Czech University of Life Sciences

Faculty of Tropical AgriSciences

Department of Animal Science and Food Processing in Tropics and Subtropics

Flight distance and response with special attention to ungulates: Does the type of stimuli matters?

Bachelor thesis

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Supervisor:

Ing.Radim Kotrba, Ph.D.

Author:

Lukáš Pelikán

Author's declaration

I, Lukáš Pelikán, hereby declare that I have elaborated my thesis: „Flight distance and response with special attention to ungulates: Does the type of stimuli matters?“ independently, only with expert guidance of my thesis supervisor Ing.Radim Kotrba, Ph.D. and used only cited literature. I agree to deposit my thesis to library of Czech University of Life Sciences and opened up as a study material.

In Prague 1st of May 2013

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Lukáš Pelikán

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I am indebted to Ing.Radim Kotrba, Ph.D. for his great guidance of my bachelor thesis. I would like to thank for technical and material support, advices and recommendations and willingness. I would love to thank to family and friends for their support, help and patience.

Abstract

Flight initiation distance (FID) is used by many authors to describe animal’s tolerance to source of disturbance. It is also used to evaluate well-fare and human caused stimuli influencing species in and off the proximity to human residency, infrastructure, roads and trails. I prepared this review to compare and evaluate many factors affecting ungulate’s FID (e.g. habitat type, predator behavior, group behavior and finally human disturbance). Across all studies I found evidence that ungulates pay attention as a response to specific predator’s / stimuli behavior. Direct gaze is more threatening to them and their response is greater. Also speed of approach is making differences. Habitat type and height makes a difference in response, because animals in short vegetation are showing more intensive response than in higher vegetation. There is a prove that specific group composition is affecting prey’s behavior (male groups don’t show equal or greater flight distance than female groups with offspring). The influence of hunting and poaching is also discussed. Humans on foot are more disturbing stimuli than vehicles or aircraft. Results also show that flight distance is increasing with rising distance to touristic circuits. All these factors are summarized and tabularized based on published data.

Key words: Anti-predator behavior, Deer response, Escape behavior, Escape reaction, Flight distance, Group behavior, Predator behavior, Ungulate responses

Abstrakt

Útěková vzdálenost je užívána mnoha autory k popisu tolerance zvířat ke zdroji vyrušení. Také se používá k hodnocení kvality well-fare a vlivu stimulů, způsobených lidmi, které ovlivňují druhy nejen v blízkosti, ale i mimo dosah lidských sídel, infrastruktury, silnic a tras. Připravil jsem tuto rešerši, ve které porovnávám a vyhodnocuji mnohé faktory ovlivňující útěkovou vzdálenost kopytníků (např. typ habitatu, chování dravců, skupinové chování a nakonec rušení způsobené lidmi). Skrze všechny studie jsem našel důkazy, že kopytníci zbystřují v reakci na chování dravců / stimuly. Upřený pohled je pro ně větším rizikem a jejich reakce je markantnější. Také rychlost přiblížení vykazuje rozdíl. Typ a výška vegetace vytváří rozdíl v reakci, protože zvířata v nižší vegetaci ukazují více intenzivní odezvu než zvířata ve vyšší. Bylo prokázáno, že specifické složení skupiny ovlivňuje její chování (skupiny samců nevykazují stejné nebo delší útěkové vzdálenosti než skupiny samic s mláďaty). Také pojednávám o vlivu lovu a pytláctví. Chodci jsou větším rušivým elementem než vozidla nebo letadla. Výsledky ukazují, že útěková vzdálenost vzrůstá s rostoucí vzdáleností od turistických tras. Všechny tyto faktory jsou shrnuty a zapracovány do tabulky, založené na publikovaných datech.

Klíčová slova: Chování proti dravcům, Reakce jelenovitých, Útěkové chování, Reakce útěkem, Útěková vzdálenost, Skupinové chování, Chování predátorů, Reakce kopytníků

Contents

1 Introduction

Through recent years, scientists are trying to answer questions about human effects to nature. Effects are not measurable often but few of them are. Flight initiation distance is one of them and is measured to find out how species are tolerant to human disturbance.

Flight initiation distance(FID) is based on Ydenberg and Dill’s model (Ydenberg and Dill, 1986). This model is graphical variation of cases of the flight. Many scientists tried to explain it and also make a mathematical model of that (Cooper and Frederick, 2007). Those formulas should be applicable to different cases and types of disturbance.

Most of the questions are aimed to effects by various stimuli. They are studying effects and differences between reaction to walkers, vehicles or aircraft. Or they study influence of habitat, altitude, group behavior etc. We can find many observations and paper works made by professors at great universities. When you are looking for information online first of the names is usually Theodor Stankowich. His observations are all about ungulates, especially deer in North America. He also wrote work where he summarized all observations and answered questions about influence and types of stimuli (Stankowich, 2008). This type of review we can also find in Frid and Dill, (2002).

It is interesting that due to results, ungulates are responding to hikers and people on foot in general more than to vehicles or aircraft. FID is also affected by environment but it is not by every part of it. The biggest problem is that this influence is observed only shortly and they are not long term. We don’t know long term effects yet and it should be improved.

1.1 Goals of the thesis

Goal of the thesis is to make a new order and summarize reviews and observations which have been made in past and answer to tasks if and how flight distance is affected by types of stimuli. Main task was human disturbance to ungulates and its influence. Comparing different types of stimuli and if they matter to FID.

In parts below I explain two concepts to improve understanding of my thesis and at the end of introduction part is the list of species I write about. First of my questions was how is flight distance influenced by habitat type. Next are group and predator behavior and finally human sources of disturbance.

1.2 Flight initiation distance

Flight initiation distance (FID) is distance between predator and prey when prey starts escape (this distance is also called approaching distance) (Cooper and Frederick, 2007, Stankowich, 2008). It can indicate fear in animals and can show us another view to animal welfare. In fact even disturbance can be detected and it is increasing alertness and heart rate (Stankowich, 2008). *Range of disturbance is greater than flight initiation distance (Stankowich, 2008).* Some researchers think that FID is not accurate indicator of human disturbance because there are differences between areas with regular disturbance where animals are in contact with humans daily and areas with almost none touch of human disturbance. So because of this we can measure more indicators of disturbance. For example: Alert distance (AD), where prey is alerted to presence of predator, flight initiation distance to roads or to sources of disturbance (Stankowich, 2008, Frid and Dill, 2002, Cooper and Frederick, 2007, Stankowich and Blumstein, 2005).

1.3 Ydenberg and Dill model (1986) and its modifications

This model has been leading many studies about economy of predation risk and its costs. It had a great influence to them, especially its graphical presentation (Ydenberg and Dill, 1986, Cooper and Frederick, 2007). But still this model has its own deficits. In premise there is not counted fact that prey should not escape from predator immediately after seeing predator. Model is premising that escape begins when predator reaches distance where costs of resting and escaping are equal. There are many new modified models showing situations when escape is immediate (minimum distance) and situations when there is no fleeing from predator (maximum distance) (Blumstein, 2003, Stankowich, 2008). These models refer that prey cannot increase its fitness when meets the predator. At this time for prey are costs of loosing opportunity and risk of predation are equal and escape is only chance to stay alive.

Ydenberg and Dill’s model shows indirectly relationships between fitness and flight distance but there is no quantitative prediction about approaching distance and there is no empirical information about form of such function (Cooper and Frederick, 2007). As a result this model shows regular predictions about approaching distance, predation risks and its costs. Cooper tried to develop a mathematical version of Ydenberg and Dill’s graphical model (Cooper and Frederick, 2007). He presents prey with starting fitness when prey detects predator. Costs of escape are benefits which can be lost. Those benefits can be obtained by not escaping or by emerging.

Cooper shows in his research two cases for new model. First one is when benefits are lost because prey is killed and another one is that benefits are kept even after death. In model, when cost of remaining are greater or equal to cost of escaping prey should escape, in another case when benefits are greater than cost of remaining prey stays at same place (Cooper and Frederick, 2007, Ydenberg and Dill, 1986).

1.4 Ungulates

Through the years, FID is measured to different species. Stankowich and others are specialized to ungulates (Ungulata) (class: Mammalia, infraclass: Eutheria, super-order: Laurasiatheria). This group of animals is divided into Perissodactyla (contains horses, zebras, tapirs and rhinoceroses) and Artiodactyla (camels, llamas, pigs, giraffes, antelopes, deer etc.). Most of researchers is specialized to artiodactyls especially, deer. Theodor Stankowich made in his research (2008) table (I add this table into attachments) containing many species which were observed because of the flight distance.

These species are: Columbian black-tailed deer (*Odocoileus hemionus columbianus*), white-tailed deer (*Odocoileus virginianus*), fallow deer (*Dama dama*), roe deer (*Capreolus capreolus*), red deer (*Cervus elaphus*), chamois (*Rupicapra rupicapra*), mule deer (*Odocoileus hemionus*), North American elk (*Cervus canadensis.*), moose (*Alces alces*), caribou (*Rangifer tarandus*), dall’s sheep (*Ovis dalli*), bighorn sheep (*Ovis canadensis*), muskoxen (*Ovibos muschatus*), mouflon (*Ovis aries orientalis*), guanacos (*Lama guanicoe*), vicuñas (*Vicugna vicugna*), blesbok (*Damaliscus pygargus phillipsi*), North American bison (*Bison bison*), European bison (*Bison bonasus*), gazelles (*Gazella sp.*), giraffe (*Giraffa camelopardalis*), ibex (*Capra ibex*), impala (*Aepyceros melampus*) etc. (Stankowich, 2008).

2 Methods

As primary source of information the Web of Knowledge, Science-direct and Google Scholar were used. Most of researches I found and which have been found on web were written by Theodor Stankowich (Stankowich and Blumstein, 2005, Stankowich and Coss, 2006, Stankowich and Coss, 2007a, Stankowich and Coss, 2007b, Stankowich and Coss, 2008, Stankowich, 2008, Stankowich and Caro, 2009) or D.T. Blumstein (Blumstein *et al.*, 2003, Blumstein, 2010). I looked inside their work and looked at references they have there. Then I used online search to find them.

After this procedure I sorted all of researches I found into groups by stimuli they discussed. I had group of habitat types, behavioral changes and its factors and human disturbance types. I collected about 50 references.

To make an order in my references and easier used citations of them in my thesis I used "Endnote.web". I created profile in online version and inserted references there. Endnote.web allows me to connect my word file with online databases to work on my thesis easier and more effective. I had to download application word Windows 7.

Almost every online database was connected to Endnote. I collected 51 references and then I examined them to the topic of my thesis. Not every result was actually used for comparison, because online search can show aircraft problematic when you look for flight distance. And of course when you search for longer terms, internet search software finds single words in whole titles and in 80% they are not what we need. For example if you tape keyword "escape distance", there are 2495 results but you have to sort them or specify topic you are looking for. If you just add word "deer" number of results decreases rapidly to 31.

After organizing all papers I collected I had to go through them and make a list of factors I write about. I marked group of factors as an "external" what means habitat, vegetation, elevations and altitude to me. Other group was called as a "behavior factors" (presence of lamb, group size and reproduction season), then "predator behavior", last group "human disturbance". Last one includes all types of human effects to animals in general, especially to ungulates. Include hunting, poaching, stimuli types (walkers, vehicles and aircraft) and infrastructure. I asked simply questions and used results of observations which have been made. I resorted all results and studies and discuss it in my Discussion part of my thesis.

3 Results and discussion

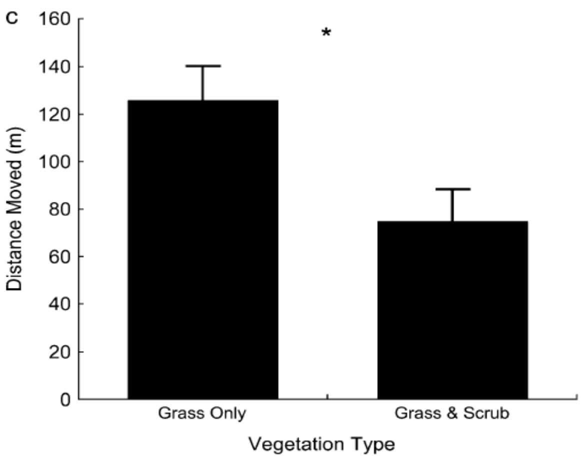
3.1 *Is there any influence by habitat type to flight initiation distance to ungulates?*

In Sibbald 2011 (Sibbald *et al*., 2011) was proved that there is a difference in type of habitat in relationship with number of hikers. Observation was shown on Sundays and Wednesdays, at day (8:00-20:00) and at night (22:00-8:00). Following habitats were *rough grassland, smooth grassland, woodland, heather moorland, grass/heather mosaics.* Distance was measured in meters.

	Day		Night			
Habitat type	Sunday	Wednesday	Sunday	Wednesday	SED	MCP
Rough grassland	118	107	112	88	13.1	106
Smooth grassland	191	182	185	177	7.1	173
Woodland	393	344	266	296	48.5	350
Heather moorland	433	325	443	390	55.2	843
Grass/heather mosaics	516	323	356	175	42.9	1,085

Table 1: adopted from (Sibbald *et al*., 2011).

If we compare day period in simple habitats we can see differences only in grass/heather mosaics where during the day distance is as twice longer as during the night (Day Sun 516m – Day, Wed 323m x Night Sun 356m – Night Wed 175m). We can also see little diff in woodland, but it's all about 1/3 of distance and it's not so obvious just like in G/H mosaics. In general there are small differences between days in week, but differences between days were little if we count diff in numbers of walkers. If we take a look at woodland animals there are further from roads on Sundays during day than at night (day x night: S 393/ W 343 x S 266/ W 296). Other option for me is observation in day and comparing types of habitat and its effect to distance. There is a mark able difference when we compare Grasslands and Woodland / Heather. Distance in grasslands is not reaching 200 meters but in woodlands and heathers for example is always higher than 300 meters. The highest is in Grass/Heather mosaics where on Sundays is over 500 meters and on Wednesdays is over 320 meters. In heather moorland we can see 2nd highest distance at day on Sundays = 433m (more hikers). There is almost no diff in distance in heather/grass mosaics and heather moorlands on Wednesdays during the day (8-20). But on Wed is the highest distance in woodlands. Otherwise, in grasslands in general there are distances lower than in other habitats. The lowest is in rough grassland (Sun 118m/ Wed 107m). In smooth grassland is distance Sun= 191m/ Wed= 182m. As we can see diff in day of the week is not so obvious so the number of visitors is not important. When I compared distances at night I can see similarity to day's distances. But there is a change in maximum distance and it's in heather moorland (Sun 443m/ Wed 390m). And there is not obvious change in diff on Sundays to Wednesdays. What we can is that in grass/heather mosaics is huge difference during the week. On Sundays is distance = 356m and on Wednesdays = 175m. Little change is in woodlands where animals are farther on Wednesdays than on Sundays but it could be caused by errors in measures or by missing dates (Sibbald et al., 2011). The expectations of similar diff like in day distances were confirmed. We can see one more time that in grasslands are distances smaller than in woodlands and heathers. Due to Stankowich (Stankowich and Coss, 2007a, Stankowich, 2008) there is a no connection in escape and vegetation height. In 72 reps deer escaped to taller vegetation in 21 trials and to lower vegetation in 7 trials. In most cases there was no change in vegetation height (44 reps). Stankowich mentioned that "*during these observations deer had a equal chances to run uphill or downhill and run to different vegetation height*" (Stankowich and Coss, 2007a). We can also see that there was a difference in flight distance depending on vegetation type. In land with grass only ungulates run away farther than in area with grass and scrubs. And there is a dependence of trotting duration on vegetation height. In lower vegetation deer is running longer than in higher (Stankowich and Coss, 2007a). When we are talking about use of habitat we have to count with elevation changes as well. In Stankowich and Coss, (2007a) is observing changes in elevation during escaping from approaching predator (or human). In total of 88 trials deer didn't change elevation or escaped uphill for 75 times. In 32 trials ran uphill and in 43 did not change elevation at all, only in 13 trials deer fled downhill (Stankowich and Coss, 2007a). Ungulates are also running for a longer time when they are escaping uphill or they're not changing elevation. If they run downhill time of trotting is shorter.



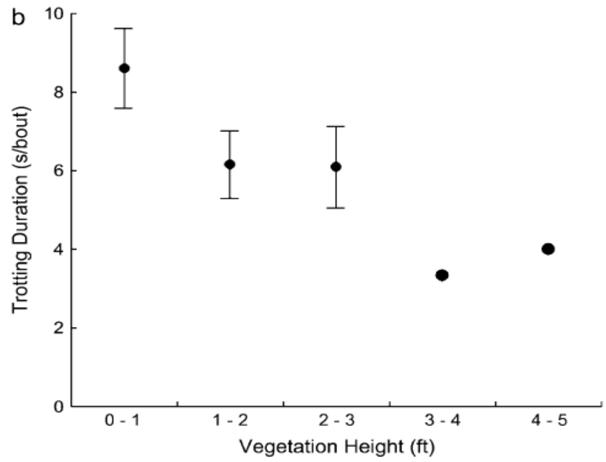


Figure 1(a) and 2(b): adopted from (Stankowich and Coss, 2007a).

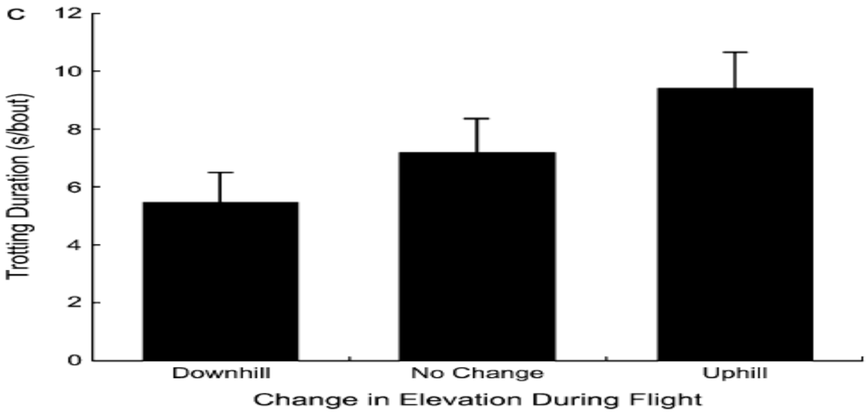


Figure 3(c): adopted from (Stankowich and Coss, 2007a).

3.2 How is angle of escape changed by approaching predator?

Stankowich was observing the angle of flight depending on the approaching predator (Stankowich and Coss, 2007a). During his research he found out that there is no influence by predator behavior, group size, vegetation, sex of group or elevation (Stankowich and Coss, 2007a). Ungulates, Columbian black-tailed deer in this case, ran away in average angle of 135.9° +/- 3° away from threat (predator, human) with range of 70° to 100° (Stankowich and Coss, 2007a). Deer is escaping in greater angle when it's running longer distance.

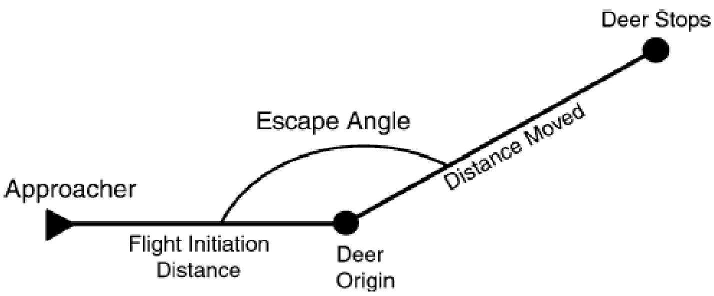
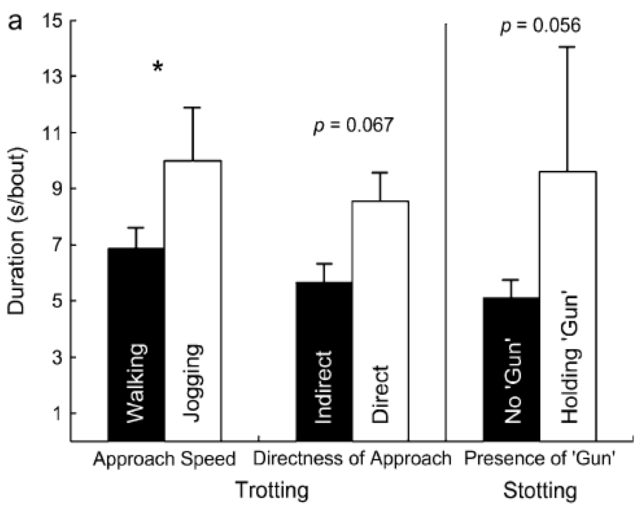


Figure 4: adopted from (Stankowich and Coss, 2007a).

3.3 Is flight distance regulated by behavior of approaching predator?

As I mentioned above, predator behavior could be stimuli to flight initiation distance to ungulates. We can find some results in Effects of Predator Behavior and Proximity of Risk Assessment by Columbian black-tailed deer (Stankowich and Coss, 2006) where is evident effect of predator speed and directness of approach. When predator (or human) is coming towards to animals more accurate or faster, ungulates are running longer distance. Stankowich used two types of closing distance to them – walking and jogging. It's showing that faster approach is causing longer flight. Same sample is when we take a look at directness of approach. If predator is coming directly towards to prey, they evaluate it as a more threatening and run greater distance. Ungulates are responding also to intention. Predator can gaze prey directly and respond is same as in previous cases. Averted gaze is not so threatening for them so they escape shorter distance. Ungulates are reacting for alerts. We can measure alert distance. But when we talk about FID, we can observe how it is regulated by alerts from predator. It could be caused by sharp moves or sounds. There is big difference between Not Alerted Prior and Alert Prior. When animals are alerted earlier they run longer distance. Due to Stankowich and Ydenberg and Dill (Stankowich, 2008, Stankowich and Coss, 2006, Ydenberg and Dill, 1986) we can prove that ungulates react to predator behavior by escaping further distances. But we have to count that in these observations were counted cases only for each type of stimuli. For example when they observed speed of approaching predator they did not simulated "holding gun". All other effects can change our results and have an impact to flight initiation distance. Combining these effects should be more studied because there are not so many studies focused to predator behavior and its effects to ungulates and flight initiation distance.



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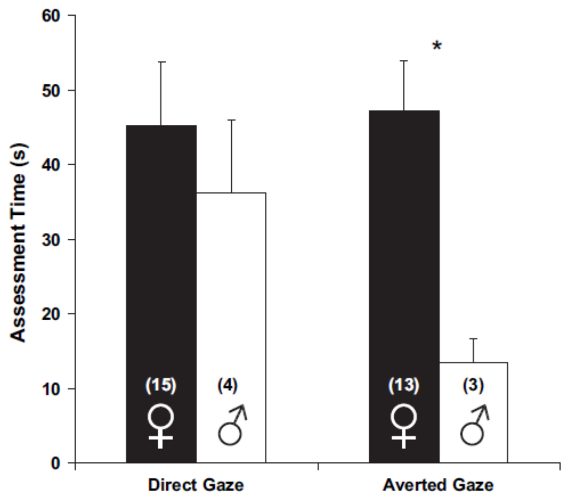

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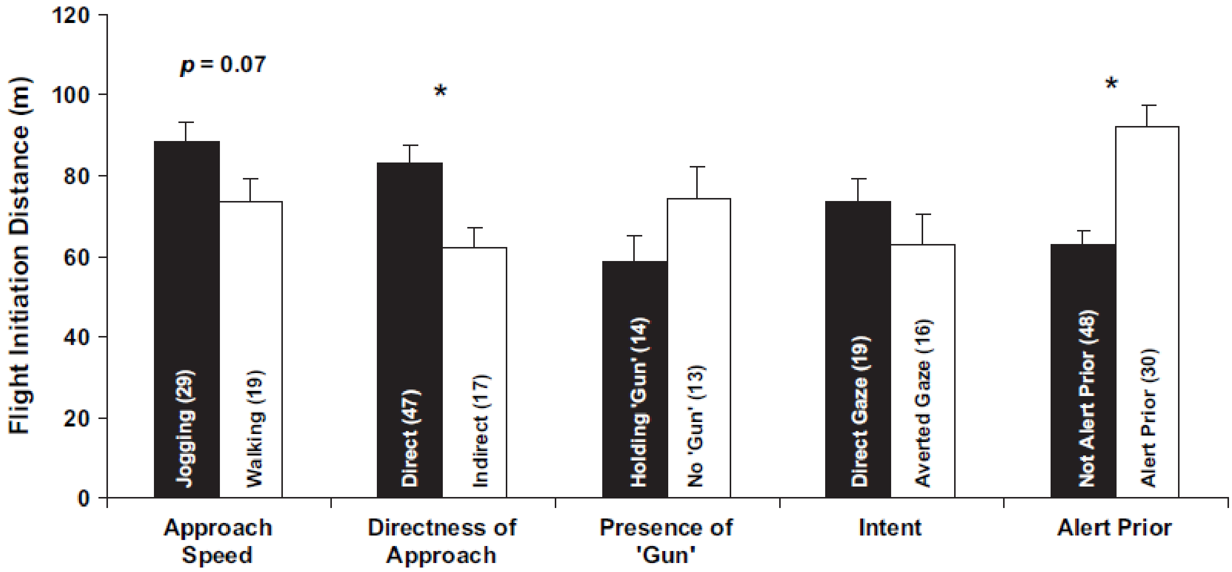


c

Figure 5 a, b, c : 5a adopted from (Stankowich and Coss, 2007a), 5b and 5c adopted from (Stankowich and Coss, 2006)

3.4 Does the type of predator camouflage matter? How are ungulates reacting to that?

When we are talking about behavior of predators we have to count with their natural appearance. It means type of camouflage for us. In Re-emergence of Felid Camouflage with the Decay of Predator Recognition in Deer under Relaxed Selection (Stankowich and Coss, 2007b) we can study on free-living deer in California in different types of vegetation. They used electronically scanned models of predators in high quality. Models were positioned in distance of 15 – 70 meters from focal individual to avoid sudden surprise (Stankowich and Coss, 2007b). Stankowich and Coss observed and analyzed deer responses to appearance of predator. Starting with "warning behavior" as a snorting ("*audible expulsions of air through the nose*" (Stankowich and Coss, 2007b)) and "alarm-walking" ("*Deer walk more slowly and limbs are raised in the air in exaggerated fashion, this behavior was proved in mule deer predator-prey circumstances*" (Stankowich and Coss, 2007b, Caro et al., 2004)). Every trial was taped on video-camera and time of this behavior was counted since model of predator was detected. For these observations were used four types of model – Puma, Leopard, Tiger and Deer.

As we can see in figure, reaction to deer model was minimal. There were no occurrences of snorting and foot-stamping was counted only three times. Deer model was not threatening individuals so reaction was almost none (Stankowich and Coss, 2007b). *Foot-stamping and snorting are proved indicators of predator recognition in many ungulates species* (Caro *et al.*, 2004, Stankowich and Coss, 2007b). *Two-dimensionality of models did not effected results* (Stankowich and Coss, 2007b). If we compare each predator model, only tiger and puma caused not only snorting but even foot-stamping more than deer model and only tiger model evocated alarm-walking. Deer model and Leopard model had similar results in foot-stamping and alarm-walking. The frequency of deer snorting or alarm-walking when tiger was indicated was intermediate to that leopard and puma, but only differences between tiger and leopard were relevant (Stankowich and Coss, 2007b). In fact all of three predator models had a big impact to deer more than deer model and also reaction to tiger and puma was markedly lower than to leopard (Stankowich and Coss, 2007b). Stankowich and Coss examined latency of foot-stamping and alarm-walk from the first time of predator detection. Latency was much faster to tiger and puma than to deer and leopard. When we compare pairs of models – Tiger and puma and Deer and leopard, we can see that there is no significant difference between those pairs. Same trends we can watch in observing alarm-walking. We can see sooner reaction to tiger and puma model than to deer and leopard model. In this observation there was no effect of herd size to responds on predator presence (Stankowich and Coss, 2007b).

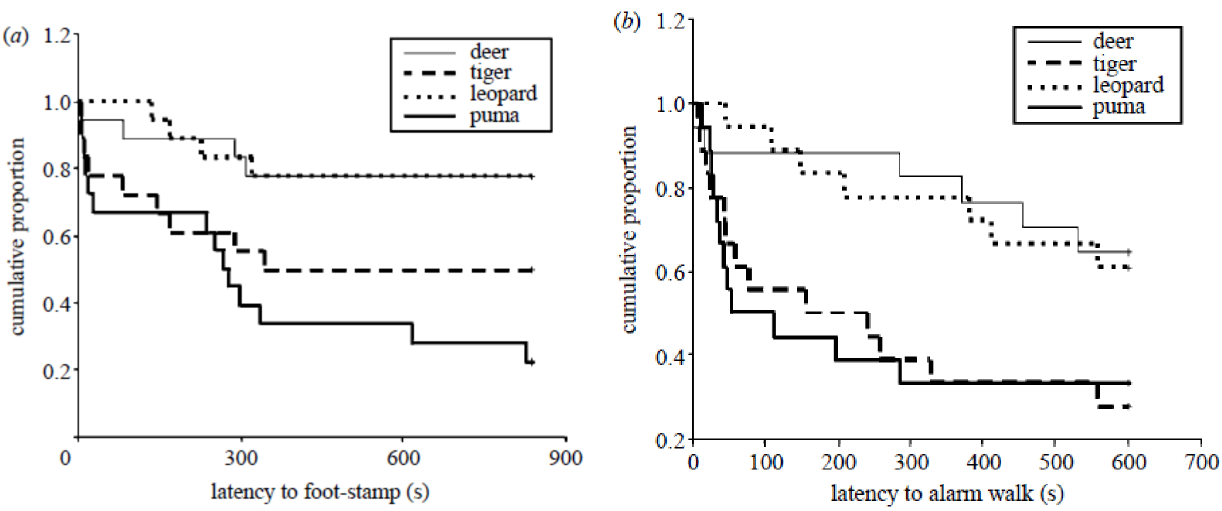


Figure 6a and 6b : adopted from (Stankowich and Coss, 2007b).

3.5 How is group size affecting ungulate behavior?

Solitary species are usually small in comparison with others. But there were proved exceptions, when bovid and artiodactyls live in herds or groups. It's usually associated with living in great open areas. We can find ungulates living in groups in deserts, grassland, scrub and in tundra (Caro *et al.*, 2004). We can also find behavior called "the follower strategy". With group living is associated scattering as an anti-predator behavior. It is typical for species living in open environments. Scattering means that individuals are running to different directions to confuse predator and increase chances to survive. *Scattering was not associated with species pursued by coursing predators* (Caro *et al*., 2004). For groups of big number of individuals is strategy bunching. Mostly bunching species are also large in size (weight). It means that individuals are moving closely to avoid predator attack.

In fact, we can say that there is not so big effect by size of group to flight initiation distance or escape distance. Differences in FID are very weak (Stankowich, 2008). All what we can observe is that larger groups are more patient about predator presence.

3.6 Is lamb presence and sex of group affecting flight response to ungulates - Sardinian mouflon (Ovis orientalis musimon)?

Simone Ciuti was observing Sardinian mouflons and The Key Role of lamb presence in affecting flight response in Sardinian mouflon (*Ovis orientalis musimon*) (Ciuti *et al*., 2008). In results of study we can see that mixed groups appeared during the rut (23 - 37%), then gradually decreased in following month and almost did not appeared during the lambing season (6 – 10%) (Ciuti *et al*., 2008). When we take a look at effect by lamb presence in individual groups divided into male groups, female without lambs, mixed groups and female with lambs we can see that male groups are escaping at the shortest distance followed by female groups without lambs. Than Mixed groups and female groups with lambs are running at the longest distances. If we want to compare these groups we have to think about lamb presence in mixed groups and females with lambs. In mixed groups is consequence of the lamb presence (Ciuti *et al*., 2008). We can see differences between sex groups and their natural behavior to predator presence and their reaction. Groups where are females and lambs are running at greater distances to increase chances of surviving their offspring (Ciuti *et al*., 2008, Mooring *et al*., 2003). It's caused by different strategies in reproduction (Ciuti *et al*., 2008, Mooring *et al*., 2003, *Main et al*., 1996). It shows not only differences caused by lamb presence but also sexual dimorphism (Ciuti *et al*., 2008) in Sardinian mouflons. When we compare groups during the year we can see differences in appearance of each group. As I mentioned above, mixed groups are appearing mostly during the rut and then their appearance is decreasing. In male groups we can see a little difference between lambing and the rest of the year but it is not so big. When we follow female groups we can that during the rut they almost disappear and then is their appearance increasing and they reach a peak during lambing season (Ciuti *et al*., 2008). In this study we can see differences of flight distance during the year depending on the seasoning in reproduction. We can see the lowest flight distance during the rut and the lambing. Male groups did not show any differences between seasons in flight distance and female groups without lambs showed shorter distances during the rut then during lambing season (Ciuti *et al*., 2008). When we follow female groups with lambs we cannot see any difference between these seasons (Ciuti *et al*., 2008). We can see priority in protecting offspring in comparison to finding a mate. Otherwise females without lamb are behaving like male groups and prefer finding mate and start their reproduction in a proper time (Ciuti *et al*., 2008).

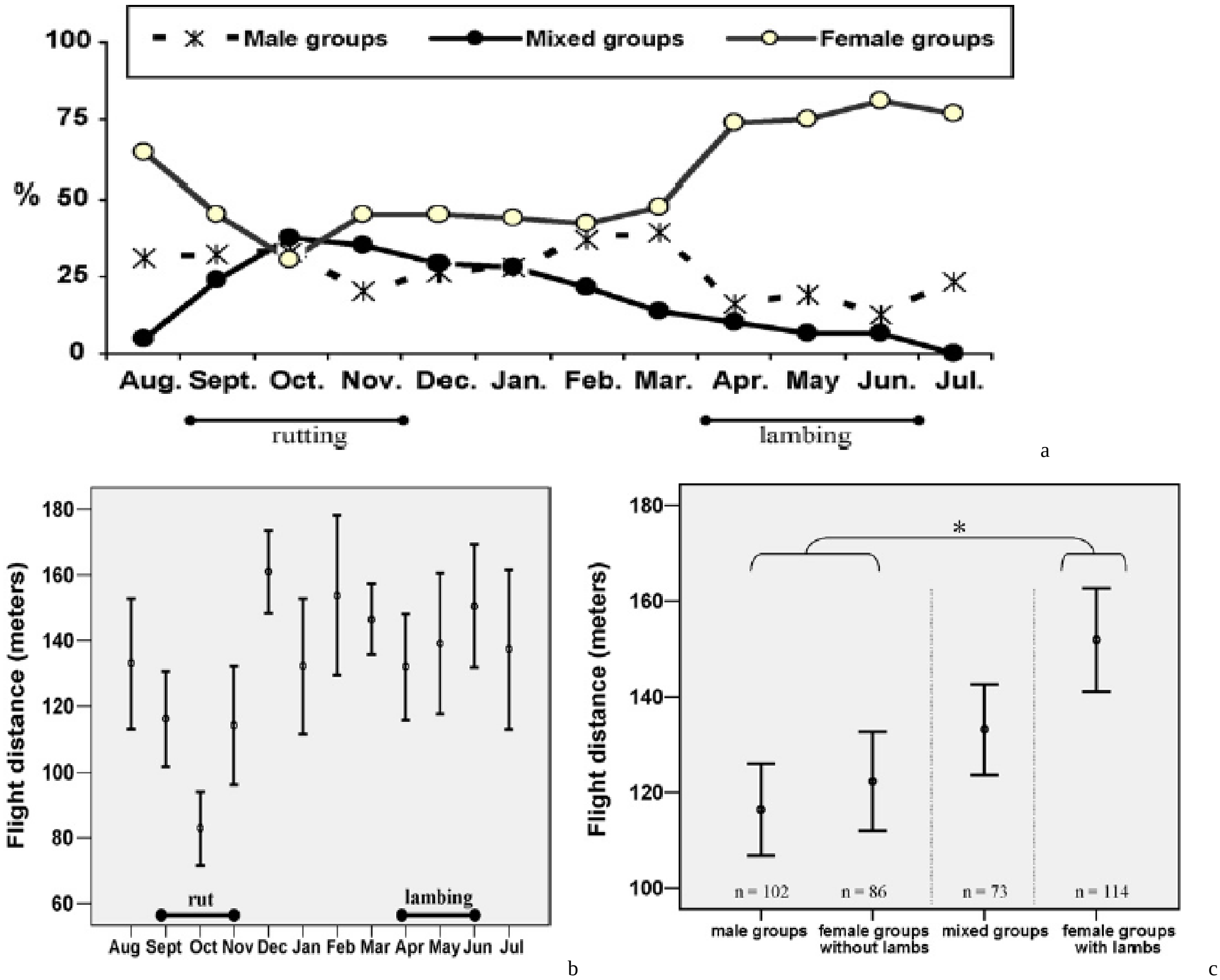


Figure 7 a, b, c: adopted from (Ciuti *et al*., 2008).

3.7 *What are effects of human-caused disturbance?*

For many years is human disturbance observed because of its impact to wildlife. Every new road, aircraft route, building new residences in environment around us has a huge effect to nature. Scientists are trying to understand and find out what stimuli have the greatest impact and how it is possible to regulate them.

3.7.1 What effects are caused by disturbance by hunting? Is Vigilance affected?

De Boer is observing roe deer and fallow deer in four areas in Netherland. His study is aimed to find any connection between hunting and flight distance to ungulate (de Boer *et al.*, 2004). Weather, wind, group size, vegetation and species have also effect to flight distance to ungulates and we have to think about it. But for this study is our interest aimed to hunting. As we can see, roe deer is hunted in 3 of 4 studied areas (Kennemerduinen - KD, Hoge Veluwe - HV and Kootwijk - KO) and they are not hunted in Amsterdam Water Supply Dunes - AWD. Fallow deer is appearing in 2 of these areas – AWD and KD and this species is not hunted. In table bellow we can see each species in areas, their population density to 100 ha, characteristics of area and visitors appearance (de Boer *et al.*, 2004). HV and KO are open areas and AWD and KD are rolling dunes.

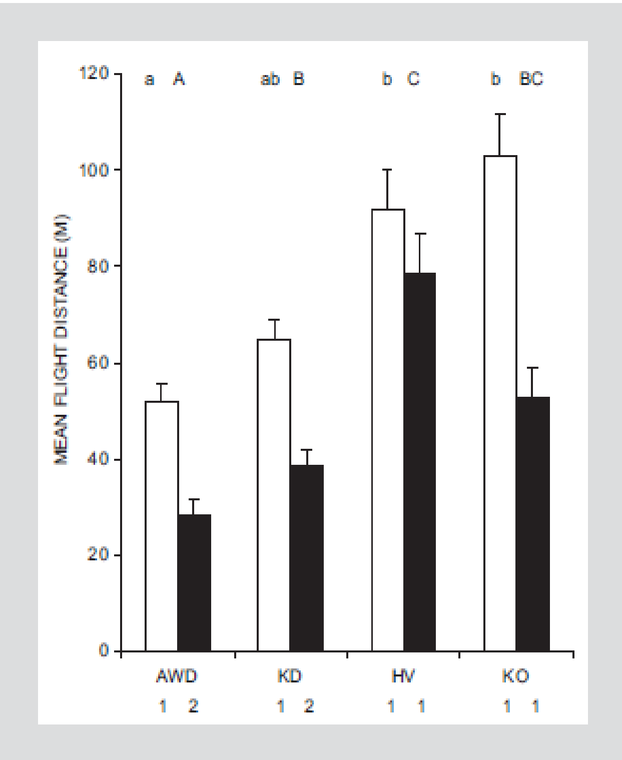


Figure 1. Mean flight distances (± 1 SE) for roe deer in the study areas AWD, KD, HV and KO in relation to open (□) and closed (■) vegetation structure. Mean flight distances with different letter/number differ significantly ($\alpha = 0.05$). Significant differences within areas are symbolised by 1-2, between areas within open field vegetation by a-b and between areas within closed vegetation by A-B-C.

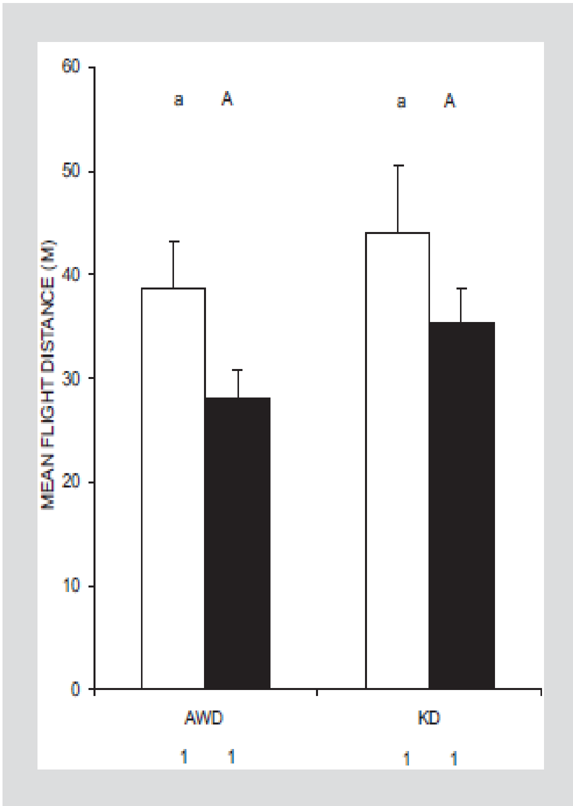


Figure 2. Mean flight distances (± 1 SE) for fallow deer in the AWD and the KD in relation to open (□) and closed (■) vegetation structure. Mean flight distances with different letter/number differ significantly ($\alpha = 0.05$).

Figure 8a, 8b : adopted from (de Boer *et al.*, 2004).

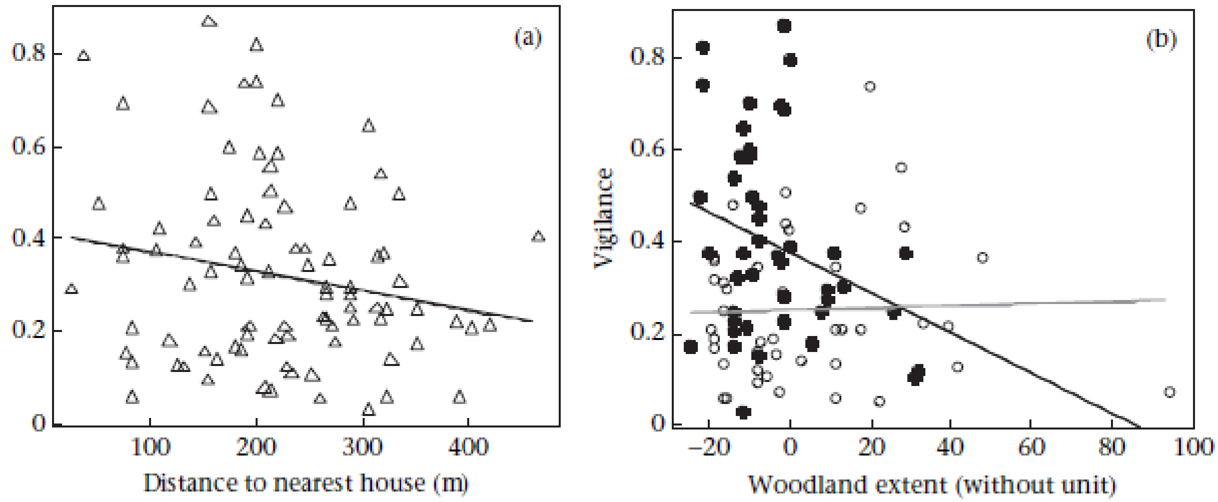
In observation of 291 deer were 240 roe deer and 51 fallow deer. Significant differences were found between Amsterdam Water Supply Dunes and other 3 areas. We can also compare distances in areas depending on characteristics, if area is with open or closed vegetation type. There is no difference between open and closed vegetation in HV to flight distance. It is proved that flight distance in open areas is greater than in closed ones. When we compare each followed species (roe deer and fallow deer) there is a difference between them because roe deer is hunted. Fallow deer lives only in two observed areas and is not hunted there so escape distance is obviously shorter. Also difference between open and closed vegetation type is little. It is possible that roe deer accustomed to human presence and threat that hunting is causing (de Boer *et al*., 2004).

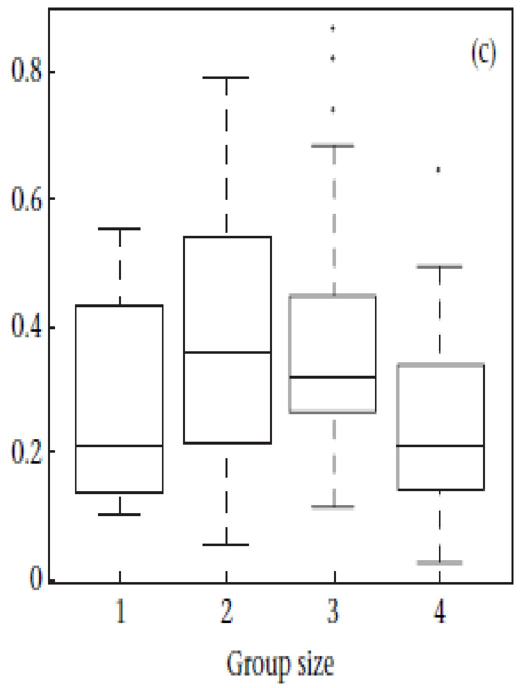
Table 1. Hunting regime (+: hunting; -: no hunting), size (in ha), population density/100 ha, area characteristics and recreation pressure expressed by number of visitors (in thousands/year and ha) for each of the four study areas. Data were not available on density in the KO area.

Area	Species	Hunting	Size	Density	Characteristics	Visitors/year	Visitors/ha	Visitor regulations
AWD	roe	-	3400	17.6	rolling dunes	715	210	Off tracks
	fallow	-		9.6				
KD	roe	+	1250	17.0	rolling dunes	1000	800	On tracks
	fallow	-		2.8				
HV	roe (+red)	+	5000	3.6	flat and open	650	130	Off tracks
KO	roe (+red)	+	5000		flat and open	few	few	On tracks

Table 2 : adopted from (de Boer *et al*., 2004).

In fact, hunting increases vigilance in ungulate (deer). Hunting means higher mortality risk and animals are made to change their feeding sites (Benhaiem *et al*., 2008). Predictions were confirmed that deer are more vigilant during hunting season even they do not change their behavior and they spent a lot of time feeding. Also size of group has an effect to vigilance and it is decreasing with bigger group size. . When we compare sex groups, there is no difference between male and female group in vigilance. Increasing distance to the nearest house means that time of vigilance is decreasing but visibility featured with landscape, distance to the nearest road and distance to the nearest wood had no significant effect to time of vigilance (Benhaiem *et al*., 2008). It means that ungulates (deer in our case) are feeling rising risk of mortality with increasing distance to the houses and with more and more opened landscape (Benhaiem *et al*., 2008).





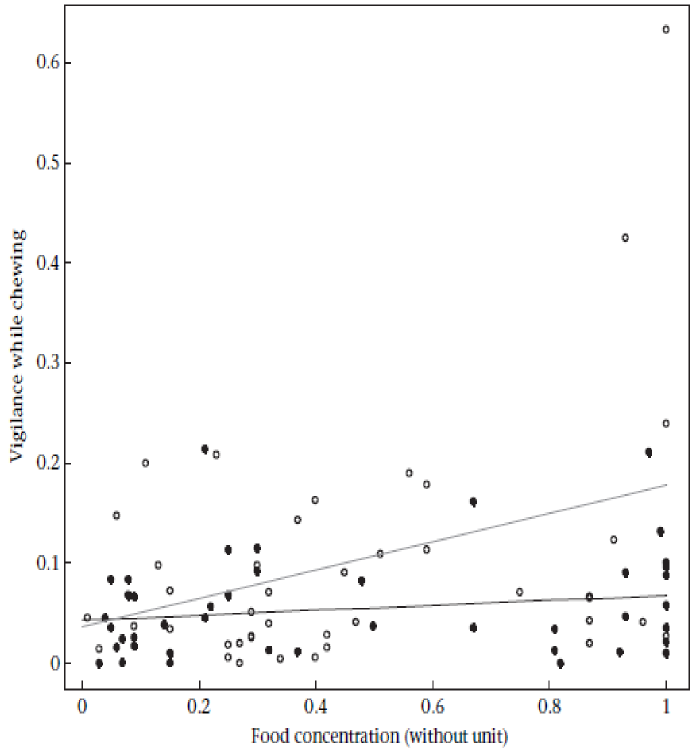


Figure 2. Proportion of time spent in vigilance while chewing (arcsine square-root transformation) as a function of food abundance (ratio of edible vegetation biomass/total vegetation biomass) in relation to the season for 88 roe deer observed in a fragmented landscape. Closed circles and the black best fit line represent data collected during the hunting season, open circles and the grey line data collected outside the hunting season.

Figure 9 a, b, c: adopted from (Benhaiem *et al*., 2008), Figure 10 (down on the right + caption (figure 2) above): adopted from (Benhaiem *et al*., 2008).

First 3 figures are showing effect of distances to a) the nearest house b) woodland extent and c) group size to time spent in vigilance. Fourth figure is showing Vigilance while chewing in association with food concentration (food abundance) (Benhaiem *et al*., 2008). It was observed that there is effect in between season and food abundance. With increasing food abundance was increasing time in vigilance while chewing outside of hunting season but much less during hunting season (Benhaiem *et al*., 2008). Food concentration increased with shorter distances to houses during hunting season but out of hunting season it was opposite. Feeding sites have a greater food concentration than random paired sites out of the hunting season and they were closer to woodlands as well. Otherwise, during the hunting season, there was no difference between sites. So during hunting season, deer is making compromise between food abundance and predation (mortality) risk (Benhaiem *et al*., 2008).

For another view of hunting, I have to mention poaching problem. In observing Vicuñas and Guanacos in areas with poaching and without poaching, we can see differences between each species and also in areas in relationship to flight distance (Donadio and Buskirk, 2006, Malo *et al*., 2011). To find significant results were used medians of measured flight distance. Flight distances were greater in areas with poaching than without it for vicuñas but it was not similar for guanacos. There was no difference between Guanacos and Vicuñas in areas without poaching (Donadio and Buskirk, 2006). Escape distance was not affected by group size or composition in areas with poaching. Time to first flight was shorter in areas with poaching for vicuñas than guanacos. Results for time to first flight were similar to results for flight distances with same dependence (group size, composition) (Donadio and Buskirk, 2006). Also, in areas without poaching there was higher relative density of pumas. You can see results below, all observed individuals were reacting to appearance of vehicle (Donadio and Buskirk, 2006).

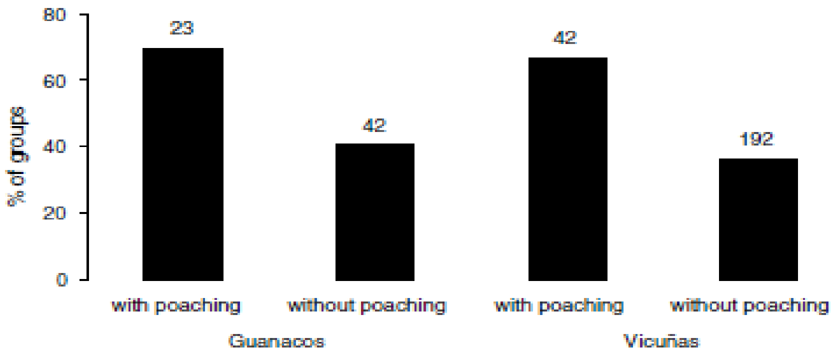


Figure 11: adopted from (Donadio and Buskirk, 2006).

Table 2 – Flight distance (in meters) and time to first flight (in seconds) for groups of wild South American camelids in areas with and without poaching of western Argentina, winter 2004

	With poaching			Without poaching		
	n	Median	Min–max	*n*	Median	Min–max
Flight distance						
Guanacos	21	433[a,1]	150–1000	29	390[b,2]	50–1850
Vicuñas	66	1000[c,1]	152–1000	91	318[c,3]	35–1700
Time to first flight						
Guanacos	16	1[a,1]	0–240	33	15[b,3]	0–340
Vicuñas	38	1[c,2]	0–107	106	27[c,4]	0–480

Lettered superscripts represent same-species comparisons between areas with and without poaching.
Numbered superscripts represent comparisons between species in the same area.
Medians sharing a superscript were significantly different at $\alpha = 0.05$.
Medians with different superscripts were not significantly different (see Section 3).

Table 3 (Table 2 in caption): adopted from (Donadio and Buskirk, 2006).

3.7.2 Disturbance caused by approaching vehicle

Malo (2011) (Malo *et al*., 2011) observed groups of guanacos near San Juan. He tested their response to approaching vehicles and influence to flight distance. In proximity to tourist circuit, flight initiation distance was significantly shorter (76 – 98 m on the circuit and 143 – 183 m off the circuit). Reaction also depends on season. In average of events showing in distance of 144 +/- 44 meters led into flight reaction. In contrast of events in 285 +/- 28 meters that did not caused flight from vehicle (Malo *et al*., 2011). The highest flight response was in family herds, mediocre in groups without offspring and the lowest in individuals (Malo *et al*., 2011).

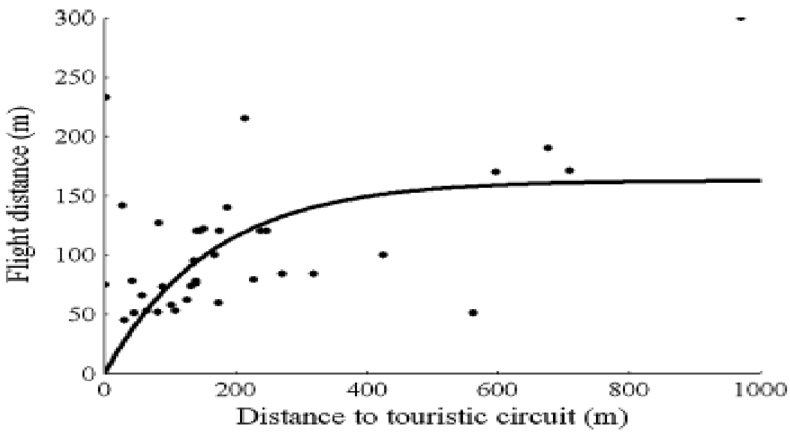


Figure 12, adopted from (Malo *et al*., 2011).

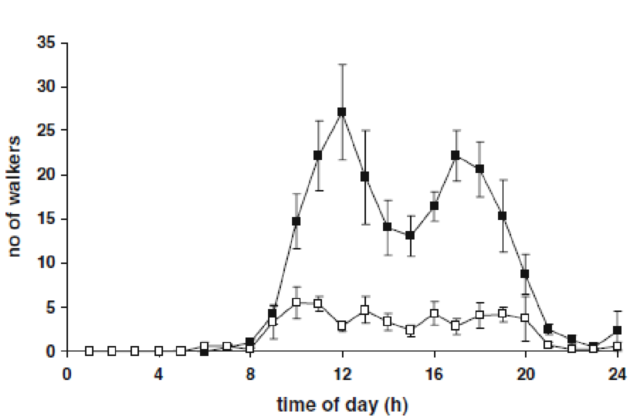
In case of bighorn sheep, we can see that there is flight distance is increasing when vehicle is approaching more directly and distance from refuge is greater and also bighorn sheep are more vigilant in case of greater group size (Frid and Dill, 2002). In observations and its results, which Frid used (Frid and Dill, 2002) we can see, that long-term stimuli could cause habitat shifts and cost ungulates access to food resources. These types of stimuli could be for example road traffic, vehicular disturbance or related disturbance (Frid and Dill, 2002).

3.7.3 Are ungulates affected by aircraft and helicopters?

We can see same type of vigilance and similar reaction to aerial threat as we can see in case of approaching vehicles. When aerial threat is approaching more directly, fleeing probability or flight distance is increasing. Also in same case of direct approach ungulates are spending more time vigilant and less time they spend with feeding or resting (Frid and Dill, 2002).

3.7.4 How are ungulates affected by hikers and people on foot?

In general, ungulates are trying to avoid areas with high expectations of disturbance. Proximity of human residence, roads or tourist traffic zones can cause changes in habitat. Ungulate can adapt to these changes and they can move away, further from, these places. It can correspond to natural behavior to protect offspring or just minimize risk of predation. Sibbald 2011 (Sibbald *et al*., 2011) shows relation of distance which deer holds from tracks. As you can see in figure 13 and 14, deer is taking longer distance from tracks when many hikers show up. During the day we can see that the highest number of walkers is around noon (12 am) and afternoon (4 pm). At this time, deer is in greater distance from track to avoid disturbance and possible predation risk. To compare we can see results from two days during the week – Sunday and Wednesday (black squares in figures showing Sunday and white ones show Wednesday). In conclusion there is not so significant difference between these days. However number of walkers is much higher on Sundays than on Wednesdays, deer is still in greater distance from tracks. When we take a look at figures above, we can see that deer is staying in the highest distances from tracks on Sundays in two amplitudes. First of them is when deer is resting during the night, it is starting increasing at 10 pm and highest point is at midnight. Then distance is little decreasing but when more people is coming to tourist circuits, deer is taking longer distance from tracks. Greatest distance we can observe at 9am to 12 am.



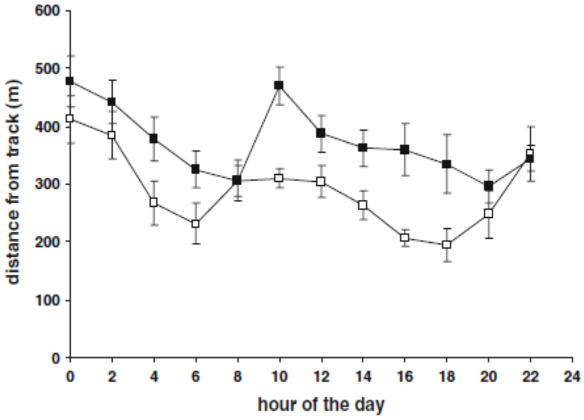


Figure 13 and 14, adopted from (Sibbald *et al*., 2011)

After this time, deer distance is shorter but still higher because of number of walkers. Two lowest points in figure 13 we can see at 8 am and 8 pm (Sibbald *et al*., 2011). Almost similar situation is on Wednesdays when peaks and bottoms are about same time as on Sundays but every measured distance is lower than during weekend, because the number of walkers is lower (Sibbald *et al*., 2011).

We can find correlation to increasing altitude where deer is staying because of distraction by walkers. In Figure 15 we can see that deer is in higher places (bigger altitude) during the night and when there are more hill-walkers on tracks on Sundays. Results are coinciding with Distance from tracks. During the day, peaks are at 10 am and about 4 pm when there are many tourists on circuits. And also at night when deer is resting in woods to avoid predation risk (Sibbald *et al*., 2011).

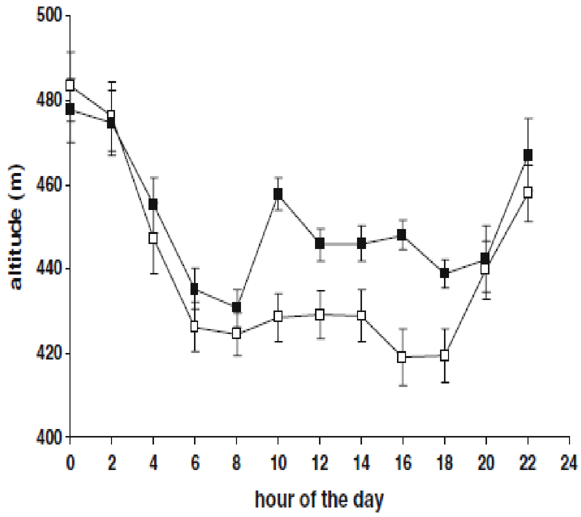


Figure 15, adopted from (Sibbald *et al*., 2011).

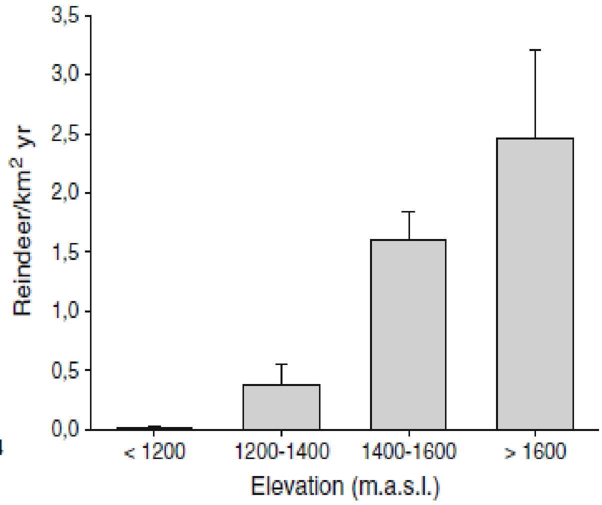


Figure 16,adopted from (Vistnes *et al*., 2008).

In fact, deer (reindeer, (Vistnes *et al*., 2008)) occur in higher elevations. In Figure 16 is evidenced that most of reindeer is at higher elevation (more than 1400 m.a.s.l.). Highest number of reindeer is staying at >1600 meters.

3.7.5 Does infrastructure affect ungulates and their behavior?

When we compare distances to infrastructure and we divide it into three groups - >2,5km from source, <2,5km from source and >5km from source of distraction, we can find out that most of deer is using areas at distance >5km more than others. In figure 17 we can see results of observation (Vistnes et al., 2008) through the years. Reindeer occur areas in distance >5km from tourist resorts and major roads more than areas <5km. Also we can see that they use areas at distance between 2,5km – 5,0km more than places at distance of <2,5km from source. Places at distance of 2,5km – 5,0km from power lines and minor roads are used often and more than places in closer distance (<2,5km). But we can see 2 exceptions, in 1983 and 1993 when reindeer were more observed in proximity of power lines and minor roads (<2,5km). Marked tourist trails are all about the same. Reindeer is using areas in greater distance more often than areas <2,5km from trails. Only significant exception is 1993 again. In case of closed maintenance roads, deer used further areas in 1985, 1993 and 1995 but in remaining years, they were observed in areas <2,5km from closed maintenance roads or did not showed up at distance >5,0km.

However, deer used areas at distance 2,5km – 5,0km more often, still most of deer is staying at distance higher than 5,0km from source of disturbance.

To compare and to confirm results that deer is staying in higher altitude you can take a look at figure 18, 19 a) and b) bellow. In figure 18 you can see density of reindeer depending on sources of disturbance and in relation to altitude. In figures 19a and 19b we can see proportions of study areas from human infrastructure at distance of <5,0km and “undisturbed” areas are showing distance of >5,0km and density of reindeer. Figure 19 a) is showing altitude of <1400 m.a.s.l. and b) is showing altitude of >1400 m.a.s.l.

Table 4(bellow), adopted from (Vistnes *et al*., 2008)
Shows numbers of reindeer observed during aerial surveys in 1983-1997.

	1983	1985	1986	1992	1993	1995	1996	1997
Tourist resorts and major roads								
<2.5 km	0	0	0	0	0	0	0	0
2.5–5.0 km	40	0	0	74	112	21	56	0
Power lines and minor roads								
<2.5 km	100	0	0	0	407	0	0	0
2.5–5.0 km	0	239	351	66	0	859	0	0
Marked tourist trails								
<2.5 km	403	0	0	0	881	0	21	70
2.5–5.0 km	789	10	0	32	14	20	0	233
Closed maintenance road								
<2.5 km	0	245	753	69	0	0	0	922
2.5–5.0 km	0	616	0	0	706	659	0	311
Undisturbed areas								
>5.0 km	164	357	756	1,896	271	644	1,457	591
Total number of reindeer	1,496	1,467	1,860	2,137	2,391	2,203	1,534	2,127

km from infrastructure	km^2 (proportion of study area)		Reindeer km^{-2} year		95% confidence interval of proportion of reindeer observed		Use according to availability	
	<1,400 m	>1,400 m	<1,400 m	>1,400 m	<1,400 m	>1,400 m	<1,400 m	>1,400 m
Tourist resorts and major roads								
<2.5 km	404 (0.20)	52 (0.03)	0	0	–	–	L	L
2.5–5.0 km	228 (0.11)	111 (0.05)	0.03	0.27	(0.003, 0.006)	(0.013, 0.019)	L	L
Power lines and minor roads								
<2.5 km	149 (0.07)	30 (0.01)	0.09	2.31	(0.005, 0.009)	(0.023, 0.031)	L	M
2.5–5.0 km	61 (0.03)	41 (0.02)	0	9.02	–	(0.092, 0.107)	L	M
Marked tourist trails								
<2.5 km	60 (0.03)	204 (0.10)	2.40	0.14	(0.070, 0.082)	(0.012, 0.017)	M	L
2.5–5.0 km	25 (0.01)	96 (0.05)	0.00	1.43	–	(0.066 0.078)	L	M
Closed maintenance road								
<2.5 km	11 (0.01)	47 (0.02)	0.00	5.29	–	(0.123, 0.139)	L	M
2.5–5.0 km	2 (0.001)	82 (0.04)	0.00	2.60	–	(0.142, 0.160)	L	M
Undisturbed areas								
>5.0 km	126 (0.06)	301 (0.15)	0.50	2.34	(0.029, 0.038)	(0.358, 0.382)	L	M

Letters indicate whether the number of reindeer observed is significantly less (L) or more (M) than expected from availability

Table 5, adopted from (Vistnes *et al*., 2008).

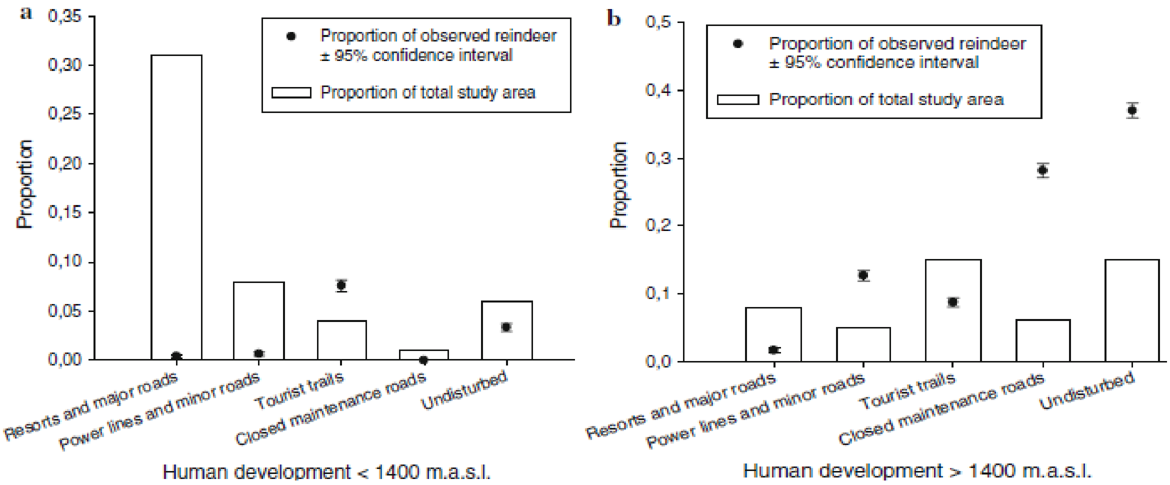


Figure 17a and 17b, adopted from (Vistnes *et al*., 2008).

3.8 *Summary of the factors influencing of flight distance*

In following chapter I summarize all results and discussions I mentioned above. To overview I prepared this table. Stimuli and factors are sorted into groups and are discussed in following text. I mentioned species which have been observed for each type of disturbance or factor of flight, sex, season or day if it's recommended, type of reaction, distances or number of trials and references as well. To complete this table I used data from observations and works I found and used for my thesis. This table contents data from my references (Stankowich and Coss, 2007a, Stankowich and Coss, 2007b, Andersen *et al*., 1996, Sibbald *et al*., 2011, Donadio and Buskirk, 2006, Malo *et al*., 2011, Ciuti *et al*., 2008).

Table 6 – summary table of chapter Results and discussion

Type of stimuli or factor	Species		Reaction		References
3.8.1 Habitat type					
Vegetation	*Red deer (Cervus elaphus)*	Day	Type	Distance (m)	(Sibbald, Hooper *et al*. 2011)
Rough grassland		Sunday - Day	Flight	118	
		Sunday - Night	Flight	112	
		Wednesday - Day	Flight	107	
		Wednesday - Night	Flight	88	
Smooth grassland		Sunday - Day	Flight	191	
		Sunday - Night	Flight	185	
		Wednesday - Day	Flight	182	
		Wednesday - Night	Flight	177	
Woodland		Sunday - Day	Flight	393	
		Sunday - Night	Flight	266	
		Wednesday - Day	Flight	344	
		Wednesday - Night	Flight	296	
Heather mooreland		Sunday - Day	Flight	433	
		Sunday - Night	Flight	443	
		Wednesday - Day	Flight	325	
		Wednesday - Night	Flight	390	
Grass/heather mosaic		Sunday - Day	Flight	516	
		Sunday - Night	Flight	356	
		Wednesday - Day	Flight	323	
		Wednesday - Night	Flight	175	
Vegetation type	*Columbian black-tailed deer*		Type	No. of trials	(Stankowich and Coss 2007)
Escape to lower vegetation	*(Odocoileus hemionus columbianus)*		Flight	7	
Escape to higher vegetation			Flight	21	
No change of vegetation			Flight	44	
Vegetation height	*Columbian black-tailed deer*		Stotting	No. of trials	(Stankowich and Coss 2007)

0 - 1 feet	*(Odocoileus hemionus columbianus)*		Present	7	
1 - 2 feet			Present	10	
2 - 3 feet			Present	10	
3 - 4 feet			Present	1	
4 - 5 feet			Present	0	
0 - 1 feet			Absent	30	
1 - 2 feet			Absent	10	
2 - 3 feet			Absent	2	
3 - 4 feet			Absent	0	
4 - 5 feet			Absent	1	
Change in elevation	***Columbian black-tailed deer***			**No. of trials**	**(Stankowich and Coss 2007)**
Downhill	***(Odocoileus hemionus columbianus)***			**13**	
No change of elevation				**43**	
Uphill				**32**	
3.8.3 Predator behavior					
3.8.4 Approach speed	***Columbian black-tailed deer***		**Type**	**Distance (m)**	**(Stankowich and Coss 2007)**
Jogging	***(Odocoileus hemionus columbianus)***		**Flight**	**88**	
Walking			**Flight**	**73**	
Directness of approach	***Columbian black-tailed deer***		**Type**	**Distance (m)**	**(Stankowich and Coss 2007)**
Direct	***(Odocoileus hemionus columbianus)***		**Flight**	**83**	
Indirect			**Flight**	**62**	
Intent	***Columbian black-tailed deer***		**Type**	**Distance (m)**	**(Stankowich and Coss 2007)**
Direct Gaze	***(Odocoileus hemionus columbianus)***		**Flight**	**73**	
Averted Gaze			**Flight**	**62**	
Alert prior	***Columbian black-tailed deer***		**Type**	**Distance (m)**	**(Stankowich and Coss 2007)**
Alert prior	***(Odocoileus hemionus columbianus)***		**Flight**	**92**	
Not alert prior			**Flight**	**63**	
Presence of the gun	***Columbian black-tailed deer***	**Sex**	**Type**	**Distance (m)**	**(Stankowich and Coss 2007)**
Holding Gun	***(Odocoileus hemionus columbianus)***	**Male**	**Flight**	**46**	
No Gun		**Male**	**Flight**	**71**	
Holding Gun		**Female**	**Flight**	**69**	
No Gun		**Female**	**Flight**	**75**	
Group behavior					
3.8.7 Group composition	***Sardinian mouflon***	**Season**	**Type**	**Distance (m)**	**(Ciuti, Pipia *et al*. 2008)**
Male groups	***(Ovis orientalis musimon)***	**lambing**	**Flight**	**115,4**	
Female groups without lambs		**lambing**	**Flight**	**150,8**	
Female groups with lambs		**lambing**	**Flight**	**146,4**	
Male groups		**rut**	**Flight**	**93,1**	
Female groups without lambs		**rut**	**Flight**	**87,3**	
Female groups with lambs		**rut**	**Flight**	**125,2**	
3.8.8 Human disturbance					
Poaching			**Type**	**Distance (m)**	**(Donadio and Buskirk 2006)**
Area with poaching	***Guanacos (Lama guanicoe)***		**Flight**	**433**	
Area without poaching	***Guanacos (Lama guanicoe)***		**Flight**	**390**	
Area with poaching	***Vicuñas (Vicugna vicugna)***		**Flight**	**1000**	

Area without poaching	***Vicuñas (Vicugna vicugna)***		**Flight**	**318**	
3.8.8.1 Approaching vehicle	***Guanacos (Lama guanicoe)***		**Type**	**Distance (m)**	**(Malo, Acebes *et al*. 2011)**
Proximity to the circuit			**Flight**	**76 - 98**	
Off the circuit			**Flight**	**143 - 183**	
Vehicle - military	***Moose (Alces alces)***		**Flight**	**854 +/-424**	**(Andersen *et al*. 1996)**
Approaching aircraft	***Moose (Alces alces)***		**Flight**	**1250 +/-250**	**(Andersen *et al*. 1996)**
3.8.8.3 Approaching pedestrian	***Guanacos (Lama guanicoe)***		**Type**	**Distance (m)**	**(Malo, Acebes *et al*. 2011)**
Inside the Park			**Flight**	**89 - 102**	
Outside the park			**Flight**	**154 - 184**	
Pedestrians - military	***Moose (Alces alces)***		**Flight**	**1147 +/- 537**	**(Andersen *et al*. 1996)**
Distance from tourist track					
Sorted by vegetation type	***Red deer (Cervus elaphus)***			**Distance (m)**	**(Sibbald, Hooper *et al*. 2011)**
Rough grassland		**Sunday - Day**		**448**	
		Sunday - Night		**511**	
		Wednesday - Day		**451**	
		Wednesday - Night		**570**	
Smooth grassland		**Sunday - Day**		**443**	
		Sunday - Night		**390**	
		Wednesday - Day		**276**	
		Wednesday - Night		**380**	
Woodland		**Sunday - Day**		**410**	
		Sunday - Night		**200**	
		Wednesday - Day		**359**	
		Wednesday - Night		**408**	
Heather mooreland		**Sunday - Day**		**393**	
		Sunday - Night		**289**	
		Wednesday - Day		**431**	
		Wednesday - Night		**216**	
Grass/heather mosaic		**Sunday - Day**		**440**	
		Sunday - Night		**397**	
		Wednesday - Day		**339**	
		Wednesday - Night		**465**	

3.8.1 Habitat type

In first case of influence to flight distance, I aimed to changes caused by habitat. Results showed up, that type of habitat matters but only in few meanings. Ungulates are living in different types of areas. In woodlands, grassland, plains etc. In observations what were made and specialized to this problematic we can see that ungulate (deer in most cases) are escaping into further distances when they are disturbed in grassland or short habitat type. Maybe it is caused because long grass, grass with scrubs or even trees make species feeling more save. And provide better conditions for escape from approaching predator or predation risk. We can also see, that time of trotting is much longer when deer is in short grass habitat. Otherwise, grassland offers better prospect and it is possible that potential predator will be discovered earlier and group or individual will gain higher chance to run away and increase chances to survive. But elevations, I don't mean altitude, has no effect to flight distance to ungulates. In all observations, results were not significant and deer during escaping did not change elevation or ran uphill, but in fact elevation doesn't matter in case of impacts to FID. My expectation was that deer will escape uphill more often than it did. Reason for me to think this was that uphill run is raisin chances to escape from predator and also it is harder for predator to chase prey and hunt it down. My expectation was not proved. Possibly it is connected to energy costs because uphill run is more exhausting for prey as it is for predator. What surprised me is fact that time of trotting downhill is shorter than it is for uphill. Unfortunately I have no explanation for this. But this part of study should be more observed to provide any influence by elevation correlated to speed of escape.

3.8.2 Altitude

Altitude is not affecting flight distance but it affects ungulate behavior from start. It's proved that deer is staying in higher altitude no matter what type of human disturbance is in proximity. Most of observed individuals or groups occur at >1400 m.a.s.l.

3.8.3 Predator behavior

When we post question if flight distance is influenced by predator behavior, we have to separate it into several cases. We can distinguish few stimuli. In case of approaching predator matters if predator (human) is coming directly or not. Direct approach is more threatening to ungulates and they evaluate this as a high risk of predation and their escape distance is greater, also time of reaction to direct approach is shorter. With direct move is connected direct gaze as well. When predator or human is gazing directly to observed individual, reaction is shorter and it is affecting flight distance. Animals are running further to avoid possibility of predation. It could be connected with behavioral psychology because even humans are feeling more threatened in case of direct gaze. And it makes them feeling less comfortable. Escape distance is getting longer because of direct gaze.

3.8.4 Speed of approach

Another factor is speed of approach. In observation which Stankowich did we can see 2 types of approaching speed – walking and jogging. In case of jogging, flight distance was greater and reaction time was shorter. Time of escape was longer when object- human/predator is coming faster. With speed is connected alert behavior. It is possible that predator coming to hunt can make a sharp move or can be approaching downwind. Whatever it is, prey, deer in our observation, is reported about upcoming threat. In fact, when this situation is on, ungulates are escaping for a longer time and father then it is not alert prior case. Before searching for these results I guessed that not alerted individual will feel more threatened and run further and longer, but this thought was unconfirmed.

3.8.5 Camouflage

Last, but no less important factor is camouflage. It is making huge role in nature and it should mean raisin chance of surviving or on the other hand chance of being hunted. Camouflage has an impact to alert/warning behavior to ungulates. In comparing 4 models- tiger, puma, leopard and deer, Stankowich and Coss registered reaction to different types of camouflage. Due to expectation, reaction to deer was minimal and it was caused because of almost none risk of predation, only explanation in reaction could be territorial behavior in male groups. Leopard model did not cause expected result and reaction was minimal. But there is significant difference between leopard and tiger model. In tiger model observation, reaction was relevant. It is caused because of type of camouflage, which tiger has, but there is similarity to leopard's camouflage however leopard model did not show up big reaction. Tiger model evocated foot-stamping and alarm walking, both showing alert behavior. Another expectation was confirmed, reaction to puma model. It is caused because this observation took place in North America, where puma is main type of large predator. Reaction to puma is genetically coded in every individual and it is connected to personal experience or it could be. In conclusion, every predator model caused one or both types of observed alarm behavior. Deer model did not caused reaction to predator risk.

3.8.6 Group size

Expectations if group size matters in flight distance were confirmed. Ungulates are living in herds, but there is no effect of group size to escape distance. Only effect is that group size changes type of escape behavior. In large herds of large scale ungulates we can see called "bunching". This behavior can be a good defense against predator. And it is also better to protect offspring, which can be kept in middle of group. At the opposite scattering is proved in case of small animals in groups. Running into different angles and directions can increase their chances to avoid predator's attack.

3.8.7 Group composition

Group size has no effect but group composition has. It is proved that presence of offspring causes changes in behavior of whole group. Also sex and season matters. In observations was recorded that male groups have lower reaction to predation risk then female groups. Males are in this case braver and they don't run into greater distances. In fact mono-sexual groups are less reacting to direct threat than mixed groups or groups with offspring. It could be caused by effort to provide reproduction by guarding lambs. In results you can see that groups with offspring were reacting most of our observed groups. Mixed groups are reacting strongly and more than mono-sexual groups. Male groups have lowest reaction to risk. We can see that season has an effect to behavior and during the rut flight distance is lowest. Opposite, flight distance during lambing is highest and this is significant to female groups with lambs. Only-male groups are almost not affected by season. Again, it could be caused by predation risk and fact that lambs are most harmful after breeding and for few months after. So females are trying to provide surviving of offspring. It is surprising that flight distance of mixed groups is not influenced by season. I expected that presence of females will cause differences but there is no.

3.8.8 Human disturbance

Main task and most important is effects of human disturbance to ungulates. Because of human activity there are a lot of noises, disturbing elements and infrastructure devices or installations which affect nature behavior to animals in general. We can see effect especially in areas with hunting or even poaching. Animals got used to these types of risk. In areas with poaching problem and in areas during hunting season, we can see that ungulates are behaving more carefully than it is in normal areas. Deer spent more time vigilant to avoid and minimize risk of being hunted. Also flight distance is greater. Ungulates adapted to higher risk and their occurrence is affected. For example in areas with poaching in South America, llamas (guanacos) are staying in areas where risk is not so high and they try to avoid it. I expected that when they are threatened, presence of the gun will make a difference but it is not proved and in these areas animals are reacting to human presence at all. Even presence and approach of vehicle is causing escape. It is interesting that there is a difference between 2 species at same area. One of them is hunted and another is not. Species, which is not hunted, is not affected by human presence strongly as it is in case of hunted one.

3.8.8.1 Human caused stimuli

Human disturbance is heterogeneous and could be caused by many stimuli types. First of them is aerial traffic. It is proved that low flying planes are more disturbing than high flying ones and evocate bigger reaction to ungulate. It is possible that direct approach of terrestrial vehicle can cause greater flight distance than plane but there are no studies to this type of stimuli and differences between them. Human on foot are the most disturbing stimulus than any other. Reaction to people on foot is faster and cause greater flight distance.

3.8.8.2 Infrastructure

Human infrastructure is changing landscape and also deer's behavior. As you can see in results, ungulates are keeping greater distance to power lines, to residencies and tourist resorts, major and minor roads and tourist trails and marked off road circuits. Most of observed animals showed up at distances greater than 5km from infrastructure. This progression is observed through the years. In long term results there is almost 86% of observed animals staying at distance >5,0km from source of disturbance. Again, all of this could be caused by behavior to avoid predation risk and minimize probability of mortality. Closer distance to source of disturbance is meaning higher risk.

3.8.8.3 Hikers – people on foot

In case of hikers, observations were made in wildlife parks. As you can see in results, ungulates are staying in greater distances from tracks and circuits. It depends on day in week and also number of walkers occurring there. It is proved that walkers cause greater flight response than vehicles and planes and also their behavior matters. As we can see in figures, distances are developing due to number of potential threat and increases with raisin predation risk. Also walkers make human-caused noises and ungulates are reacting to that.

4 Conclusion

The thesis entitled “If type of stimuli matters to flight initiation distance to ungulate” summarized present knowledge and the factors are discussed based on published sources. Stimuli matters, because through all results and discussion we can find out differences between single factors and groups. Flight distance, escape distance and escape behavior at all is in conclusion affected by external factors (habitat, altitude, group size etc.) and (especially) stimuli causing that. This part of behavioral responses should be more intensively studied in complex approach, because human activities have an impact on behavior of free ranging and also domestic animals. Not only human made infrastructures or vehicles we drive but even place we visit. Highest impact to ungulate and their flight response has a human presence itself. This review should be a preview of my potential diploma thesis where I would like to do my own experiment and prove influence of published stimuli and its impact in flight distance in certain species.

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6 Apendix

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