Elephant damage in Masai Mara

Elefantskador i Masai Mara

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Skara 2010

Studentarbete 384

Swedish University of Agricultural Sciences
Department of Animal Environment and Health
Ethology and Animal Welfare programme

Student report 384

ISSN 1652-280X

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Grund C, 15 hp, Etologi och djurskyddsprogrammet, självständigt arbete i biologi, kurskod EX0520

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Nyckelord: elephant, damage, Acacia, Balanite, Masai Mara

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SAMMANFATTNING

Elefanter är och har varit mycket hotade genom tiderna men har börjat öka i antal på grund av kontroll av tjuvskytte, förbud av elfenbensförsäljning, samt en förändring av såväl mänsklig utbredning samt regn mönster, och flera nationalparker upplever nu ökade skador på grund av rikliga elefantpopulationer, det så kallade elefantproblemet. Det finns sen 30 år tillbaka rapporter från östra och södra Afrika om minskning av Acacier och andra kapellträd på grund av elefantbetning. Några av dessa skador kan till och med leda till lokal utrotning av vissa arter. På grund av detta finns det en konflikt inom bevarandeprogram mellan att bevara livskraftiga elefantpopulationer och bevara den biologiska mångfalden i växtriket. Syftet med denna studie var att se om det fanns något problem med elefanter i Masai Mara Nationalreservat, Kenya, genom att göra en beteendestudie om deras matvanor och jämföra skador på de två träden *Acacia gerrardii* och *Balanites aegyptiaca*. Trädstudiens resultat är inte fullständigt statistiskt trovärdiga med anledning av för lite införskaffade uppgifter, på grund av brist på tid, utrustning och information men det finns en tydlig trend. En trend som pekar mot mer skador på Acacia träd, då bara de är fällda av elefanterna. Elefanterna verkade äta mer örter än träd, som kan leda till en obalans mellan dessa arter och påverka balansen i ekosystemet. Taggstorleken hos Acacia och Balanites är signifikant olika långa, där Balanites är längre, vilket kan vara av intresse för elefanters val av vilket träd de väljer att äta. Då längre taggstorlek verkar skydda mot skada. Det verkar inte finnas några akuta problem med elefanterna i Masai Mara men mer forskning måste göras för att erhålla tillräcklig information för att göra några riktiga slutsatser om elefanters påverkan på träd och vegetation i reservatet.

SUMMARY

Elephants are and have been very threatened over the decades but have started to increase in numbers due to control of poaching, prohibition of ivory sales, and a change in both human distribution and rainfall patterns. Several national parks are now experiencing increased damage because of abundant elephant populations, the so called elephant problem. There have been reports from eastern and southern Africa on reduction in Acacias and other canopy trees due to elephant browsing for over 30 years. Some of these damages can even lead to local extinction of species. Because of this there is a conflict within conservation programmes, between conserving viable elephant populations and conservation of plant biodiversity. The aim of this study was to see if there were any elephant damages in Masai Mara National Reserve, Kenya, by performing a behavioural study on their eating habits and comparing damage caused to the two trees *Acacia gerrardii* and *Balanites aegyptiaca*. The results from the tree study are not fully statistically reliable because of too little contained data material, due to lack of time, equipment and information. However there is a trend pointing toward more damage caused to Acacia trees while only they are the ones that have been pushed over by elephants. The elephants seemed to eat more herbs than grass, which may lead to an unbalance between these species and then affect the balance in the ecosystem. The thorn size of Acacia and Balanites is significantly different, where Balanites have longer thorns, and might be of interest in elephants' choice of which tree they will eat. The longer the thorns the less damage, in other words less eating of that tree. There seems to be no urgent problem with the elephants in Masai Mara, but more research has to be done to retain sufficient data to make any real conclusions about elephants' impact on the trees and vegetation in the reserve.

INTRODUCTION

Elephants are the largest land living animal today (The Colombia Encyclopedia, 2011). It is a mammal in two genera of the family *Elephantidae* in the order *Proboscidea*; *Elphas maximus* (Asian elephant) and *Loxodonta africana* (African elephant). The African elephant can be divided additionally into Forest elephant (*Loxodonta Africana cyclotis*) and Savanna elephant (*Loxodonta africana africana*).

There are no natural predators to adult and healthy elephants, though lions may take calves and weak individuals (Joubert, 2006). They are however threatened by human intrusion and poaching (Barnes, 1983). Though elephants are protected worldwide, with restrictions in place on capture, domestic use, and trade in products such as ivory, there have been an increase in poaching during the recent years and the African elephant is listed as "vulnerable" in the International union for conservation of Nature red list of threatened species (IUCN Red List, 2010). They are also listed in Appendix 1 and 2 in Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES 2010).

African elephants are found in habitats such as forest edges, woodlands, bushlands and wooded or bushed grasslands (Laws, 1970). They are herbivores with a very varying diet both seasonally and regionally, and can spend up to 12-15 hours a day foraging (O'Connor *et al.* 2007). The diet consists of leaves, bark, and fruits of trees and shrubs, and grass and herbs. During the wet season elephants mainly eat green grass and herbs. In the late wet and dry season they eat green browse, and following leaf fall they eat bark and root (O'Connor *et al.* 2007). Elephants are primarily browsers with less than approximately 15% grass in their diets (van der Merwe *et al*. 1988, 1990; Tieszen *et al.* 1989; Vogel *et al.* 1990; Cerling *et al*. 1999; Cerling *et al.* 2004). They are non-ruminant ungulates and because of their diet their digestive system requires the function of fermentative digestion of cellulose through the action of bacteria, so called hindgut fermentation (Van Hoven *et al.* 1981). Because of their digestive system they can only digest approximately 40% of what they consume, so to compensate for this inefficiency they eat great volumes of food every day. An adult elephant can consume approximately 200 kg dry matter/day, and also drink up to 200 liters of water every day.

African elephants have started to increase in number again since 1946 due to control of illegal shooting, prohibition of ivory sales, and a change in both human distribution and rainfall pattern. Several national parks are now experiencing increased damage because of abundant elephant populations, the so called elephant problem (Barnes, 1983; Calenge *et al.* 2002). There have been reports in eastern and southern Africa on reduction in Acacias and other canopy trees due to elephant browsing for over 30 years (Barnes, 2001). Elephants browsing can by itself or in combination with fire avert woodland regeneration (Barnes, 1983; 2001) and even survival of sensitive habitat types (Bell 1971; Barnes 1982; Lewis 1986; du Toit and Owen-Smith 1989; de Beer *et al.* 2005). Woodland provide important forage and shade for wildlife and the decline in adult canopy trees especially in riverine areas, where animals concentrates during the dry season, is a big concern for wildlife managers (Barnes, 2001). The damage African elephants are causing is uprooting of the tree, breaking of the main stems, making crevices in stems, and stripping away bark and wood (Laws, 1970; Pringle, 2008). This is done because it increases the food availability (Pennycuick, 1979). Some of these damages can even lead to local extinction of species (Douglas-Hamilton, 1972). Local extinction can then increase the population size of other species, creating an unbalance in the ecosystem within the protected area and then lead to damages due to high browsing and grazing pressure as in the case with elephants. More and more natural habitats have been transformed into cultivated areas around protected parts of Africa over the decades (Newark *et al*. 1994; Galanti *et al*. 2006). This has resulted in loss of suitable habitat for many animal species and has made seasonal migration difficult (Woodroffe and Ginsberg, 1998; Balmford *et al*. 2001). African elephants have even started to raid crops, which makes the elephant problem even more complex (J. Keoco, Amboseli Elephant Research Project, pers. com. 27 February 2010). Because of this there is a conflict within conservation programs between conserving viable elephant populations and conservation of plant biodiversity (Lombard *et al*. 2001; Leader-Williams *et al.* 2001). The reason for this might be that most reserves in Africa are inadequate in both size and configuration, and thus cannot support the large number of animals existing (Lombard *et al.* 2001).

The Masai Mara National Reserve has a wide range of different habitats with pure savannas and forest areas. Vegetation varies due to soil and drainage type but also by fire, rain and grazing animals (Barnes, 2001). Savannas can support more animals than any other land type, one being the bush elephant (Noad and Birnie, 1989). It is a semi-arid landscape consisting of open grassland, woodland and all mixtures of grass and trees in between. Due to drought, fires and constant crush of large herbivores, Masai Mara is dominated by resilient grass species but also inhabit the two solitary tree species Grey-haired Acacia, *Acacia gerrardii* and the Desert date, *Balanites aegyptiaca*.

The Acacia tree has been found to contain high biodiversity and influence the ecology of various species of large browsing animals (Pellew, 1983; Mwalyosi, 1990). It is a genus of shrubs and trees that tend to be thorny and pod-bearing with sap and leaves typically containing large amounts of tannins, which is an antinutritional compound (Prasad, 1995). *Acacia gerrardii*, which is called grey-haired Acacia because of their grey velvety hair on the branches, belongs to the subfamily *Mimosoidae* of the family *Leguminosae* (Hines and Eckman, 1993). It grows in arid river valleys and shrubby uplands and tolerates all soil types but prefer brackish or clay soil and occurs in woodlands and wooded grasslands (Noad and Birnie, 1989). It can become 9-10.5 meters high. It produces scattered shade with its crown and has white colored flowers in spring that develops into curved, gray, velvet seed pods. The young trees has numerous brightly white thorns that sloughes off when the branches mature and layers of bark peels of, making the mature trees almost thorn free. The tree crown is broad and is either flat topped or dome shaped. *Acacia gerrardii* loses its leaves seasonally. It can sustain at least -6.7°C and only get minor damages from temperatures as low as -9.4°C (Noad and Birnie, 1989).

Balanites aegyptiaca, also called Desert date because of its date-like nut, is commonly mistaken with Acacia trees but can be separated by looking at its green thorns (Noad and Birnie, 1989). It belongs to the subfamily *Tribuloideae* of the family *Zygophyllaceae*, but is also placed in the family *Balanitaceae* (GRIN Taxonomy, 2008). The desert date is native to most of Africa and parts of the Middle East (Hall, 1992). It grows in several kinds of habitat and tolerates a wide variety of soil types, from sand to heavy clay, and climate moisture levels, from arid to subhumid. It is rich in saponins that have been shown to have health promoting functions (Wiesman and Chapagain, 2003). The thorns are photosynthetic and so the tree is alive and functional even without its leaves (Noad and Birnie, 1989). The fruits ripen during the late dry season and early wet season and are much favored by elephants and other animals (Noad and Birnie, 1989). *Balanites aegyptiaca* can grow up to

12 meters high with a generally narrow form. It has thorny branches and several forms of inflorescence bearing yellow-green bisexual flowers which exude nectar (Ndoye *et al*. 2003). The tree also serves as shade for several animals and plants, thus minimizing the effects of hot climate and facilitating in plant growth beneath its crown (Hall, 1992). It is a highly distinctive component in the habitat due to its size, tendency to retain foliage throughout the year, massive spines and bifoliolate leaves. The desert date has adapted to the extreme ecosystem in Kenya by deep tap roots, thick bark that protects it from bush fires and it can also withstand seasonal flooding, strong winds, livestock activity and shallow and compacted soils (Hall, 1992).

Most studies on the elephant problem are about the elephants' selection of trees according to two levels of characteristics:

(1) Individual characteristics, for example tree size or species (see Owen-Smith 1988 for a review)

(2) Ecological and environmental factors that affects the spatial damage distribution, like distance between water and the trees (Field and Ross 1976, Napier Bax and Sheldrick 1963) or the tree density (Buechner and Dawkins 1961, Wing and Buss 1970).

The aim of this study was to investigate if there were any elephant damages in Masai Mara National Reserve, Kenya, by studying their eating habits and comparing damage caused to the two trees *Acacia gerrardii* and *Balanites aegyptiaca*. This would show if one tree was more preferred than the other and therefore more damaged. This study will give an over-view on how they use their habitat and how this affects the vegetation, and if they are a threat to other species in the environment by taking other animal's food or eradicate plants by overeating. Questions asked were:

(1) What do elephants eat most of and therefore cause the most damage to, small plants or trees?

(2) Do the elephants only damage big Acacias and not big Balanites?

(3) Do the thorn size on Acacia and Balanites differ?

The hypotheses were that the elephants would spend a lot of time eating and therefore affect the vegetation a lot by grazing and browsing. They were believed to damage trees more than small plants and the thorn size were believed to differ between the two trees.

MATERIAL AND METHODS

Study area

The study was done in the eastern part of the Masai Mara National Reserve (1° 25' 0 S, 34° 55' 0 E, Latitude -1,416667, Longitude 34,91667) called the Mara Triangle, covering an area of about 510 km^2, which is part of the Serengeti-Mara ecosystem (Broten and Said, 1995, Masai Mara Guide, pers. medd. 18 mars 2010). It was done in the late dry and ongoing wet season 2010. The Mara Triangle borders to Tanzania in the southeast, to the Mara River in the east and to Oloololo Escarpment in the northwest (see figure 1). Masai Mara National Reserve has a wide range of different habitats with pure savannas and forest areas. Vegetation varies due to soil and drainage type but also by fire, rain and grazing animals. There are some rocky areas and seasonal swamps, where the special soil called black cotton makes the area especially damp during the rain seasons. Masai Mara is dominated by resilient grass species but the two solitary trees Acacia and Balanites are also common in the ecosystem.

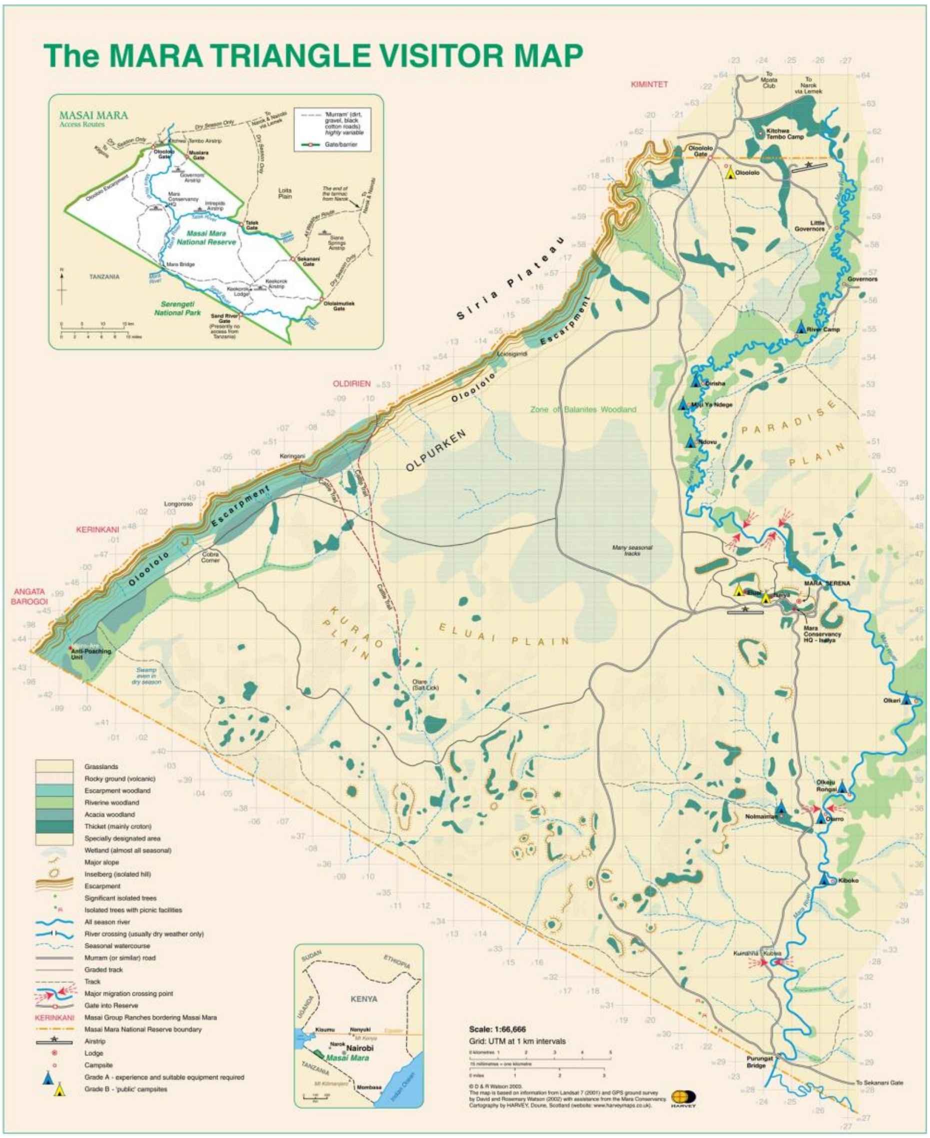

Figure 1. The Mara Triangle visitor Map. Mara Conservancy. http://www.maratriangle.org/maps/

Study design for elephant observation

Several elephant groups were randomly chosen every day and six focal animals, both female and male, were randomly chosen to represent the whole group. The elephants were observed approximately from 8 to 17 for approximately 100 hours distributed over eight days, giving a total of 48 observed elephants. We were three Swedish students and three masais that made the recordings. The elephants were observed by car (Land Cruiser) and binoculars were used to see what they were doing or eating when they stood far away. This was vital for distinguishing between grass and herbs, where grass was plain long green straws and herbs were straws with small leaves on them. When the area got to inaccessible the group was left and another were chosen instead, but to get little bias the same elephant group was followed the whole day if possible. Each observer also kept their focal animal as long as possible. Their behaviour was recorded in an ethogram by recording their behaviour every minute (instantaneous recording, at one minute interval). After recording their behavior we kept track of our focal animal until the next minute. One of us always kept the time and told us when to record the behavior. If one of us would loose its focal animal he/she would inform us and choose another one that was not one of ours. This was chosen while it is an easy way of recording how often certain behaviour is performed by the animal:

The following behavioural recording on elephant behavior was done:

- Grazing is when the animal is chewing and putting vegetates into its mouth with its trunk.
- Browsing is when the animal is having its trunk on a bush or tree (Big >2 m or Small < 2 m), putting bush or tree parts into its mouth with its trunk.

These behaviours were chosen to show to what proportion they eat certain plants (figure 2).

Study design for tree study

Observations of 11 *Acacia gerrardii* and 10 *Balanites aegyptiaca* (total 21 trees) (figure 3) trees was done in a random way, by recording elephant caused damage based on other researchers discoveries about what damage they can cause:

Data collection for tree study

- Fallen/Lying tree – The trees main stem is lying on the ground
- Broken branches – The branches are removed from their original position on the tree, either lying on the ground or hanging from the severed part
- Crevices in stem – A fracture made to the trees stem by the elephants' tusks, that splits apart the bark
- Branches missing – The branches that has been broken are not anywhere near the tree they belong to
- Leaves missing – Obvious blank spots on branches, where leaves should be
- Bark/Wood missing – Blank spots on tree stem and branches, where bark should be

These observations were made by 1/0 registration, where 1 stands for “yes” and 0 stands for “no” because it is an easy way to register certain existing or non-existing conditions. The trees position were gathered by GPS and their stem size were measured, to be able to see that they grow in the same area and were about the same size, so they could be statistically compared. The tree stem should measure between 200 and 350 cm in diameter to be an adult tree. Also the size of the thorns was measured with a measuring stick. Two thorns were measured for each tree, giving 22 thorns for *Acacia gerrardii* and 20 thorns for *Balanites aegyptiaca* (total 42 thorns). They were chosen randomly.

Statistical analysis

The statistical computer program Minitab was used to perform statistical validations of the results. Only nonparemetric tests, Mann-Whitney and Kruskal-Wallis, were used due to the factors being not normally distributed according to the normality test. Because the large amount of animals, normal distribution was chosen. The computer program Excel was used to draw diagrams that show the distribution between the different behaviours.

RESULTS

What do elephants eat most of and therefore cause the most damage to, small plants or trees?

The elephants in Masai Mara were eating mostly grass and herbs and almost no observation of browsing were done (figure 2).

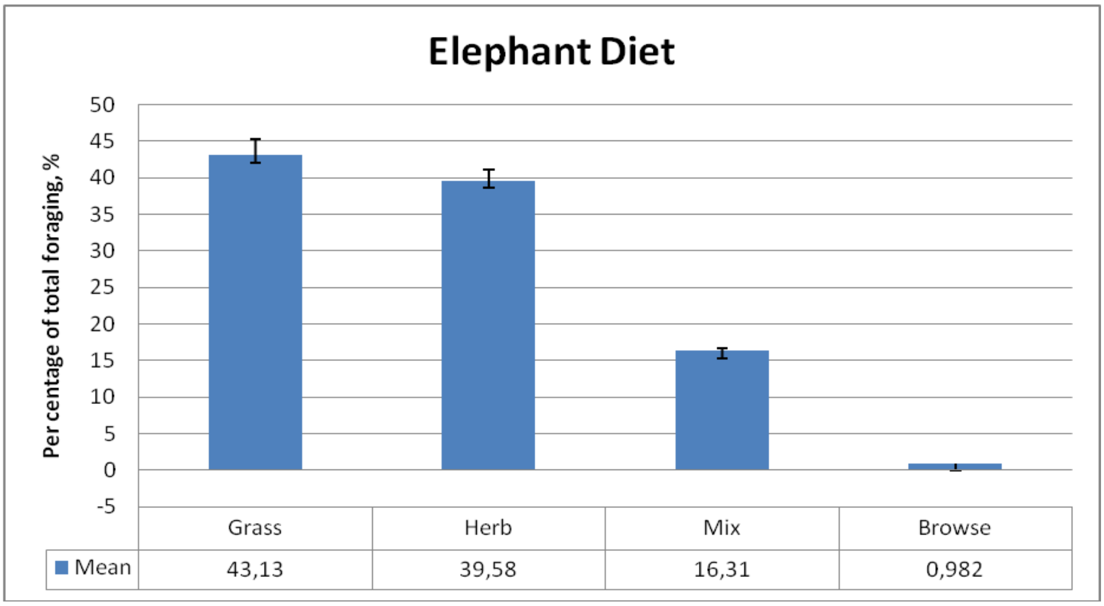

Figure 2. Mean percentage (± SE) of recordings of elephants eating grass, herbs or mix of grass and herbs or browsing during daytime in Masai Mara (n=48 elephants).

During the observation the elephants seemed to eat almost exclusively herbs. Though according to the data analyze (figure 2) this was not the case. Still the proportion of recordings of eaten grass and the proportion of eaten herbs differ only by approximately five percent. A statistical test was performed and showed that there is no difference in the proportions of recordings of eaten grass and eaten herbs ($p=0.438$). The proportion of recordings of eaten both grass, herbs and mix was however larger than the proportion of eaten browse ($p<0.05$).

Do elephants only damage big Acacia trees and not big Balanites trees?

According to the data analyze (figure 3) both big Acacias (mean 200 cm in diameter) and big Balanites (mean 300 cm in diameter) were damaged by elephants.

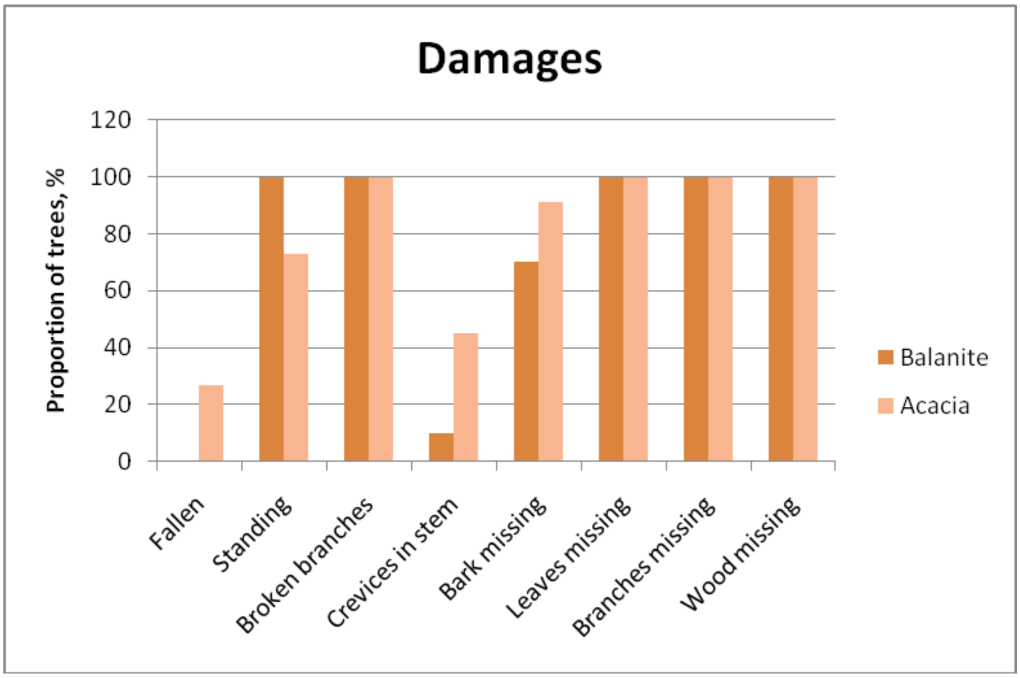

Figure 3. Proportion of trees damaged of Acacia gerrardii and Balanites aegyptiaca by elephants in Masai Mara, n= 11 Acacia and 10 Balanites. (Standard error is not shown due to them being so small and almost not visible.)

The results show no clear significant differences between the levels of damage between the trees. There tended to be a small difference between the trees in the "fallen"-category ($p=0.082$) and in the "Crevices in stem"-category ($p=0.08$), pointing on Acacias beeing more damaged.

Do the thorn size on Acacia and Balanites differ?

The thorn size of Acacia and Balanites were different (figure 4). The statistical analyze show that their thorn size is significantly different, Balanites being longer (p>0,001).

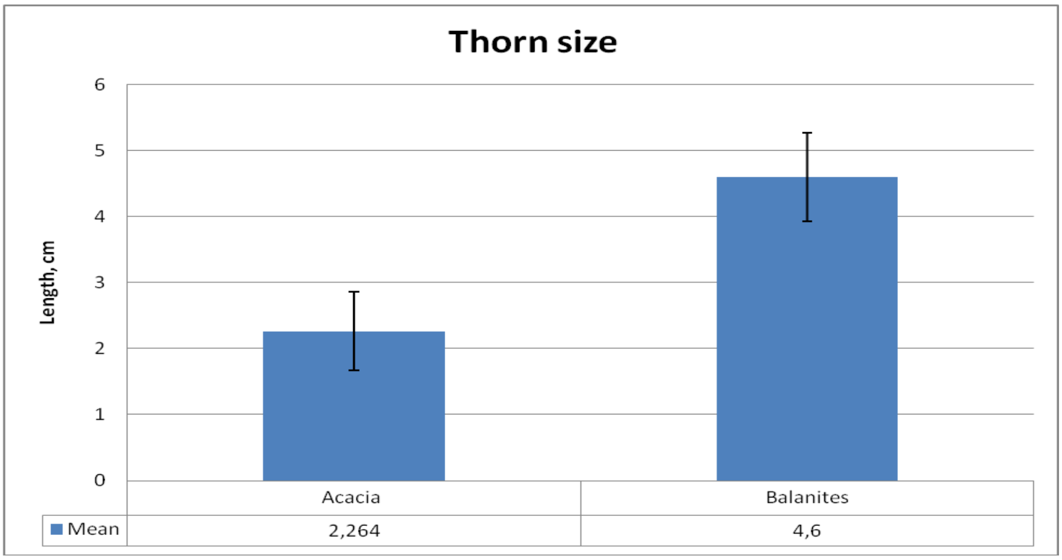

Figure 4. Mean length in cm (± SE) of thorns of Acacia gerrardi an Balanites aegyptica (n= 22 Acacia thorns and 20 Balanites thorns).

DISCUSSION

The aim of this study was to see if there were any elephant damages in Masai Mara National Reserve, Kenya, by performing a behavioural study on their eating habits and comparing damage caused to the two trees *Acacia gerrardii* and *Balanites aegyptiaca*. This is important to know in conservational situations, to establish if one species is threatened by another species, as in the case of elephants and some trees. So by investigating how elephants affect the environment in Masai Mara it can lead to future knowledge about how threatened certain trees are and lead to more interest in the matter and continuing research that leads to more secure and groundbreaking results for elephants and their habitats future.

What do elephants eat most of and therefore cause the most damage to, small plants or trees?

The elephants in Masai Mara spent a lot of their time, as has been shown for all elephants (Briggs, 2007), eating and searching for food so they have an obvious impact on their environment.. There were a lot of vegetation because of the recent rain and often during the study the elephants moved in areas where they were alone and therefore did not compete so much with other animals.

Elephants are so called ecosystem engineers which affect the abundance and diversity of sympatric species (Pringle, 2008). Their change in environments influences availability and distribution of resources for other animals (Rutina *et al*. 2005). For example the conversion of woodland to shrubland has been shown to favor the impala *Aepyceros melampus* population. The created shrubland has contributed with more available dry-season browse and has lead to an increase in impala population in some areas. They have also complex scale-dependent effects on habitat structure and studies have shown that elephants serve as agents of habitat creation for small vertebrates (Pringle, 2008). By breaking tree limbs and stripping bark they create crevices that lizards and other small vertebrates use as refuges. Lizard densities even seem to be regulated by the local density of elephant-damage trees, and vacate trees that lack these special crevices (Pringle, 2008).

However their role in increasing habitat complexity at restricted spatial and temporal scales, by modifying woody-plant architecture and increasing exposed woody surface area is not widely accepted (Pringle, 2008) and several means to solve the elephant problem, such as artificial water supplies, improved fire control, reducing human pressures, culling, noninterference, and poaching, have been discussed (Barnes, 1983). Culling of elephants has though been ruled out in all problem areas as an option to reduce the grazing pressure but there are both economic and social reasons to controlling them, and their range in certain areas may have to be artificially restricted (Lombard *et al.* 2001; Skarpe *et al.* 2004.

While this study was performed during the late dry and ongoing wet season it does not reflect the elephants preferred diet during the dry season and do not give the whole picture on how they affect the vegetation. However the observations do concur with elephants' usual wet season diet of grass and herbs. No elephants were spotted in the woodlands, though evidence such as fallen trees and severe browsing pointed at them being there at some point. Instead they were out on the savannas eating grass and herbs. The tree damages could though been caused earlier, concurring with elephants' dry season diet, but this cannot be proven because of no observations during the dry season. However some of the fallen Acacias still had green leaves on them suggesting that the tree was recently pushed over, concurring with O' Conner *et al.* (2007) conclusion that elephants eat woody plants for a longer period during the year. They also seemed to be eating almost exclusively green herbs but the data analyze shows differently, but this may be due to a misunderstanding in how to register behaviours. The masais did not understand right away that they were supposed to discriminate between grass, herbs and mixed when registering grazing and just wrote grazing, so many of the herb data might have been lost. This can also be due to lost data in the form of "Unknown", which was not accounted for in the proportions of the diet products. The unknown data showed unspecified foraging which could have been any of the diet products. However if the elephants were eating more of one plant they could cause an unbalance in the ecosystem and affect other herbivores choice of food. As conclusion the elephants did not seem to affect the vegetation in a severe way that could cause extinction, but to know that you have to also register the change in nature over time in the areas where they foraged. So in future researches there must be a longer research period, both rain and dry season, and a comparison of the nature before and after elephant foraging.

Do elephants only damage big Acacia trees and not big Balanites trees?

The elephant study took a lot more time than planned because the elephants were difficult to find and could not be followed everywhere, as when they moved into rocky and swampy areas. Bad weather made the roads that consisted of black cotton soil very slippery and hard to drive on, and therefore made it difficult to get to both the elephant and the tree research areas. The masai that was supposed to help with the recognition of the trees could not partake and so the determination of every tree took much longer then it was supposed to. This resulted in that not as many tree data as planned (50 or at least 25 of each tree) were collected and that makes the results not statistically reliable enough to make clear statements about their damages.

The recordings also contribute to the result not being reliable. Both "leaves missing" and "broken branches" are misleading registrations because they only show that they are missing and broken but not to what extent. It could as easily been insects or other browser that had eaten the leaves, and not browsed as severely as by an elephant. The number of broken branches would also be fewer if not being browsed by so many elephants. The "proportion of leaves missing" would have given a better view on the damage level between the trees. In that way you could see that if a large proportion of the leaves were gone and at the same height from the ground it could be more applicable to elephant harm, or at least a big animal, than just acknowledge them being gone. The same applies for "broken branches", the "proportion of broken branches" would have shown if more or less branches were broken on one of the other trees and so point towards one of them being more damaged. Both of the tree species have been damaged but to different degrees, which the registrations do not successfully show because of too few recordings.

By just looking over the Balanites-woodland and the Acacia-forest you could see a clear difference, where the Acacia-forest looks much more damaged due to all the fallen trees. None of the Balanites trees have been pushed over but several small Acacias around them were severely browsed of what can be elephants. There is a trend pointing on Acacias being more damaged than Balanites but not necessarily by elephants in all cases, while also small Acacias are affected and they can be reached by smaller animals, and also insects can contribute to the damage on both big and small trees. This trend concur with the statistical data that shows that there is a tendency of significance between the damage level in Acacias and Balanites for "Fallen" and "Crevices in stem" pointing on Acacias being more damaged. Acacias are the only one of the species that has been pushed over and that is most definitely by elephants, because no other animal in the reserve could be able to do that or have been reported to perform such behaviour. Though for future researcher a camera filming the area would make the method and the results much more reliable.

Researchers have shown that elephants are selective according to tree species (Jachmann and Bell, 1985; Laws, 1970) and vary in the damaged caused to different species (Buechner and Dawkins, 1961; Leuthold, 1977). Elephants also cause more often damage to short trees, causing problems in regeneration (Laws, 1970; Wing and Buss, 1970) and knock down large trees to reach the leaves (Jachmann and Bell, 1985). Calenge *et al.* (2002) also show in their study that elephants seem to be selective, where the *Acacia seyal* woodlands in Zakouma National Park, Chad, suffered more severe damage than the Combretaceae woodlands. They further concluded that the elephants were selecting trees also according to height, which cannot be ruled out in this study. However it was not possible to collect the heights of the trees due to lack of necessary equipment. The trees were of similar age though according to the stem size but may have varied to some degree. Balanites can become slightly higher than Acacias, 12 meters versus 10.5 meters, and that can explain why Balanites are not pushed over. Their stems also often were broader than the Acacias during the measurements, more often over 300 cm. This might make them sturdier and more difficult to push over, which concurs with them being able to stand against hard winds and floods (Hall, 1992). Perhaps elephants just prefer the taste of Acacias and therefore browse them more severely, due to different content of compounds as tannins and saponins. Although Acacias has been shown to contain high concentrations of tannins that are antinutritional compounds, they might have lesser content than Balanites and therefore have a higher nutritive value. While elephants already have an ineffective digestive system it would be smart of them to choose the tree with the highest nutritive value. To know if this is true for all Balanites further investigations has to be done.

However there have been studies indicating that drought and other herbivores have a greater impact on tree mortality than elephants (de Beer *et al.* 2006). Elephant bulls have also been shown to damage woody vegetation more because of their larger body size, which makes them need more food (Guy, 1976; O'Conner *et al*. 2007).

Other studies even show that elephants can be of an advantage to the trees by for example seed dispersal of *Acacia erioloba* (Dudley, 1999) and *Balanites wilsoniana* (Cochrane, 2003). Elephants eat their fruits and pass out the seeds with their faeces, which help in their germination. They even germinate quicker from elephant dung than seeds dispersed from trees (Cochrane, 2003). Cochrane showed that seeds that passed through an elephant's gut, improved its germination (54.9% vs. 2.9%) and reduced its time to germination (82 vs. 132 days). The absolute and relative germination was expected to improve by 66% and 4000% respectively, by elephant gut passage. Dispersed seedlings also had greater survival (diverse environments, high-light conditions, negligibly affected by post-dispersal density) and height than non-dispersed seedlings, which makes *Balanites wilsoniana* dependent on elephants for its long-term persistence.

There is ongoing research on Balanites because of their decline in Masai Mara (J. Jung, Institutionen för Husdjurens miljö och hälsa, pers. medd. 25 januari 2010). Most of the Balanites in Masai Mara are not taller than one meter or they are fully grown and at least 100-150 years old. One theory to why they have such low regeneration in one study was herbivores, one being elephants. This seems to show that elephants might browse and cause severe damage to small Balanites but not to big ones while they are not as damaged as Acacias. This can be due to their deep tap root system that makes them much sturdier or them being a bit taller than Acacias. Or the Acacias in Masai Mara just grow in a less compact soil and are therefore easier to uproot. However this research is not finished so there are no clear results yet and so no clear conclusions can really be made from these. Further research has to be made to conclude if Acacias really are more damaged than Balanites and in that case why. This information is needed to be able to conclude if Acacias should be made a protected species, perhaps even listed as endangered for conservational purposes.

Do the thorn size on Acacia and Balanites affect the elephants' choice of which tree they will eat?

Some plants have been shown to increase structural defenses, such as thorns, when exposed to destructive browsing (Karban & Baldwin, 1997) and thereby limit the time which the herbivores spend eating on each individual plant (Cooper & Owen-Smith, 1986; Milewski, Young & Madden, 1991). Because of this I had a hypothesis that the thorn sizes on the trees might have an impact on how browsed and therefore damaged the tree would become. The tree with the longest thorn would be less browsed and have sustained less damage.

The measurements and statistical analyze show that the thorn size of *Acacia gerrardii* and *Balanites aegyptica* is significantly different and could therefore be of interest in elephants' choice of food and how much damage they can cause to trees. This could be the reason why *Balanites aegyptiacas* are less damaged than *Acacia gerrardiis*, because they have longer thorns thus making the tree more difficult to eat and therefore more energy is required to eat them than is retained from them. While elephants already have an ineffective digestive system, they should choose to spend as little energy on collecting food as possible if given a choice, to obtain more energy in food than they loose in work. This might be why they seem to choose Acacias before Balanites. However young *Acacia gerrardiis* have a lot of long thorns and they are eaten rigorously, but this can be due to several herbivores browsing because more animals can reach their leaves and branches. Also Milewski and Maddens (2006) showed that even some Acacias, exposed to intense browsing, produced long thorns. More research has to be done to get a certain result, both on big and small Acacias and Balanites to see if it is only elephants that causes the most damage to the small trees. Much longer time is also needed to be able to see if both trees develop longer thorns after heavy browsing. Other reasons than thorn size should also be tested, for example height and broadness and their connection with how sturdy the tree is, difference in compound content of for example tannins and sapponins and their connection with palatability, and difference in nutritive value to see if perhaps Acacias have a higher nutritive value and therefore is eaten more.

CONCLUSIONS

The results from the tree study are not statistically reliable because of too little contained data, due to lack of time, equipment and information. The elephant affect the grass/herbs and trees a lot because they spend most of their days eating and they are causing damage to Acacias. Both Acacia trees and Balanites trees were damaged in a way that only an elephant could have done it, referring to broken head branches and fallen trees, but only Acacia trees had been pushed over. So, there is a trend that is pointing towards more damage caused to Acacia trees, while they are the only once that are fallen. The elephants seemed to eat more herbs than grass but not according to the data analyze. However if they would eat more of one species it could lead to an unbalance between these species and cause problems in the ecosystem. The thorn size of *Acacia gerrardii* and *Balanites aegyptiaca* is significantly different and might be of interest in elephants' choice of which tree they choose to eat. More research must be done to retain sufficient data to make any real conclusions about elephants' impact on the trees and vegetation in Masai Mara. Much more time is also needed to be able to retain as much data as possible, due to all the complications that can occur. More elephant studies are needed to be able to get an answer to the elephant problem and so save the elephants and their habitat, to obtain both a healthy viable elephant population but also protect the Acacias for conservational purposes and future populations.

While this research was incomplete due to unplanned obstacles the results are also incomplete and nothing can be really said about elephants affect on their environment and what it means for their future in the reserve or if Acacias or Balanites are threatened species. However this little project might have tickled someone's interest and may lead to future research that can secure elephants and trees survival in the future. Different methods can be tested and so probably obtain better results while this method had its faults and failed in getting a reliable result.

ACKNOWLEDGEMENTS

Maria Andersson, Jens Jung, Lena Dahlström, Lina Olofsson, Gilbert, Daniel, Kimia, Silooloo, Mikaela Persson Wallenius och Linda Andersson, for all the help with the registrations, driving, statistical analyze and composition of the report.

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