. pattersonianus*
Mean	206.5	187.333
N	2	6
Std dev	9.192	6.282
Min	200.0	180.0
Max	213.0	198.0
C.D = 1.239		
Diagnosis: subspecies boundary		



e) Measurement no. 21 (lenght of molar row) – all females (independent on age)

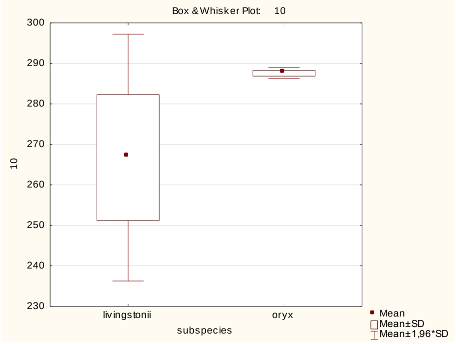
	T. o. oryx	*T. o. pattersonianus*
Mean	100.35	81.292
N	2	13
Std dev	1.626	4.794
Min	99.2	67.8
Max	101.5	87.6
C.D. = 2.968		
Diagnosis: separate species		



3) ***T. o. livingstonii* was distinguished from *T. o. oryx* in those measurements:**

a) Measurement no. 10 (dental lenght) – females of the age class B

	T. o. livingstonii	*T. o. oryx*
Mean	266.750	287.6
N	4	2
Std dev	15.552	0.707
Min	243.6	287.1
Max	290.0	288.1
C.D. = 1.252		
Diagnosis: subspecies boundary		

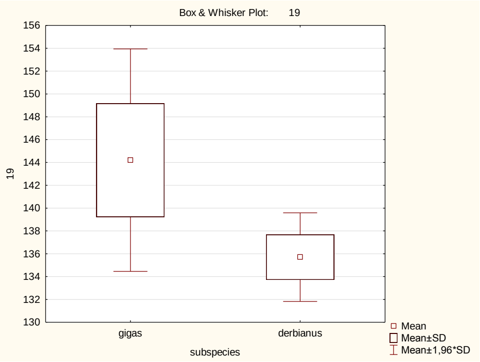


***4.2.3.1.3 Differences between subspecies of Taurotragus derbianus*:**

Between subspecies of Derby eland, only one small difference can be found in lenght of cheektooth row, which is slightly bigger in *T. d. gigas*. This difference is near the soubspecies boundary.

Measurement no. 19 (lenght of cheektooth row) – males of the age class B

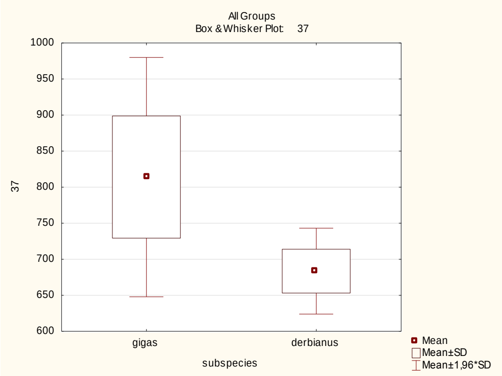
	T. d. gigas	*T. d. derbianus*
Mean	144.2	135.7
N	5	2
Std dev	4.971	1.980
Min	140.0	134.3
Max	151.6	137.1
C.D. = 1.223		
Diagnosis: near subspecies boundary		



It is possible that also horn length could advocate a subspecies classification for both subspecies, when one specimen of *T. d. gigas* was excluded from my analyse of horns. It exhibited atypically gracile horns, after its removal, horn lenght supports a subspecies classification of both Derby eland´s subspecies.

Measurement no. 37 (horn lenght) – males of the age class B. Analysis with atypical specimen of *T. d. gigas*:

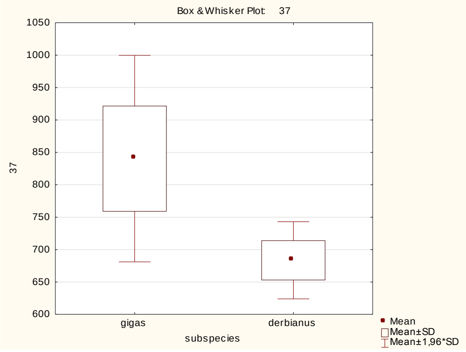
	T. d. gigas	*T. d. derbianus*
Mean	814.0	683.5
N	4	2
Std dev	84.731	30.406
Min	735.0	662.0
Max	932.0	705.0
C.D. = 1.128		
Diagnosis: below a conventional subspecies boundary		



Note: convetional subspecies boundary is associated with C. D. = 1,28 which is equal to 90 % of nonoverlap of partionally overlapping curves with stated values. Here found C.D. 1.13 is equal to 87 % of nonoverlap. Albeit being below a conventional subspecies boundary, it indicates some inherited differences between both subspecies.

Analysis without an atypical specimen of *T. d. gigas*:

	T. d. gigas	*T. d. derbianus*
Mean	840.333	683.5
N	3	2
Std dev	81.292	30.406
Min	777.0	662.0
Max	932.0	705.0
C.D = 1.401		
Diagnosis: well-supported subspecies		



4.2.3.2 Bivariate analysis

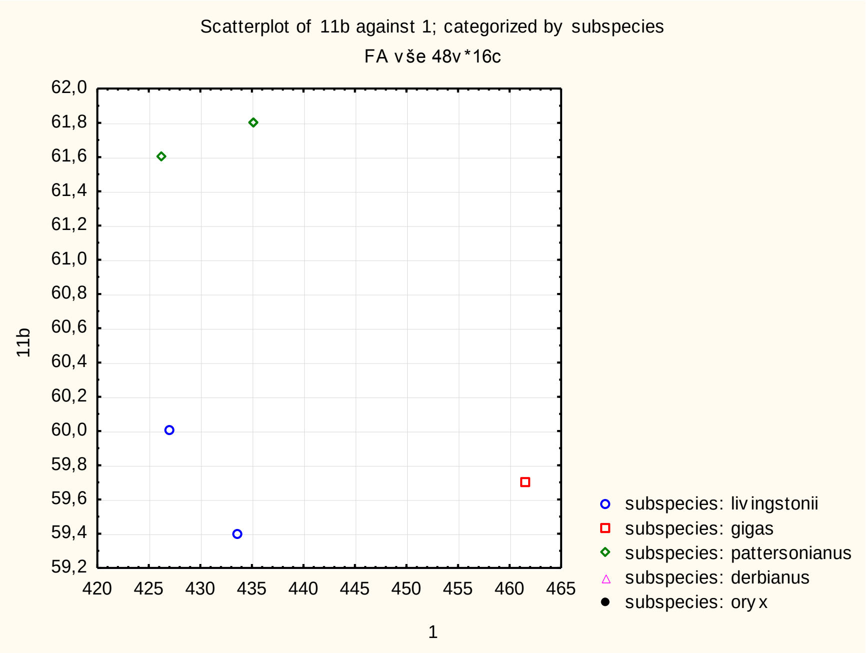
Bivariate analysis was evaluated from graphs for each two measurement in each group (mentioned in Methodology). From all of graphs, only infinitesimal number of them were showing some differences – and in addition to this, most of them are not really significant. Unfortunately, bivariate analyses are often of the smaller sample size, because some measurements were not obtainable for the same specimen.

Considering the very good support for two species of *Taurotragus* (*T. oryx* and *T. derbianus*), I select only bivariate analyses of subspecies within both separate *Taurotragus* species.

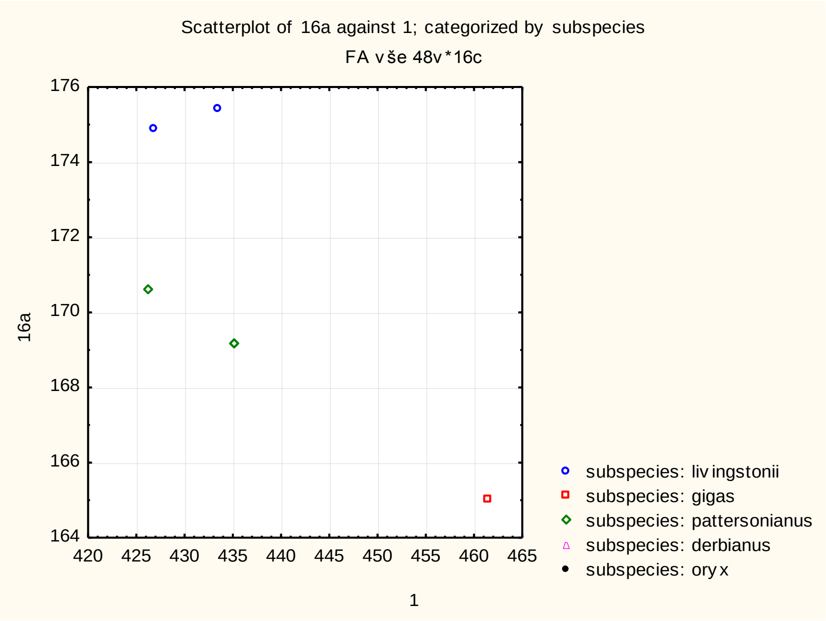
4.2.3.2.1 Differences between subspecies of T. oryx

T. o. livingstonii **and** ***T. o. pattersonianus***

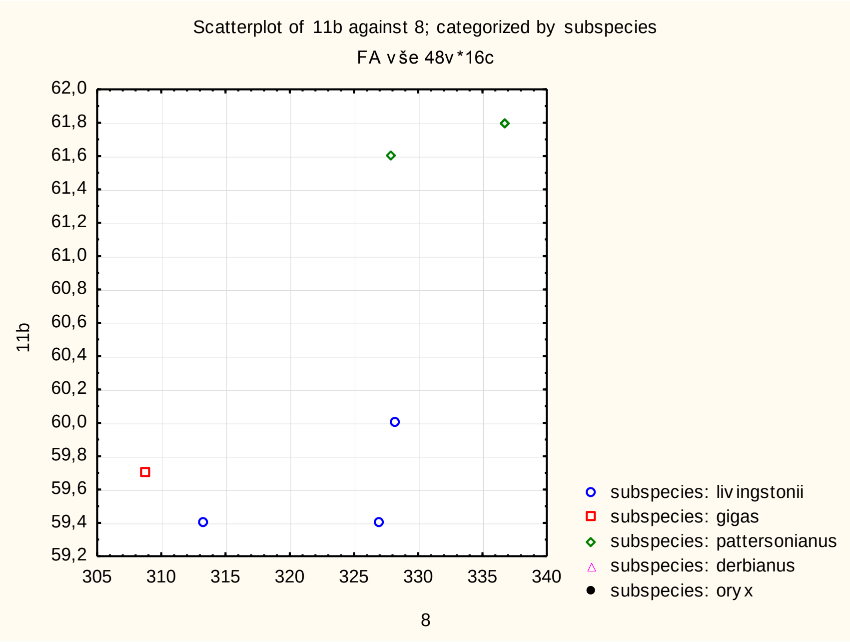
1) Measurement no. 11a against no. 1 (females of age class A)



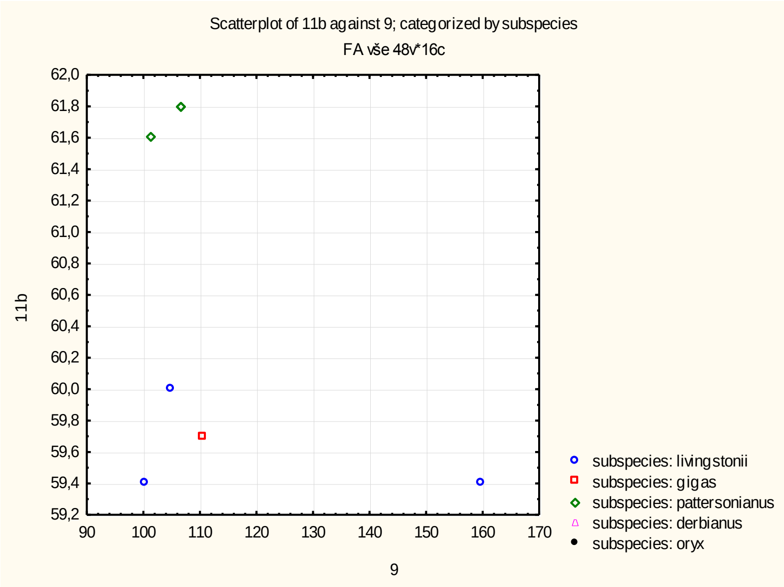
2) Measurement no. 16a against no. 1 (females of age class A)



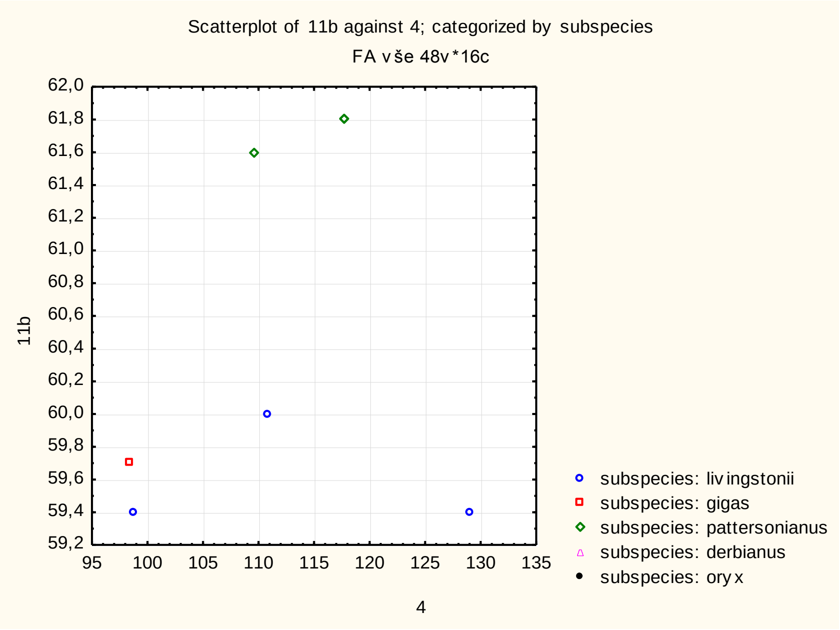
3) Measurement no. 11b against no. 8 (females of age class A)



4) Measurement no. 11b against no. 9 (females of age class A)



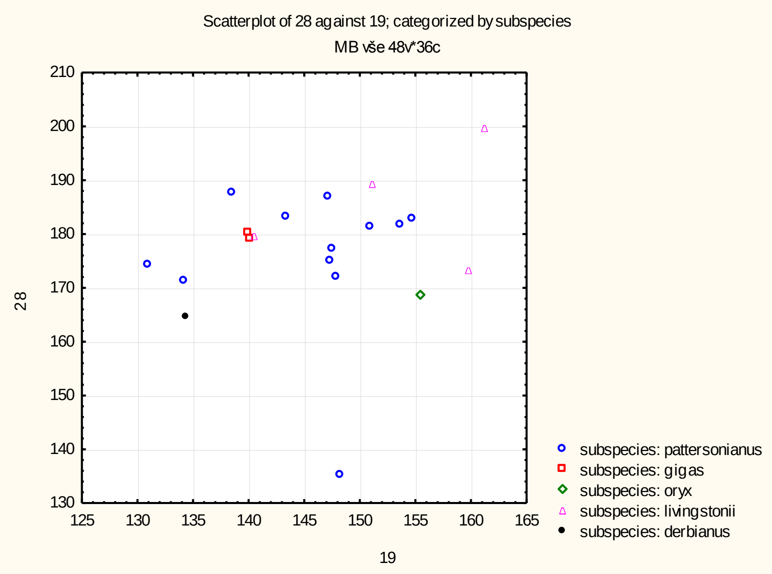
5) Measurement no. 11b against no. 4



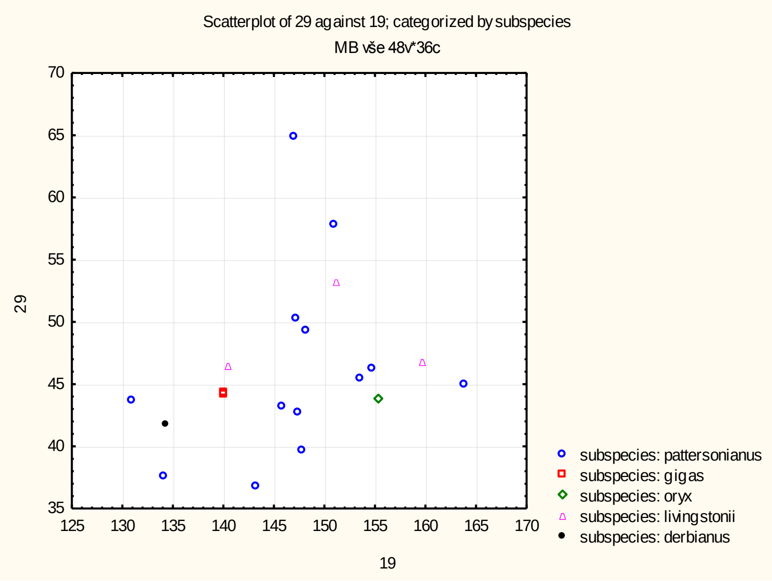
4.2.3.2.2 Differences between subspecies of T. derbianus

No difference was found between subspecies of this species for more individuals per both subspecies (except no. 15. – zygomatic breadth against tip-to-tip). On the other hand, it is possible that below mentioned measurements for mostly one individual of *T. d. derbianus* and two *T. d. gigas* are of the great interest, because they could be maybe diagnostic at the subspecies level. My samples are very small, but better evidence is not available (see Groves and Grubb 2011 with two horn pairs available).

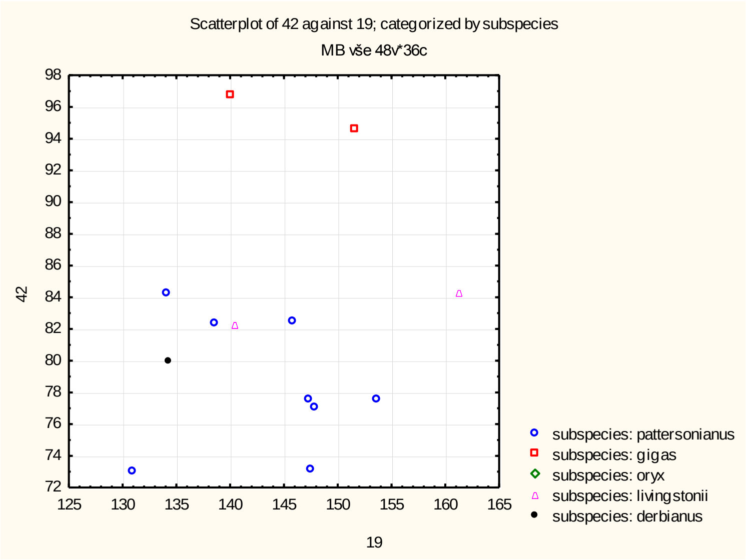
1) <u>Measurement no. 19 (cheektooth row) against no. 28 (zygomatic breadth) - males of the age class B</u>



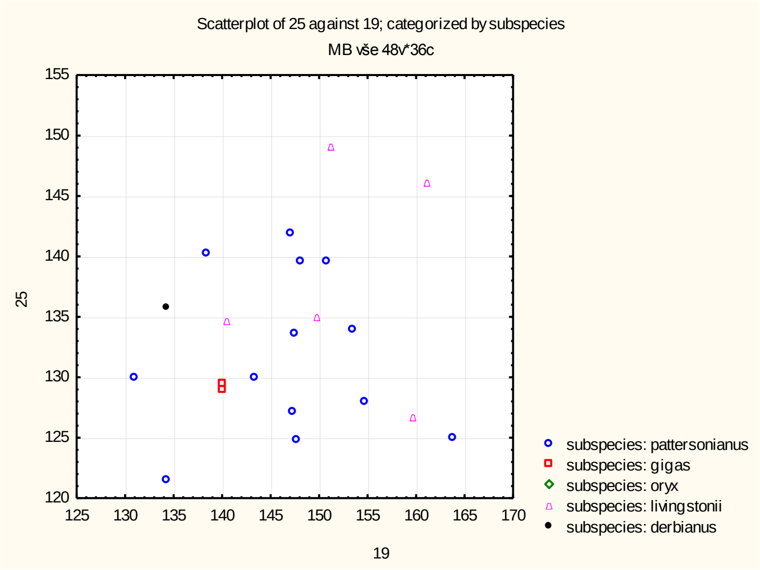
2) <u>Measurement no. 19 (cheektooth row) against no. 29 (greatest breadth across the nasals) - males of the age class B</u>



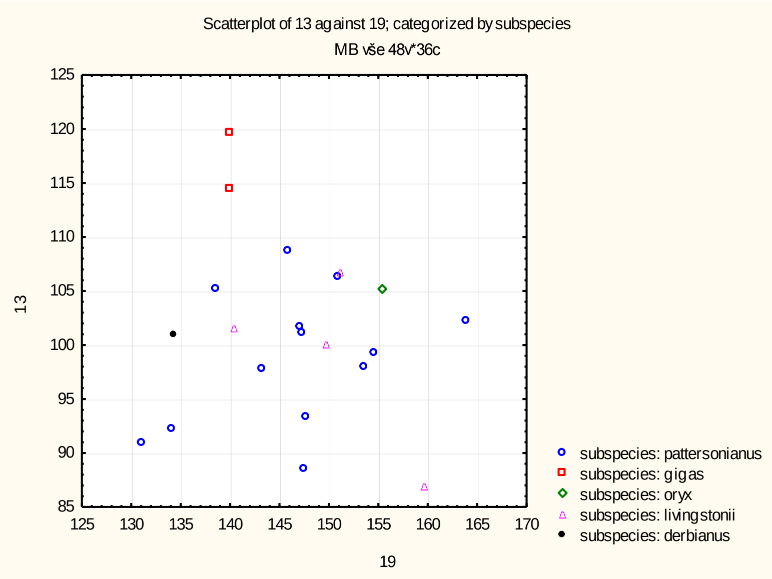
3) Measurement no. 19 (cheektooth row) against no. 42 (diameter of circumference of horns) - males of the age class B



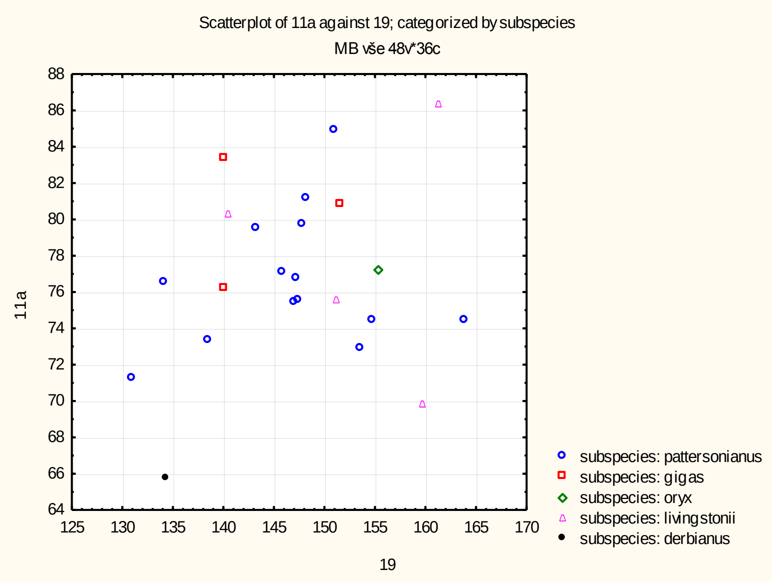
4) Measurement no. 19 (cheektooth row) against no. 25 (greatest breadth between cheekrows) – males of the age class B



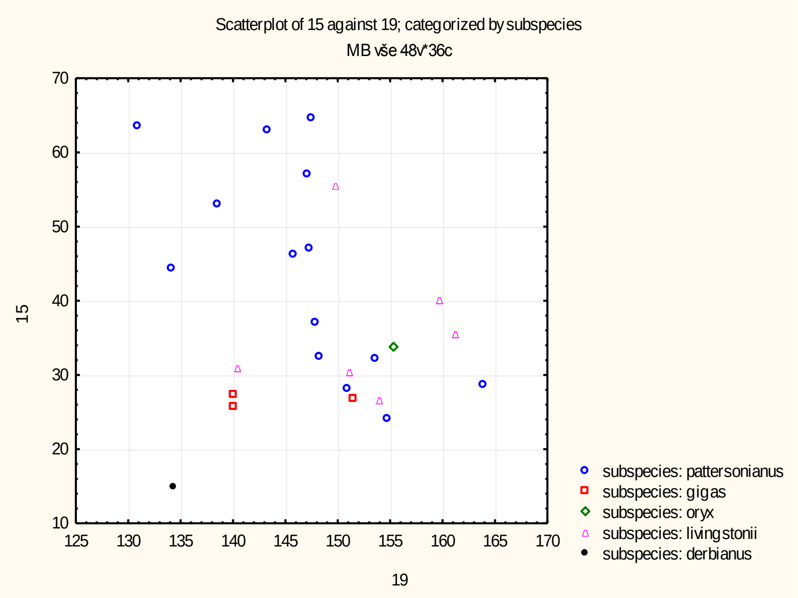
5) Measurement no. 19 (cheektooth row) against no. 13 (breadth of occipital condyles) - males of the age class B



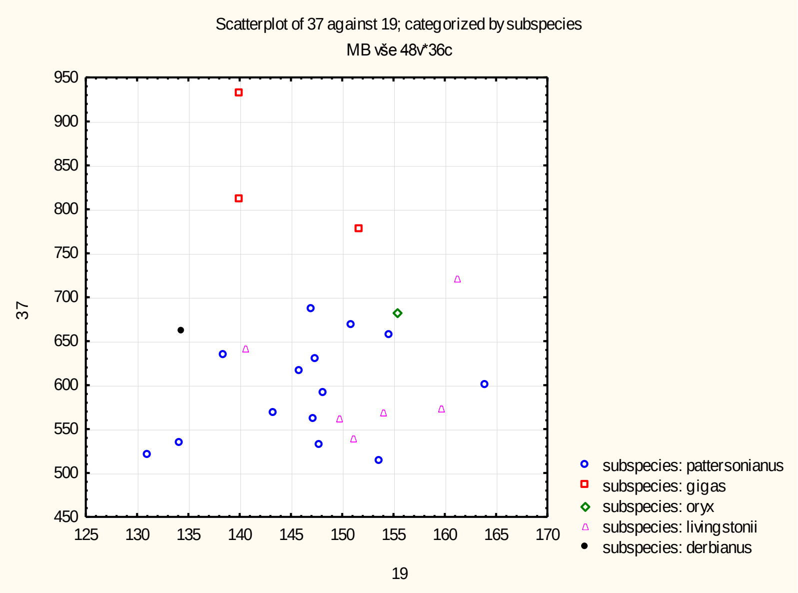
6) Measurement no. 19 (cheektooth row) against no. 11a –(inner lenght of the orbit) - males of the age class B



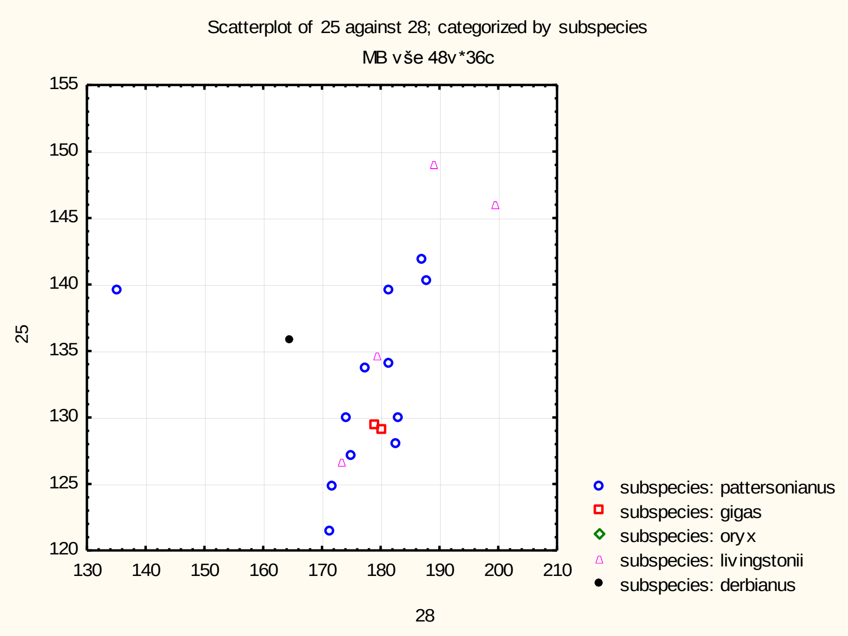
7) Measurement no. 19 (cheektooth row) against no. 15 (frontal breadth between horns) - males of the age class B



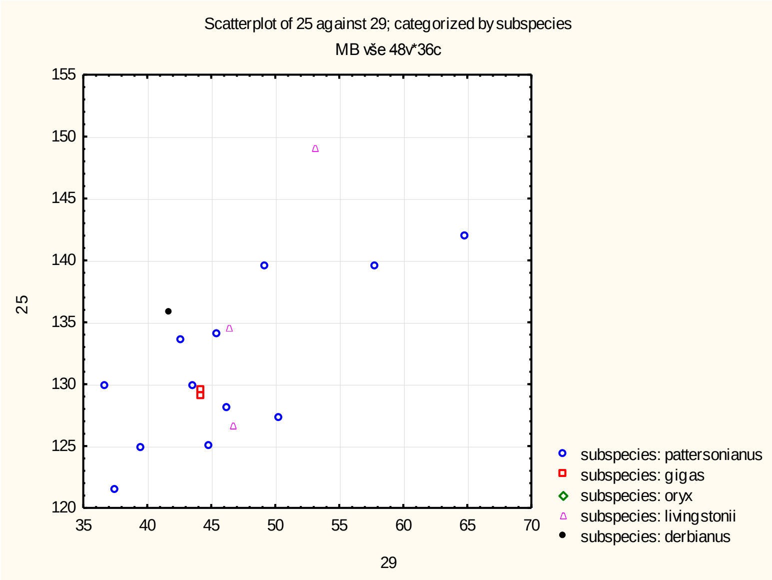
8) Measurement no. 19 (cheektooth row) against no. 37 (horn lenght) - males of the age class B



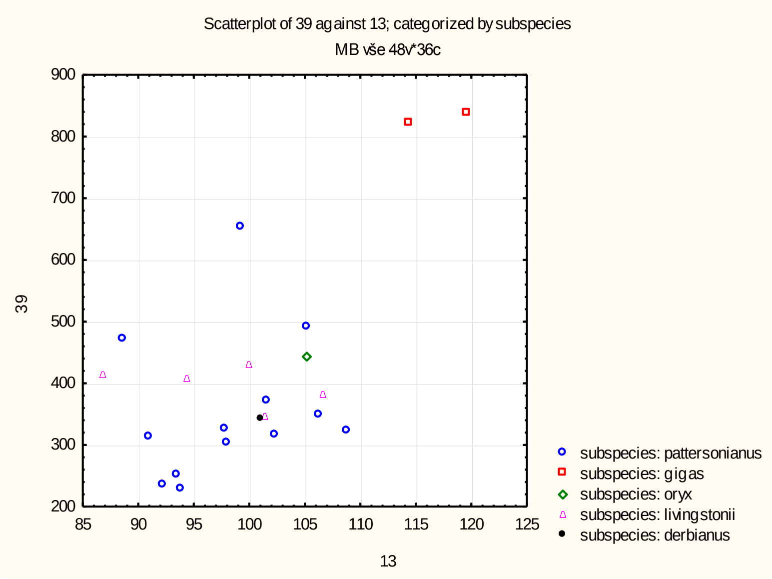
9) Measurement no. 25 (greatest breadth between cheekrows) against no. 28 (zygomatic breadth) - males of the age class B



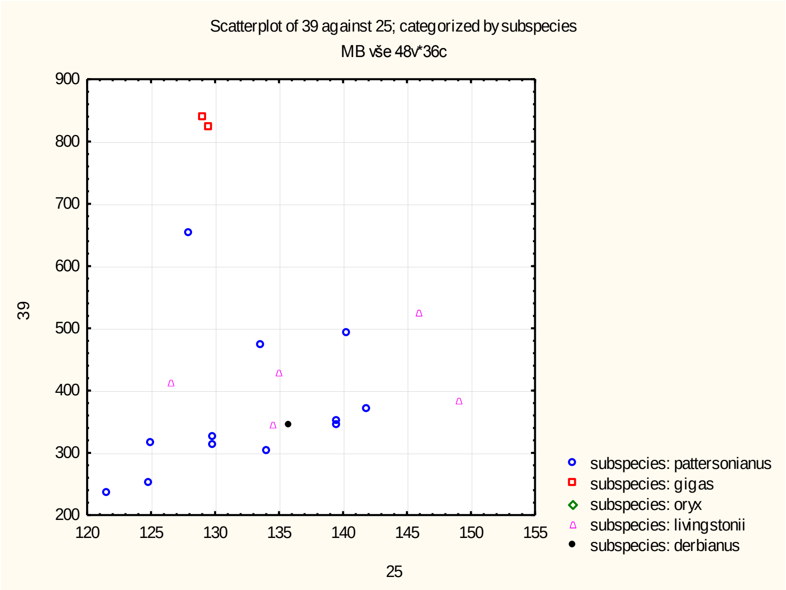
10) Measurement no. 29 (greatest breadth across the nasals) against no. 25 (greatest breadth between cheekrows) - males of the age class B



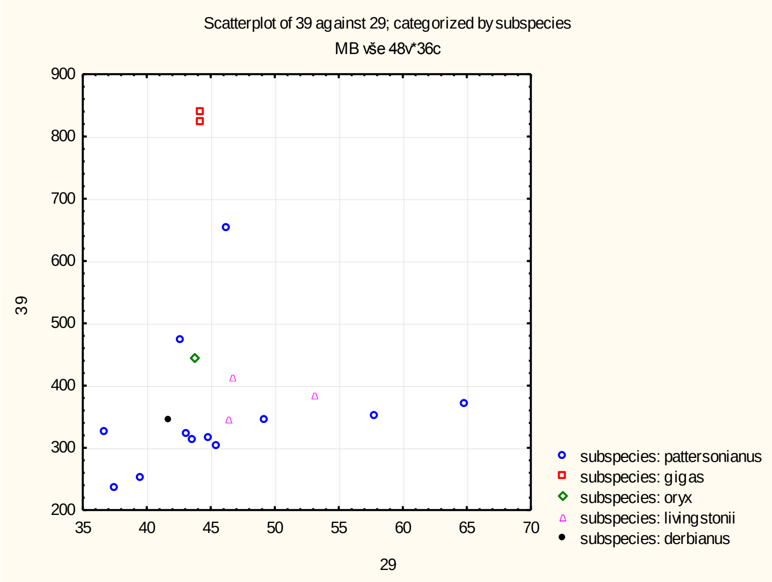
11) Measurement no. 39 (tip-to-tip) against no. 13 (breadth of occipital condyles) - males of the age class B



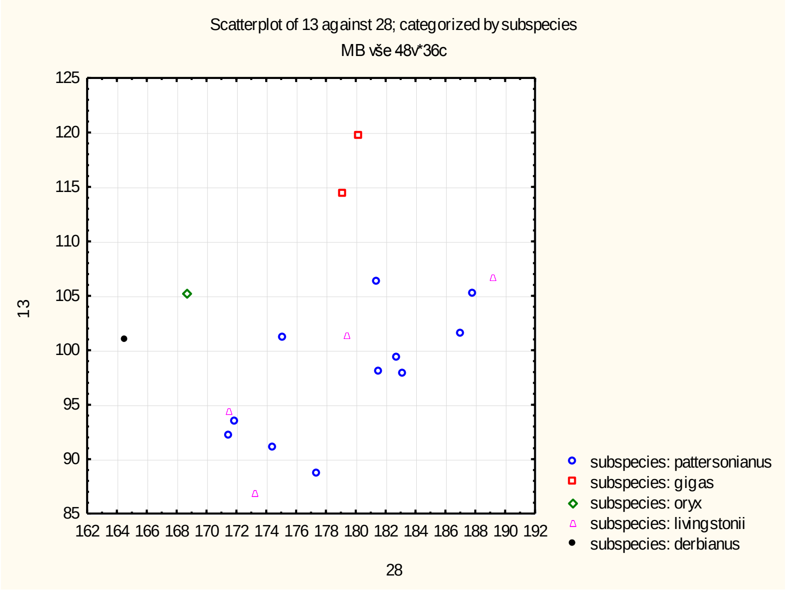
12) Measurement no. 39 (tip-to-tip) against no. 25 (greatest breadth between cheekrosw) - males of the age class B



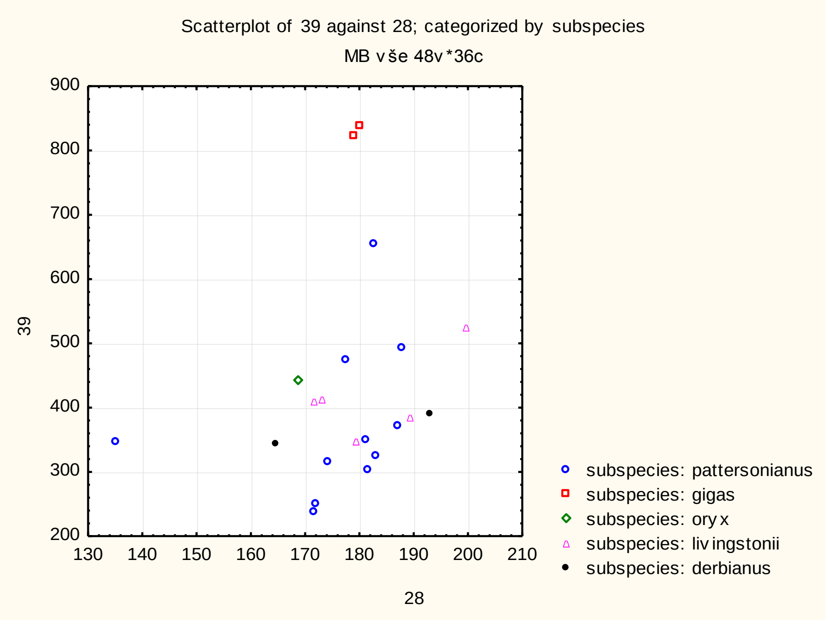
13) <u>Measurement no. 39 (tip-to-tip) against no. 29 (greatest breadth across the nasals) - males of the age class B</u>



14) <u>Measurement no. 28 (zygomatic breadth) against no. 13 (breadth of occipital condyles) - males of the age class B</u>



15) Measurement no. 28 (zygomatic breadth) against no. 39 (tip-to-tip) - males of the age class B



4.2.3.3 Multivariate analysis

Considering well supported differences between eland species and subspecies within common eland, I tried to calculate discriminant analyse for *T. derbianus* only. Due to lack of data after the respect to the significant sex and age classses differences, discriminant analysis was not applicable on my sample size for skull measurements. Only horn parameters seem to be applicable for discriminant analysis, but my sample size was not able to exclude a type I error, because as noted Groves and Grubb (2011) „as a rule of thumb, most of the groups should have more specimens than there are variables, or we run the risk of a type I error (i.e. an false positive)“. So, multivariate analysis is, unfortunately, not applicable for my sample size.

5 Discussion

Until recently (2011), there was not any available revision of the genus *Taurotragus* based on modern species concepts (e.g. Phylogenetic species concept, PSC), accumulated knowledge about the variability of elands and modern statistical methods. This state was changed by Groves and Grubb (2011) - their revision of the ungulate diversity disttinguished two species in *Taurotragus*, common and Derby elands, only two subspecies of the common eland, and no subspecies of the Derby eland (for detail see above), albeit their sample for the western subspecies was extremely small (only two horn pairs).

My work started two years before the „Ungulate Taxonomy“ attempt to analyse both eland antelopes with the special attention to the Derby eland subspecies. In spite of my attempt to accumulate as much samples as possible, and in spite of the fact, that I was able to for example obtain larger samples size of *T. d. derbianus* than Groves and Grubb (2011) – (2 skulls and 10 horns), number of specimen is still very low.

In the discussion I comment my inspections of photos and my results based on detailed comparison of skull and horns characters. My comments based on photos are orientational, exterior will be analysed properly (and with well specified methodology) by my colleague Zuzana Böhmová in her master thesis.

5.1 Sexual dimorphism

Elands are considered as sexually dimorphic, as mentioned by Sclater and Thomas (1899), Dorst and Dandelot (1970), Haltenroth and Diller (1980) and Kingdon (1982). Sexual dimorphism was firmly confirmed also by my research – males and females differ in most of cranial measurements and in all of horn measurements. Only lenght of premaxilla and breadth of parraoccipital condyles do not differ with sex.

5.2 Age classes differences

Eland skulls verifiably grow with age even during adulthood. Some measurements were considered as age independent, due to this elands probably do not grow much in lenght of splanchrocranium. Premaxilla and diastema, also orbits, tooth row, nasal bones, height of cranium and height of mandibula do not change with age. Also breadth of paraoccipital condyles seems to remain the same, but it can be also caused by a lack of provided measurements (due to skull conditions).

Horns do grow with age, skull grow mostly in breadth of both neurocranium and splanchrocranium. Skull grows in lenght mostly in neurocranium, especially in the frontal region. Only bones of splanchrocranium, which seems to be changing in lenght with age, are palatine bone and probably also the palatine process of maxilla.

In summary, analyses of eland skulls and horns should taken sex and age into account.

5.3 Differences between species

My inspection of credible photos from the wild or zoos (animals with a garanted origin) recognized practically similar morphological characteristic, as mentioned in literature. Shape of the dewlap and number of tufted points on the dewlap do correspond with Dorst and Dandelot (1970) and Gentry (1971), also presence of mat of hairs on the forehead, mentioned e. g. by Kingdon (1982) and Skinner and Chimimba (2005), shape of ears, mentioned e. g. by Ward (1910) and Gentry (1971), presence of white spot on cheeks mentioned e. g. by Harper (1945) and Haltenorth (1963) and coloration of the neck mentioned by Dorst and Dandelot (1970), can be confirmed by photo inspections. Colour of common eland, mentioned by Haltenorth and Diller (1980), can be considered as lighter than colour of Derby eland, but according to photos and also Patterson (1907), Lydekker (1914) and Dorst and Dandelot (1970) this can be consider to be true mostly for *T. o. oryx* and maybe *T. o. livingstonii,* but not for *T. o. pattersonianus*. Harper (1945) mentioned black stripe on belly only in Derby eland, which do not correspond with photos – this parameter is not presented in *T. o. oryx*, but it can be found in both *T. o. livingstonii*.and *T. o. pattersonianus*.

Also lower number of stripes, mentioned by e. g. Dorst and Dandelot (1970), could not be considered as truthful for whole species *T. oryx*. Haltenorth and Diller (1970) reported number of stripes in common eland from 2 to 15 – but there are no stripes in adults of *T. o. oryx* (reported e. g. by Groves and Grubb, 2011; Dorst and Dandelot, 1970; Roosevelt and Heller, 1914 and Skinner and Chimimba, 2005). Highest number mentioned by Dorst and Dandelot (1970) is only 10. This could not be consider as true for whole species – in *T. o. pattersonianus*, there are more stripes than 10.

Pappas (2002) described common eland as second largest antelope, but, as mentioned by Dollman (1936), Groves and Grubb (2011) and Bigalke (1968) and with consideration to practically identical (or at least highly similar) weight and height in both species, the term „largest antelope“ should be used for whole genus *Taurotragus*.

As craniometrical measurements and subsequent analysis showed, genus *Taurotragus* is not very morfologically different. That is concur to findings of Groves and Grubb (2011). In my research was found out, that cranium height of *T. derbianus* females is larger than cranium heigh of females of *T. oryx*, which correspond to fact, reported by Groves and Grubb (2011). Difference in skull size between males of both species mentioned also by Groves and Grubb (2011) could not be significantly confirmed. On the other hand, Groves and Grubb mentioned this difference between males skulls as really small, and even it was not confirmed by univariate analysis, largest skull lenghts were truly measured in *T. oryx*.

Largest difference, mentioned e. g. by Dorst and Dandelot (1970) and Kingdon (1982) between both species is in horns size. As also Groves and Grubb (2011) wrote and according to measurements of horns taken in my survey, horns of males of common eland are definitely shorter than horns of males of Derby eland. In females, circumference – thickness at the base, is certainly larger in Derby eland according to my observation, which correspond with Groves and Grubb (2011) and e. g. Estes (1991), but horns are not longer in females of Derby eland, a result that is in contradiction to Groves and Grubb (2011) and Dorst and Dandelot (1970). Total spirality of horns in females was found out as more massive and distinct in Derby eland, which concur with Groves and Grubb (2011), Dorst and Dandelot (1970) and Sclater and Thomas (1899). Horns of Derby eland are mentioned by Meester and Setzer (1975), Dorst and Dandelot (1970) and Groves and Grubb (2011) as more diverging. That was, due to high variability of tip-to-tip measurements, not confirmed in my research.

In general, both eland antelopes are distinct species based on craniometric and horn size comparisons. Albeit especially *T. o. pattersonianus* shares some parameters with the Derby eland, both species are distinct diagnostically also based on exterior.

5.3 Common eland subspecies

Three subspecies of Common Eland can be recognized (e. g. Meester and Setzer, 1975; Pappas 2002; Grubb 2005), albeit Groves and Grubb (2011) mentioned only two subspecies of Common Eland – *T. o. livingstonii* and *T. o. oryx*. Third subspecies, *T. o. pattersonianus*, can be recognized by some authors (e. g. Grubb, 2005) and my observation not only by differences in measurements, but also by appearance.

My inspection of photos recognized similar morphology as mentioned in literature. Adults of *T. o. oryx* can be definitely distinguished by absence of white stripes, as mentioned by Groves and Grubb (2011), Dorst and Dandelot (1970), Roosevelt and Heller (1914) and Skinner and Chimimba (2005). Coat colour seems to be variable in all subspecies of *T. oryx*, but *T. o. oryx* is, as reported e. g. by Harper (1945), the lightest one. *T. o. livingstonii* has distinctly darker colour (mentioned e. g. by Dorst and Dandelot, 1970 and Hill, 1942). Variability of number of stripes is large – some individuals have only 1 or 2 stripes, some even 8 – as mentioned by Hill (1942). *T. o. pattersonianus* has coat colour pretty similar to Derby eland, with numerous white stripes – but the number of stripes is also very variable, as already mentioned Lydekker (1914) and Haltenorth and Diller (1980). Black patch on legs is missing in all individuals of *T. o. oryx*, which was reported by Skinner and Chimimba (2005). In *T. o. livingstonii*, the patch is missing in some cases, but there are many individuals with more or less distinct patch, which correspond with Skinner and Chimimba (2005). Another parameter, which is not mentioned in literature, is black stripe on the belly - it cannot be found in *T. o. oryx*.

Groves and Grubb (2011) considered East African samples (*T. o. pattersonianus*) as the smallest, which can be definitely confirm by my results – lenght of dental row in males is longer in both *T. o. oryx* and *T. o. livingstonii* and longer skulls of *T. o. livingstonii*. Groves and Grubb did not found any differences in skulls of females, but according to my research, *T. o. oryx* females have much larger dental lenght and molar row – both differences reach even the species level of differences! Differences in thickness of horns were also measured by Groves and Grubb (2011) – they reported horns of males more slender in East African eland (*T. o. pattersonianus*). It can be confirmed by my results – massiveness of horns of males was larger in both *T. o. oryx* and *T. o. livigstonii* and (which was not found by Groves and Grubb, 2011) also the thickerness of horns at the base is larger in *T. o. oryx* than in *T. o. pattersonianus*. According to my research, horns of females of *T. o. pattersonianus* are not shorter than horns of other subspecies, which is in contrast with Groves and Grubb (2011) and so is fact, that horns of both sexes in *T. o. pattersonianus* are less diverging – I found, that horns span is very variable and can be thus of the both type – small and large.

To agree with Groves and Grubb (2011), no differences can be found in skulls and horns of *T. o. oryx* and *T. o. livingstonii*, except for slightly longer dental lenght in *T. o. oryx*. This difference is not strictly significant, but it is near the conventional subspecies level of „75% rule“.

In summary, *T. o. oryx* can be definitely distinguished by appearance from both other subspecies and from *T. o. pattersonianus* also by craniometrical measurements. Appearance of *T. o. livingstonii* and *T. o. pattersonianus* may be considered as similar, according to variability of number of stripes and coat colour in *T. o. livingstonii* and absence/presence of black patch on forelegs, but it can be distinguished by craniometrical measurements. I tend to consider *T. o. pattersonianus* to be a legitimate subspecies of the common eland.

5.4 Derby eland subspecies

Coat colour of *T. d. gigas* is often described as sandy (Dorst and Dandelot, 1970; Kingdon, 1997), according to photos, it can be variable and it also can has the same chestnut/rufous coloration as *T. d. derbianus*. Coat colour of Western Derby eland is (based on photos and personal experience from Senegal) practically uniformly chestnut and never sandy (paler) as in some individuals of *T. d. gigas*. According to this, a precise look (in prep.) based on many individuals is needed, e.g. for an estimation of % chestnut individuals of *T. d. gigas*, because 75% rule in taxonomy allows some sharing morphological characters between subspecies (75% of the taxon A from 97% of the taxon B). For this moment coat colour does not seem myself to be very good indicator of differences – I tend to concur to Groves and Grubb (2011), who was not able to find any differences between subspecies from photos.

Number of stripes in *T. d. gigas*, mentioned e. g. by Kingdon (1997) is 9 – 12 stripes. This do not concur with my photo inspection - some individuals have even 14 stripes. Also number of stripes in *T. d. derbianus* is very variable, not only 14 or 15 (mentioned by Lydekker (1914) and Kingdon (1997). But again, the precise look (in prep.) based on many individuals is needed, e.g. for an estimation of % chestnut individuals of *T. d. gigas*, because 75% rule in taxonomy allows some sharing morphological characters between subspecies (75% of the taxon A from 97% of the taxon B).

Another difference, mentioned by Lydekker (1914) and Haltenorth (1963) is the shape of white spot on cheeks. This difference also was not confirmed by my survey – cheekspot has very variable shapes and it can be round or elongated in both subspecies, also it can has different shape on each side of the head.

Analysis provided on subspecies of Derby eland are not very conclusive due to low number of horns and especially skulls. In craniometrical analysis, only one possible difference was found – the lenght of teeth row, which is longer in males of *T. d. gigas* and probably also in females (it could not be confirmed due to lower number of specimens). This measurement does not strictly separate subspecies, but it is very close to subspecies boundary. This finding is inconsistent with Groves and Grubb (2011), who reported no differences between subcpecies of Derby eland.

My analyses of horns are in contrary to Dollman (1936) – longer horns of *T. d. gigas* were not proved, the results obtained also by Groves and Grubb (2011). My research also does not correspond with Ward´s (1910) measurings, which separate subspecies by lenght and horns span (as noted above, variable spectra of their trophies are very different, nonoverlapping in fact) – my measurings showed high variability in lenght and span in both subspecies. However, albeit it was not confirmed by analysis, longest horns measured during my research were horns of *T. d. gigas*.

It is possible, that my disagreement with Ward (1910) and Dollman (1936) is caused by a low number of measured horns. After a working re-analysing males of the age class B (without *T. d. gigas* with atypicallly weak horns), my results do show horn lenght of *T. d. gigas* as larger, which correspond with Dollman (1936).

In summary, subspecies of Derby eland cannot be distinguished by coat colour or number of stripes, and I incline to agree with Groves and Grubb (2011), who considered subspecies of Derby eland as conspecific based on exterior. But albeit no strictly significant differences were succesfully confirmed, possible differences can be found - already mentioned lenght of teeth row and also in bivariate analysis, which practically confirmed the difference in teeth row and showed, that subspecies can be probably distinguished also in other patterns that only in lenght of teeth row.

A working re-analysed results of horn lenghts (after the exclusion of one male with atypically gracile and small horns) showed significant difference in horn lenght, which can significantly separate subspecies. Similarly, Ward´s measurement could have some limitations (collection of measurements from many collectors, a fraction of available specimens due to the trophy function etc.), but western subspecies is apart from the trophy records obtainable from the eastern subspecies.

In general and contrast with the influential monography by Groves and Grubb (2011) I tend to consider *T. o. pattersonianus* to be a legitimate subspecies of the common eland.and *T. d. derbianus* to be with *T. d. gigas* very close to conventional subspecies level.

6 Conclusion

First assumption, that Derby and common eland are morphologicaly different in at least one parameter, was confirmed - species of genus *Taurotragus* are significantly different (they meet with a conventional 100% rule of difference) in three parameters.

Second assumption, that subspecies of common eland are morphologically different in at least one parameter, was confirmed for subspecies *T. o. pattersonianus*, which is different from both other subspecies. From *T. o. livingstonii* in three parameters under the 75% rule of difference. From *T. o. oryx* is different in three parameters under the 75% rule of difference and even in two parameters under the 100% rule of difference. Second assumption was not significanly confirmed for subspecies *T. o. oryx* and *T. o. livingstonii* based on skull differences – but they are different in one parameter close to 75% rule of difference.

Third assumption, that subspecies of Derby eland are morpologicaly different, seems to be at least partly confirmed – subspecies of *T. derbianus* are different in one parameter of horn after an elimination of one probably atypical individual (under the 75% rule of difference) and differences in one other parameter are very close to the conventional subspecies boundary (89% of nonoverlap in contrast to 90% of nonooverlap in the 75% rule) . The assumption, that that they could be different in more parameters than common eland subspecies (due to the disjunctive range) was not confirmed.

Species are different in both exterior and cranial parameters.

T. o. pattersonianus is different from *T. o. oryx* in both exterior and cranial (skull + horn) parameters.

T. o. pattersonianus is not visibly different from *T. o. livingstonii* in exterior parameters, but it is different in cranial parameters.

T. o. oryx is different from *T. o. livingstonii* in exterior parameters, but it is not significantly different in cranial parameters.

T. d. gigas is not visibly different from *T. d. derbianus* in external parameters, but it seems to be different in cranial parameters.

Under this scope, all here mentioned taxa rather should retain their taxonomic and conservation values.

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8 Appendices

Appendix I – Photos of elands

COMMON ELAND

Taurotragus oryx oryx

Fig.1: **Male – South Africa**
© David and Amanda Mason & Pat and Judy Hayes
Source: www.realbird.com

Fig. 2: **Female – South Africa**
© Steve & Ann Tool
Source: www.toonphoto.com

Taurotragus oryx livingstonii

Fig 3: **Male (old „blue“ bull)*T. o. livingstonii***
© Gerald and Buff Corsi - California Academy of Sciences
Source: www.calphotos.berkeley.edu

Fig. 4: **Female *T. o. livingstonii***
© P&H Harris
Source: www.kenyabeasts.co.uk

Taurotragus oryx pattersonianus

Fig. 5: **Male *T. o. pattersonianus***
© Nik Borrow
Source: www.birdquest-tours.com

Fig. 6: **Female *T. o. pattersonianus***
© Ken J. Allen
Source: www.visionofnature.biz

DERBY ELAND

Taurotragus derbianus gigas

Fig. 7: **Male *T. d. gigas***
© Jorge Cruz
Source: www.flickrhivemind.com

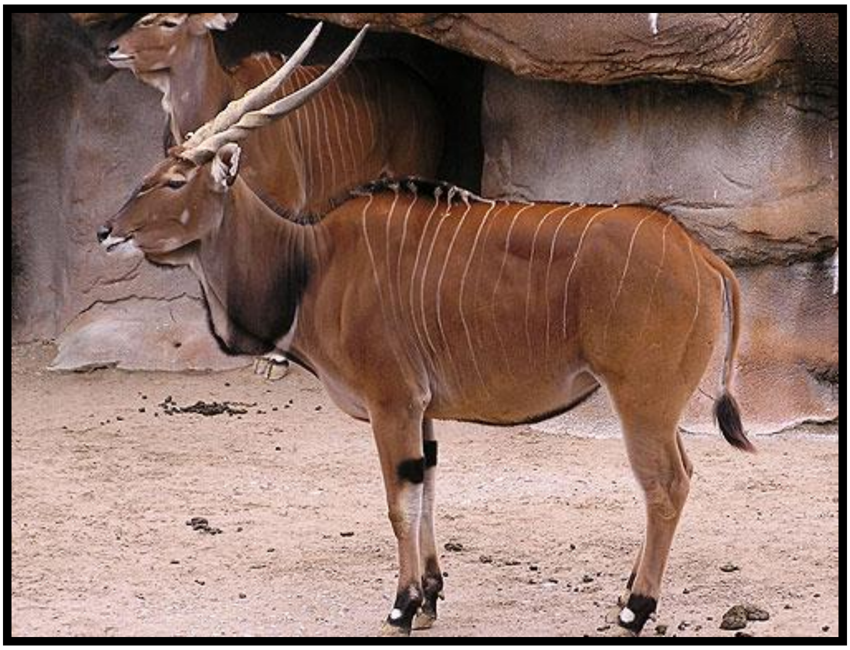

Fig. 8: **Female *T. d. gigas***
© Alex Kartovich,
Source: www.zooinstitutes.com

Taurotragus derbianus derbianus

Fig. 9: **Male *T. d. derbianus***
© Barbora Lutovská

Female

Fig. 10: **Female *T. d. derbianus***
© Barbora Lutovská

Appendix II

Tab. 1: List of measured skulls and horns (without unidentifiable specimens)

species	subspecies	area	sex	age	specimen	source	number
T. oryx	*oryx*	S Africa	M	B	skull	MFNK *	21986
T. oryx	*oryx*		M	B	skull	MFNK	
T. oryx	*oryx*		M	B	skull	MFNK	
T. oryx	*oryx*		M	B	skull	MFNK	71
T. oryx	*oryx*	S Africa	M	C	skull	MFNK	78932
T. oryx	*oryx*		M	C	skull	MFNK	49014
T. oryx	*oryx*	S Africa	F	A	skull	MFNK	
T. oryx	*oryx*	S Africa	F	A	horn trophy	MFNK	
T. oryx	*oryx*	Kalahari	F	A	skull	NHML	
T. oryx	*oryx*	S Africa	F	A	horn trophy	MFNK	
T. oryx	*oryx*		F	B	skull	MFNK	78921
T. oryx	*oryx*	Kalahari	F	B	horn trophy	NHML**	
T. oryx	*livingstonii*	Angola	M	A	horn trophy	MFNK	78877
T. oryx	*livingstonii*	Angola	M	A	horn trophy	MFNK	78866
T. oryx	*livingstonii*	Tanzania	M	A	horn trophy	MFNK	78955
T. oryx	*livingstonii*	Rhodesia	M	B	skull	NHML	
T. oryx	*livingstonii*	Rhodesia	M	B	skull	MFNK	90694
T. oryx	*livingstonii*	Angola	M	B	skull	MFNK	78867
T. oryx	*livingstonii*	Angola	M	B	skull	MFNK	
T. oryx	*livingstonii*	Angola	M	B	skull	MFNK	78944
T. oryx	*livingstonii*	Tanzania	M	B	horn trophy	MFNK	10694
T. oryx	*livingstonii*	Angola	M	B	horn trophy	MFNK	78943
T. oryx	*livingstonii*	Angola	M	B	horn trophy	MFNK	78874
T. oryx	*livingstonii*	Angola	M	B	horn trophy	MFNK	35108
T. oryx	*livingstonii*	Rhodesia	M	B	horn trophy	NHML	
T. oryx	*livingstonii*	Zambia	M	B	skull	NHML	
T. oryx	*livingstonii*	SE Africa	M	B	skull	NHML	
T. oryx	*livingstonii*	Zambia	M	C	skull	NHML	
T. oryx	*livingstonii*	Tanzania	M	C	horn trophy	MFNK	49301
T. oryx	*livingstonii*	Mosambique	M	C	skull	MFNK	78950
T. oryx	*livingstonii*	Angola	F	A	skull	MFNK	78933
T. oryx	*livingstonii*	Angola	F	A	skull	MFNK	78865
T. oryx	*livingstonii*	Angola	F	A	horn trophy	MFNK	78871
T. oryx	*livingstonii*		F	A	skull (without horns)	MFNK	109
T. oryx	*livingstonii*	Tanganyika	F	A	skull	NHML	
T. oryx	*livingstonii*	Angola	F	A	skull	NHML	27.7.3.20
T. oryx	*livingstonii*	DRC	F	B	skull	MFNK	78901
T. oryx	*livingstonii*	Mosambique	F	B	skull	MFNK	78960
T. oryx	*livingstonii*	Angola	F	B	horn trophy	MFNK	78934
T. oryx	*livingstonii*	Angola	F	B	horn trophy	MFNK	78886
T. oryx	*livingstonii*		F	B	skull	MFNK	7983
T. oryx	*livingstonii*		F	B	skull	MFNK	439
T. oryx	*livingstonii*		F	B	skull (without horns)	MFNK	1358
T. oryx	*livingstonii*	Rhodesia	F	B	skull	NHML	
T. oryx	*livingstonii*	Rhodesia	F	?	skull (without horns)	NHML	
T. oryx	*livingstonii*	Rhodesia	F	B	skull	NHML	

species	subspecies	area	sex	age	specimen	source	number
T. oryx	*livingstonii*	Mosambique	F	C	skull	MFNK	78900
T. oryx	*livingstonii*	Mosambique	F	C	skull	MFNK	
T. oryx	*livingstonii*	Mosambique	F	C	skull	MFNK	78958
T. oryx	*livingstonii*	Tanzania	F	C	horn trophy	MFNK	
T. oryx	*livingstonii*		F	C	skull	MFNK	591
T. oryx	*pattersonianus*		M	A	horn trophy	MFNK	
T. oryx	*pattersonianus*	Kenya	M	A	horn trophy	MFNK	78945
T. oryx	*pattersonianus*	Uganda	M	A	skull	MFNK	
T. oryx	*pattersonianus*	Tanzania	M	B	skull	MFNK	78917
T. oryx	*pattersonianus*	Tanzania	M	B	skull	MFNK	78888
T. oryx	*pattersonianus*	Tanzania	M	B	skull	MFNK	44801
T. oryx	*pattersonianus*	Tanzania	M	B	skull	MFNK	
T. oryx	*pattersonianus*	Tanzania	M	B		MFNK	44800
T. oryx	*pattersonianus*	Tanzania	M	B	horn trophy	MFNK	78930
T. oryx	*pattersonianus*	Tanzania	M	B	horn trophy	MFNK	
T. oryx	*pattersonianus*	Kenya	M	B	horn trophy	MFNK	78937
T. oryx	*pattersonianus*		M	B	horn trophy	MFNK	78870
T. oryx	*pattersonianus*	NE Africa	M	B	skull	NHML	
T. oryx	*pattersonianus*	Rwanda	M	B	skull	NHML	
T. oryx	*pattersonianus*	Kenya	M	B	skull	NHML	
T. oryx	*pattersonianus*	E Africa	M	B	skull	NHML	
T. oryx	*pattersonianus*	Kenya	M	B	skull	NHML	
T. oryx	*pattersonianus*	E Africa	M	B	skull	NHML	
T. oryx	*pattersonianus*	Uganda	M	B	skull	NHML	
T. oryx	*pattersonianus*	DRC	M	C	skull	MFNK	78860
T. oryx	*pattersonianus*	Kenya	M	C	skull	MFNK	38938
T. oryx	*pattersonianus*	Kenya	M	C	skull	MFNK	45707
T. oryx	*pattersonianus*	Uganda	M	C	skull	MFNK	
T. oryx	*pattersonianus*	Uganda	M	C	skull	MFNK	
T. oryx	*pattersonianus*	Rwanda	M	C	skull	MFNK	78939
T. oryx	*pattersonianus*		F	A	skull	MHNP***	64
T. oryx	*pattersonianus*	Uganda	F	A	skull	NHML	
T. oryx	*pattersonianus*	Tanzania	F	A	skull	NHML	
T. oryx	*pattersonianus*	Uganda	F	A	skull	NHML	
T. oryx	*pattersonianus*	Tanzania	F	B	skull	MFNK	78911
T. oryx	*pattersonianus*	Kenya	F	B	skull	MFNK	32377
T. oryx	*pattersonianus*		F	B	horn trophy	MFNK	
T. oryx	*pattersonianus*	Tanzania	F	B	horn trophy	MFNK	78946
T. oryx	*pattersonianus*	Tanzania	F	B	horn trophy	MFNK	
T. oryx	*pattersonianus*		F	B	skull	MFNK	128
T. oryx	*pattersonianus*	Rwanda	F	B	horn trophy	NHML	
T. oryx	*pattersonianus*	Kenya	F	B	skull	NHML	
T. oryx	*pattersonianus*	NE Africa	F	B	skull	NHML	
T. oryx	*pattersonianus*	Tanganyika	F	B	skull	NHML	24.8.8.92
T. oryx	*pattersonianus*		F	B	skull	NHML	
T. oryx	*pattersonianus*	Tanzania	F	C	skull	MFNK	78875
T. oryx	*pattersonianus*	Tanzania	F	C	skull	MFNK	78956
T. oryx	*pattersonianus*	Tanzania	F	C	skull	MFNK	44045
T. oryx	*pattersonianus*	Kenya	F	C	skull	MFNK	48714
T. oryx	*pattersonianus*		F	C	horn trophy	MFNK	78872
T. oryx	*pattersonianus*		F	C	skull	MHNP	191
T. oryx	*pattersonianus*		F	C	skull	NHML	
T. oryx	*pattersonianus*		F	B	skull	FL*****	

species	**subspecies**	**area**	**sex**	**age**	**specimen**	**source**	**number**
T. oryx	*pattersonianus*		F	B	skull	FL	
T. oryx	*pattersonianus*		M	B	skull	FL	
T. oryx	*pattersonianus*		M	B	skull	FL	
T. derbianus	*gigas*	Tierpark Berlin (from CAR.)	M	B	skull	MFNK	59068
T. derbianus	*gigas*		M	B	horn trophy	NHML	
T. derbianus	*gigas*		M	B	skull	NHML	
T. derbianus	*gigas*		M	B	skull	NHML	
T. derbianus	*gigas*	Cameroon	M	C	horn trophy	MFNK	20883
T. derbianus	*gigas*	Cameroon	M	C	horn trophy	MFNK	30397
T. derbianus	*gigas*	Cameroon	M	C	horn trophy	MFNK	48273
T. derbianus	*gigas*		M	C	horn trophy	NHML	
T. derbianus	*gigas*		M	C	horn trophy	NHML	
T. derbianus	*gigas*		M	C	skull	NHML	
T. derbianus	*gigas*		M	C	skull	NHML	
T. derbianus	*gigas*	CAR	M	C	horn trophy	MFNK	38951
T. derbianus	*gigas*	Cameroon	M	C	horn trophy	MFNK	78940
T. derbianus	*gigas*	Tierpark Berlin	F	A	skull	MFNK	63425
T. derbianus	*gigas*	Sudan	F	B	horn trophy	NHML	
T. derbianus	*gigas*	CAR	F	B	horn trophy	NHML	
T. derbianus	*gigas*		F	C	horn trophy	NHML	
T. derbianus	*derbianus*	Senegal	M	A	horns	transfers	
T. derbianus	*derbianus*	Senegal	M	A	horns	transfers	
T. derbianus	*derbianus*	Senegal	M	A	horns	transfers	
T. derbianus	*derbianus*	Senegal	M	B	horn trophy	FR*****	
T. derbianus	*derbianus*	Senegal	M	B	skull	FR	
T. derbianus	*derbianus*	Senegambia	M	C	skull fragments	MHNP	
T. derbianus	*derbianus*	Senegal	F	A	horn trophy	FR	
T. derbianus	*derbianus*	Senegal	F	A	horns	transfers	
T. derbianus	*derbianus*	Senegal	F	A	horns	transfers	
T. derbianus	*derbianus*	Gambia	F	B	head	NMHL	
T. derbianus	*derbianus*	Senegal	F	B	horns	transfers	
T. derbianus	*derbianus*	Gambia	F	C	skull	NHML	11.6.10.111
T. derbianus	*derbianus*	Senegal	F	C	horns	BR*******	

* MFNK = Museum für Naturkunde (Berlin)
** NHML = Natural History Museum (London)
*** MHNP = Muséum National d´Histoire Naturelle (Paris)
**** FL = Farm Estate Lány
***** FR = Fathala Reserve (Senegal)
****** BR = Bandia reserve (Senegal)