FACULTY OF VETERINARY MEDICINE
accredited by EAEVE

Clinical and/or environmental influences on the conservation of Asian elephants

Word count: 16 357

Line Hansen
Student number: 01303637

Supervisor: Prof. dr. An Martel
Supervisor: Dr. Trish London

A dissertation submitted to Ghent University in partial fulfilment of the requirements for the degree of Master of Veterinary Medicine

Academic year: 2019 - 2020

GHENT UNIVERSITY

Preamble

Even though my master thesis has pivoted in the process of creating it, I am very proud of what it has become. In regard to covid-19, I have tried to ensure that the impact of it would be minimal in regard to the gathering of data and information. The major impact it has had is that it forced my co-promotor, Dr. Trish London, who was supposed to be setting up an elephant health assessment in Nepal during this time, had to return to the United States. Therefore, the data that she could have been collecting and that could have been implemented in my master thesis was not available. Other than this the impact was minimal.

Acknowledgements

While thanking everybody individually would take us too far, I would like to put some people in the spotlight. Primarily, my promotor Professor Dr. An Martel, who not only supported me all the way through creating this master thesis. She also gave me the chance to work on my own subject and allowed me to pursue my passion, which resulted in what you are about to read. Secondly, my brother David Hansen, who is more fluent in English than I and was kind enough to help me improve the content of this document. Not only that, but he also listened patiently for several months to my ideas about how to approach this subject. I would also like to thank my family, who supported me in the past six years of veterinary medicine. They were always by my side when I needed them, they listened, gave guidance and supported me pursuing my goals. Also, I would like to thank my friends, for making these past six years memorable. Among them, a special thanks for Liesbeth Forier. Thanks to her, I got the chance to work with elephants in Thailand, for about a year. It allowed my passion for elephants to grow, what led to the creation of this master thesis. Finally, a word of thanks for my father who couldn't see the completion of my studies. I think he would have been very proud, to see all that I accomplished and never giving up on my dream.

Table of Contents

Abstract

This study takes a closer look at the biggest risk threatening the captive Asian elephant population and subsequently the wild population, the inadequate health care. It is proposed that this can be resolved by a mobile health clinic. The first and foremost part that is examined is the clinical examination. There it is found that there are three main parts that are required to complete this; anamnesis, observation and physical examination. From this, it can be concluded that if any veterinarian would use this in the field, they could complete a proper clinical examination of an elephant. Besides this, diseases and treatment is a major part of the mobile health clinic. By analysing all diseases, the most common ones could be identified. It was also found that due to a lack of research in medicine for the Asian elephant, it was not always possible to give exact treatment options and their effects. Out of the research into the diseases and their treatment it was also found that preventive health care is rarely implemented in the range countries of the Asian elephant. Therefore, as preventive health care is an important backbone of general health care for any animal, it has become a crucial part of the mobile health clinic. Finally, it was found that in all areas discussed there were major drawbacks of applying it to the field and these have also been discussed in detail. As it is important to ensure that the full picture is available to anyone that reads this study.

Samenvatting

In deze studie wordt nader ingegaan op het grootste risico dat de in gevangenschap levende Aziatische olifantenpopulatie en, bij afgeleide, ook de wilde populatie bedreigt: de ontoereikende gezondheidszorg. De mobiele gezondheidskliniek zou hiervoor een oplossing kunnen/willen zijn. Het eerste en belangrijkste onderdeel dat nader wordt onderzocht, is het klinische onderzoek. Om dit te voltooien zijn er drie hoofdonderdelen nodig; anamnese, observatie en lichamelijk onderzoek. Dit document stelt een dierenarts in het veld in staat een klinisch onderzoek van een olifant tot een goed einde te brengen. Daarnaast vormen ziekten en behandelingen een belangrijk onderdeel van de mobiele gezondheidskliniek. Door een grondige analyse van alle ziekten konden de meest voorkomende worden geïdentificeerd en beschreven. Een belangrijke vaststelling is dat, door een gebrek aan medisch onderzoek voor de Aziatische olifant, het niet altijd mogelijk was om de exacte behandelingsopties en hun effecten te kunnen weergeven. Uit het onderzoek naar de ziekten en hun behandeling bleek ook dat preventieve gezondheidszorg zelden wordt toegepast in het leefgebied van de Aziatische olifant. Omdat preventieve gezondheidszorg voor elk dier de ruggengraat vormt van de algemene gezondheidszorg, is de beschrijving ervan een cruciaal onderdeel geworden van dit document rond een mobiele gezondheidskliniek. Ten slotte bleek dat er voor elk besproken item grote nadelen waren op vlak van de toepassing ervan in het veld: deze zijn in detail besproken, zodat iedereen die deze studie leest zich een volledige en duidelijk beeld kan vormen.

Introduction

The conservation of Asian elephants is an intensively discussed topic. Asiatic elephants remain on the International Union for Conservation of Nature (IUCN) red list and Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) appendix I, as they are an endangered species threatened with extinction (Sukumar, 2006; Choudhury et al., 2008). In 2006 the population was estimated between 38 500 – 52 500 elephants in Asia (Sukumar, 2006). Due to lack of information about the elephant population, the use of different survey techniques and difficulty in counting elephants in rough terrain and dense vegetation, this number remains a crude guess of the real population (Choudhury et al., 2008). The population average has commonly been accepted unchanged over the last quarter of the century. This can be explained by a wildly held believe that population monitoring is unimportant. However, there is a consensus between experts that the elephant population is declining (Choudhury et al., 2008). The declining numbers of wild Asian elephants can be accounted to the loss of habitat, human-elephant conflict and elephants being captured from the wild (Cohn, 2006; Sukumar, 2006; Fowler and Mikota, 2008; Leimgruber et al., 2008). To conserve the remaining population new data and monitoring is needed (Choudhury et al., 2008). Nonetheless all involved governments acknowledge that the Asian elephant is an endangered species and in desperate need of protection (Choudhury et al., 2008). To preserve the elephant species, it is important to uphold the wild population but also to maintain a sustainable captive population (Leimgruber et al., 2008). It is estimated that one third of the total population of Asian elephants is held in captivity (Leimgruber et al., 2008; Jackson et al., 2019). Maintaining a sustainable captive population without complemented wild-captured elephants shows to be really challenging. Taking this in consideration, not only the conservation of the wild population is endangered, but also the maintenance of the captive population (Leimgruber et al., 2008; Jackson et al., 2019).

As stated before, it is necessary to create a sustainable captured population in order to preserve the wild population, therefore it is necessary to take a closer look into what the captured population is used for. Captured elephants in Asia either partake in temple ceremonies, in the logging/agriculture industry or in that of tourism (elephant camps, street begging, etc.) (Csuti, 2006; Angkawanish et al., 2009). The problem of forced elephant labour was partly resolved in 1989 in Thailand by the passing of a new law that prohibited elephants being used in the logging industry (Laohachaiboon, 2010; Bansiddhi et al., 2018; Bansiddhi et al., 2020). However, this increased the involvement of elephants in the tourism industry and developed into its own socio-economic sector (Bansiddhi et al., 2020). Due to this, it is important to take a closer look at the exact things an elephant does in the tourist industry.

Table 1. Number & percentage (in parenthesis) of elephant camps for each type of work by years of camp operation from Bansiddhi et al. (2018)

Variable	Camp N[1]	Years of operation			P
		0–5	6–15	>16	
Riding with a saddle					
Yes	17	2 (20%)[a]	7 (50%)[ab]	8 (89%)[b]	0.011*
No	16	8 (80%)[a]	7 (50%)[ab]	1 (11%)[b]	
Riding bareback					
Yes	15	4 (40%)	8 (57%)	3 (33%)	0.491
No	18	6 (60%)	6 (43%)	6 (67%)	
No riding					
Yes	5	4 (40%)[a]	1 (7%)[ab]	0 (0%)[b]	0.029*
No	28	6 (60%)[a]	13 (93%)[ab]	9 (100%)[b]	
Show					
Yes	5	1 (10%)	1 (7%)	3 (33%)	0.200
No	28	9 (90%)	13 (93%)	6 (67%)	

Notes:
* Significant at $P < 0.05$ between two variables using chi-square test of association.
[a,b] Different superscript across rows indicate significant differences for each variable ($P < 0.05$) using pairwise tests of independence.
[1] Some camps were represented in more than one category if more than one type of work was offered.

As seen in Table 1 elephant camps that are operational longer than sixteen years create heavier physical work for the elephants, such as riding with a saddle and shows (Bansiddhi et al., 2018). These shows include elephants doing activities such as dancing, painting, kicking a football, lifting legs, standing on hind legs, etc. Yet none of those camps offer no-riding policies. On the other hand, camps that have been operating between 6–15 years are divided on this subject, although most do offer less heavy physical work, such as riding bareback instead of with a saddle, they are still forcing elephants to ride tourist to the limits of their capabilities. The newest elephant camps (<5 years) include lower physical work. They do this by eliminating riding activities and instead offer activities such as feeding elephants, bathing them, walking alongside them, etc. (Bansiddhi et al., 2018). Those activities offer a more intimate contact between elephants and humans and plays exactly into the growing interest in animal welfare that tourist nowadays have (Laukkanen et al., 2016; Bansiddhi et al., 2018; Bansiddhi et al., 2020). This point was confirmed by Laukkanen (2016), Centre for Responsible Travel in 2016. There they observed that younger generations are more likely to spend more for sustainable tourism compared to older generations in the past. This was also aided by a strong criticism that was caused by violent tourist incidents (Laukkanen et al., 2016). This forced booking agencies like TripAdvisor to ban the sale of tickets to camps offering elephant trekking (Bansiddhi et al., 2019; Bansiddhi et al., 2020).

While a positive growth in Thailand can be observed in the past years with regards to the welfare of Asian elephants, it is important to note that to this day Thailand is the only country in the region that has passed laws to protect against forced elephant labour (Sofranko, 2006; Bansiddhi et al., 2020). We can observe that in the neighbouring countries this is not the case, there the Asian Elephant is still primarily seen as a work tool (Csuti, 2006; Leimgruber et al., 2008). Therefore, it is important that we do not become singularly focused on elephants employed in tourism. A report by Animal Nepal examined the welfare of 42 privately owned captive elephants through observation and interviews with mahouts (elephant handlers) (Vries, 2014; Bansiddhi et al., 2020). The results proved that 82 % of those elephants were living in unsuitable conditions (Vries, 2014; Bansiddhi et al., 2020). Even in Thailand a study done by an animal advocacy organization determining the welfare conditions of 1 688 elephants at 106 different tourist venues verified that 86% of those examined lived in inadequate

conditions (Schmidt-Burbach et al., 2015; Bansiddhi et al., 2020). A larger survey performed in Sri Lanka, Nepal, India, Laos, Cambodia and Thailand observed that of 2 923 elephants three quarters lived in unacceptable conditions (Bansiddhi et al., 2020). However due to limited assessment time and restricted access to observe individual animals, it was not achievable to measure the actual welfare outcomes of this large study (Bansiddhi et al., 2020). By inadequate or unsuitable living conditions, it is meant that these conditions did not meet the 'Five Freedoms' (Council, 1979; Bansiddhi et al., 2020). These freedoms were developed in the United Kingdom and formalised by the UK Farm Animal Welfare Council in 1979. These five freedoms stand for the following; Firstly, freedom from injury and disease, secondly freedom from fear, thirdly freedom from hunger; thirst and malnutrition, fourthly freedom from thermal or physical distress and the final freedom, the freedom to express normal behaviours. If those five freedoms are met, the basic needs of the animals have been achieved. Nonetheless this does not guarantee good animal welfare (Council, 1979; Bansiddhi et al., 2020).

Problem and goal

While one could make the argument that a captive population is not necessary for the Asian elephant, there are mitigating factors that justify the existence of the captive population (Cohn, 2006). The primary reason is to ensure the guarantee of the continued existence of the species (Cohn, 2006; Leimgruber et al., 2008; Jackson et al., 2019). The wild population is put at constant risk due to disease, drought, natural disasters, loss of habitat, etc. (Cohn, 2006; Sukumar, 2006; Fowler and Mikota, 2008; Leimgruber et al., 2008). While the captive population can be protected from this, protecting the wild population from similar factors is nearly impossible. A second reason for the captive population is the cultural aspect in the range countries of the Asian elephant (Phuangkum et al., 2005; Fowler and Mikota, 2008; Mason et al., 2013; Jackson et al., 2019). For thousands of years the local cultures have created a lifestyle of cohabitation with captured elephants, therefore, to take away the captured population would be devastating to the local cultures and could lead to the extinction of their way of life. A final factor to consider is that the captured population has become a key aspect of the working industry. For many local people this is the only form of income they can get. If one would take the captured population away it could be the final blow to the local economy (Phuangkum et al., 2005; Fowler and Mikota, 2008; Mason et al., 2013; Jackson et al., 2019). This could result in an increase in poaching of the wild population, endangering the already threatened further existence of the Asian elephant (Leimgruber et al., 2008; Jackson et al., 2019). When combining these factors, we can observe a well-grounded reason for the existence of the captured population.

Even though there is a well-grounded reason for the captured population to exist, when closer examining the captured population, there is a very concerning trend in regard to sustainability. Currently the captive population is not self-sustainable due to two major factors (Leimgruber et al., 2008; Jackson et al., 2019). Primarily, it is observed that a higher mortality rate is seen in the captive population then in the wild population (Leimgruber et al., 2008). Made even worse by the fact that there is a decreased birth rate in the captive population in comparison to the wild population. This results in a constant stream of wild elephants being added in order to maintain the captive population. A population viability analysis executed in Myanmar proves this point. The captive population has a negative growth rate with a 100% probability of extinction within the next 300 years. If mortality rates would be reduced by 50–60% extinction could be prevented, but in order to achieve a positive growth rate, reductions of up to 70% would be required. Birth rates in captivity are very low with only 7.1% females breeding. If maintaining of the current population is the goal, this has to be increased to 16%. If supplementation is implemented, when adding just 50 elephants per year, it could drastically lower the risk of extinction. Yet in order to maintain Myanmar's current captive population, a minimum of 100 individual elephants need to be captured on a yearly basis. With an estimated 2000 individuals in

Myanmar's wild population remaining, continuing at this rate extinction is predicted within the next 31 years. Although wild elephants' captures are banned, elephants are still captured in areas where human-elephant conflict requires relief. Those elephants are than 'domesticated'. This removal strategy of wild elephants is not unique to Myanmar. Estimation in other range countries cannot be given due to a lack of available data (Leimgruber et al., 2008).

Most Asian countries have implemented laws in regard to the protection and welfare of the Asian elephant (Sofranko, 2006; Bansiddhi et al., 2020). Although these laws exist, they are rarely enforced and implemented due to a number of reasons (Sofranko, 2006). The first and most important reason is that even though some countries have specialised governing bodies, they do not have the jurisdiction to enforce these implemented laws. Another major factor is that the laws that have been put in place are frequently not enforceable due to their vague wording. Thirdly the consequences of violating these laws are negligible in comparison to the profit they can make by infringing on these (Sofranko, 2006). Lastly the efficiency and enforcement of the law as it stands today remains largely untested (Bansiddhi et al., 2020). These factors establish that elephant owners use the vague wording to create their own interpretations that are more beneficial to themselves instead of the elephants (Turesson, 2014). Resulting in a climate where there is no government oversight in maintaining a well-managed captured population, which is an important stopgap to ensure a sustainable wild population. Evidence-based management standards for ensuring ethical treatment of captive elephants, would be one of the solutions for the risk on both the captive and wild population. Yet in order to do this, it needs to be supported by stronger and more enforceable regulations.

Another major concern is the lack of knowledge and finances to preserve a well-managed captive population, creating an environment where the basic needs of most elephants are not met (Miller et al., 2015). This leads to unnecessary discomfort of the elephant. As seen in Table 2 most of the physical injuries could easily be treated. However, this is not done due to the lack of knowledge and the non-availability of a veterinarian (Angkawanish et al., 2009; Miller et al., 2015). Another measurement that isn't taken is preventive healthcare. This is once again due to the lack of knowledge or the lack of finances making that they cannot afford a veterinarian on site (Miller et al., 2015). Allowing preventable risks to grow and fester, which could eventually endanger the health of the elephant. These factors combined create a major risk for the health of the individual animals and the captive population in general.

Table 2. Diagnosed conditions in Northern Thai elephants by the mobile elephant clinic (MEC) & National Elephant Institute (NEI) hospital from Angkawanish et al. (2009); Phuangkam et al. (2002)

Diagnosis	2005-2008		1999-2001	
	#	%	#	%
1.Wounds and abscesses	265	19.1	89	19.2
2. Poor condition (weak, dehydration ,body condition score <2)	244	17.6	107	23.1
3. Ecto-parasites	207	14.9	151	32.5
4. Eye (conjunctivitis, corneal ulcer, opacity, uveitis, cataract)	196	14.1	35	7.6
5. Musculoskeletal problems (lameness, bone fracture)	136	9.8	0	0
6. Gastro-intestinal (dyspepsia, constipation, colic, diarrhea)	108	7.8	26	5.6
7. Tusk problems (osteodendritis, pulpitis)	58	4.1	11	2.4
8. Skin problems (fungus, allergy)	51	3.6	0	0
9. Reproductive (musth, dystocia, abortion, vaginitis, neonatal)	49	3.5	12	2.6
10. Foot problems (cracked nail, nail overgrowth, foot-pad cracking)	44	3.1	17	3.7
11.Other causes	28	2.1	0	0
Total	1368	100	464	100

In my master thesis I will further explore one of the five basic freedoms, more specifically the freedom from injury and disease. I'll do this by creating a blueprint for a mobile health clinic, from which you read the details in this document. By doing this a solution can be created for the above-mentioned problems.

The current problem of knowledge and finances can steadily be resolved by a mobile health clinic (Miller et al., 2015). Providing a blueprint for a veterinarian that could service multiple camps, allowing the financial burden to be distributed amongst multiple camps (Bansiddhi et al., 2018). Due to lower costs, treatment will be provided in an earlier stage resulting in increased living conditions for the captured elephant population. By increasing the availability of knowledge earlier diagnosis and treatment can be easier implemented resulting in a drastic improvement of the health risks that we encounter today. Once trust has been built between owners and the veterinarians the mobile clinic could be expanded upon in the future. Allowing them to offer business guidance that will allow a better welfare for the elephants while remaining profitable and in some circumstances even increase the profits.

By attaining a healthier captured population, the life expectancy and birth rates of the captured elephants could be increased. Evolving into a self-sustainable captured population, capturing from the wild population would become unnecessary, allowing them to flourish and once again grow in the future.

In the long run, this blueprint of a mobile health clinic could even create the implementation and oversight for government institutions to protect the welfare of the captured Asian elephant. Once trust has been built between owners and veterinarians, implementing step by step measures to ensure the wellbeing of the animal could be achieved. If such mobile health clinic can do this at a large enough scale, it would allow local governments to easily implement these regulations into law. Forcing camps that do not work with the mobile health clinic to take similar measurements. Thailand seems to be a precursor in establishing a mobile veterinarian unit in combination with an actual elephant clinic (Angkawanish et al., 2009). Both are supported by government agencies resulting in costless veterinarian care for owners. It is stated and partially proven that such implements have positive effects on elephant welfare (Angkawanish et al., 2009).

1 Clinical examination

The freedom of injury and disease is one of the five freedoms to ensure the basic needs of animals (Council, 1979). Due to elephants' long lifespans, many of them will be confronted with some kind of health issue at some point in their life (Mikota, 2006c). Especially elephants kept in captivity will encounter numerous health problems (Firyal and Naureen, 2007; Angkawanish et al., 2009; Oo, 2012; Mandal and Khadka, 2013; Miller et al., 2015). An elephant veterinarian should have a basic understanding of performing a physical examination on an elephant. They should have basic knowledge about elephant biology and differentiate normal from abnormal behaviour. However, determining a definitive diagnosis of a sick elephant seems to be a challenging task (Mikota, 2006c). Like in other large mammals the approach of the patient's evaluation remains the same, although some limitations exist. When starting the evaluation of the physical health of an elephant, the first step would be to do an anamnesis. After which an observation distinguishing between the different signs of a healthy and sick elephant. Finally a thorough physical examination of the elephant can be executed (Mikota, 2006c).

As mentioned before, maintaining a healthy captive population is very important. To achieve this a minimum of at least one yearly health check of each elephant in captivity should be done (Mandal and Khadka, 2013). By this an overview of the overall health of the captive population as well as the health of each animal in question is monitored. By creating a record of the yearly checks, it creates the opportunity to discover outbreaks and early signs of diseases much easier (Mandal and Khadka, 2013).

1.1 Anamnesis

A complete anamnesis contains a thorough history and the presented complaints. A major difficulty that every wildlife veterinarian encounters is that wild animals often mask clinical signs of diseases (Fowler, 2008). The animal does this as a protective measure, hiding their weakness in order to not become susceptible to predators (Fowler, 2008). A good questioning about behavioural changes, appetite, faeces, urine and social interaction may ease the notice of small changes in physical signs relating to the presenting complaint (Mikota, 2006c). Keep in mind that any small change can be a piece of the puzzle to formulate a correct diagnosis. On the other hand, basic knowledge about a patient such as age, gender, geographical or environmental variables associated with specific problems may aid the diagnosis. While one would be prone to focus solely on yes or no questions, open ended questions will provoke additional observations from the owner and/or handler. Lastly try to determine how long the complaint has been presented and if any measurements were taken already, if so, what has been done and was there any improvement (Mikota, 2006c)? It is logical that if the animal's life is threatened, first care will be attempted to stabilize the patient. Once stabilisation of the patient is achieved an anamnesis can be done.

1.2 Observation

Observing an elephant prior to any physical contact is important. This is not only for the veterinarian's own safety but also to give the animal in question the least amount of stress possible (Phuangkum et al., 2005; Mikota, 2006c). A good observation in combination with the anamnesis can give an abundance of information about the elephant's health. Try to observe the elephant from different angles and while the animal is moving. The elephant's temperament should always be questioned and observed. Some state that the appearance of the eyes and body language of an elephant reveals their mood (Phuangkum et al., 2005; Mikota, 2006c). In case of a bull a thorough observation of the perineum and temporal gland should be done (Rajaram, 2006). If those seem to be swollen or a discharge from the temporal gland is observed the elephant is most likely in musth. A bull in musth

must be handled with extreme care due to his aggressive state of mind (Rajaram, 2006). Some cows also show drainage from temporal glands, this indicates excitement or oestrus (Mikota, 2006c).

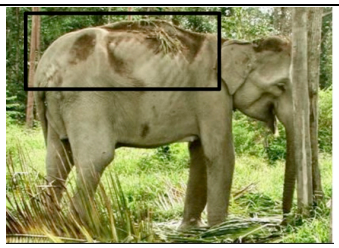
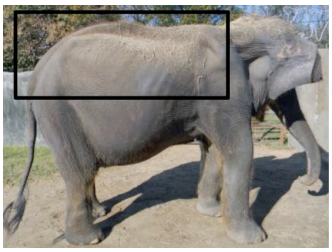
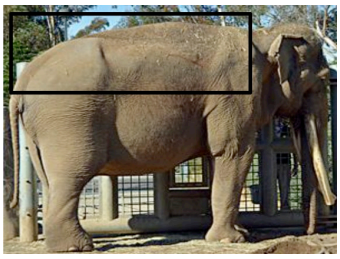
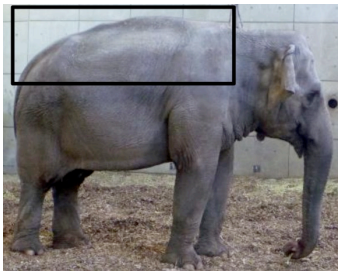
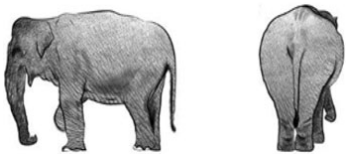
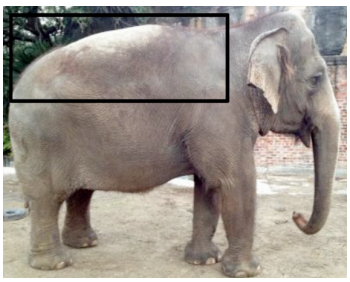
The observer should be familiar with the different signs between a healthy and a sick elephant (Phuangkum et al., 2005; Mikota, 2006c; Firyal and Naureen, 2007). A healthy elephant shows lively, in constant motion and willing to eat. In contrary to a sick elephant who will seem listless, show decreased movement and in some cases is anorectic. Like cited before a lot can be derived from the appearance of the eyes. A healthy elephant has clear and bright eyes, an unhealthy elephant on the other hand, the eyes will look dull or sunken and sometimes an abnormal discharge can be observed. Any abnormalities in movement, dung or urine can indicate sickness in an elephant. A full detailed table with indicators of good and bad health is given in Table 3 (Phuangkum et al., 2005; Mikota, 2006c; Firyal and Naureen, 2007).

Lastly an often-used observation tool to determine the general health of an elephant and in some cases determine welfare conditions in which elephants are kept is a 5-pointed body condition score index (BCS) (Morfeld et al., 2014; Morfeld et al., 2016; Chusyd et al., 2019; Schiffmann et al., 2020). This technique is based solely on the observation of three key body areas i.e. the ribs, the pelvic bone and the backbone (Morfeld et al., 2016). Those three anatomical regions are used for assessing body fat deposition patterns (Morfeld et al., 2016). This 5-pointed scale is created in this way that 1 indicates the thinnest and 5 the fattest (Morfeld et al., 2014; Morfeld et al., 2016). Either end of the scale suggests compromised health and/or welfare (Morfeld et al., 2016; Chusyd et al., 2019). For example, an elephant with BCS 1 can be the result of parasitic infection, dental problems, chronic diseases, etc. On the other end of the scale, a body condition score of 5 suggests obesity (Morfeld et al., 2016). Although not proven yet obesity could be linked to numerous health issues such as cardiovascular diseases, arthritis, foot problems and even population sustainability due to reproduction problems in female elephants (Morfeld et al., 2016). In Table 4 an overview of the body condition score index is provided.

Table 3. External signs of health & disease in elephants to Mikota (2006); Phuangkum et al. (2005)

Indicators of good health	**Indicators of bad health**
Constant motion – Ears flapping, sweeping tail and trunk swaying	Listless, decreased movement, exercise intolerance Exhaustion – little movement, end of the trunk rested on the ground for long periods of time
Eyes clear & bright; small amount of clear discharge from the conjunctival sac is normal	Dull or sunken eyes, increased tear flow, thick discharge
Mucus membranes are rosy pink in colour	Mucus membranes pale, muddy, bright red or dry
Tip of the trunk moist	Discharge from trunk, coughing, abnormal respiratory sound
Skin soft & resilient Moisture present at the base of the nail	Dry skin, loss of elasticity, wounds Skin above the toenail is dry
Good appetite, appears content Neither to fat nor to lean (See BCS)	Deceased appetite, anorexia Weight loss, sunken abdomen, prominent ribs (See BCS)
Well-formed dung, normal amount is passed with no evidence of straining, colour may vary with diet	Diarrhoea, straining
Urine copious in amount, faintly yellow, pleasant in odour & no straining during urination	Change in urine colour, odour, etc.
	Lameness, cracks in toenails, etc.
	Obvious pain – stands eyes closed, frequently yawns – gather dirt and apply on the affected area
	Any unusual swelling or protrusion

Table 4. Body Condition Scoring Index (BCS) for Asian elephants to Morfeld et al. (2016); Pokharel et al. (2017)

BCS	Ribs	Pelvic bone	Back bone	Illustrative representation	Example photographs
1	Individual ribs clearly visible	Protrudes, deep depression in front and behind pelvic bone	Protrudes from tail head to shoulders, deep depression alongside entire backbone		
2	Some ribs may be noticeable, ribs appear to be covered by a very thin fat layer	Clearly visible, obvious depression in front and/or behind pelvic bone	Prominent from tail head to shoulders, obvious depression alongside entire backbone		
3	Not visible	Visible, entire pelvic bone may not be visible, slight depression in front of pelvic bone	Clearly visible from tail head to shoulders, fat beginning to accumulate alongside backbone		
4	Not visible	Slight definition and not entirely visible, slight sunken or flattened area in front of pelvic bone	Visible as a ridge, some regions of the backbone more visible than other due to fat accumulation		
5	Not visible	Not visible	Not visible or difficult to differentiate, area alongside backbone is filled in giving a round appearance		

1.3 Physical examination

Any procedure with physical contact of the elephant should be performed with extreme care. The most important thing to remember at all times is to never approach an elephant without an experienced elephant handler. Always approach an elephant from the side and never from directly the front or back so the elephant is not scared up. A physical examination should be done as quickly and thoroughly as possible. By this the risk of injury for the examiner, the handler and the patient are reduced, as well as the stress for the examined individual. If an elephant is too dangerous to approach a sedative can be administered. In any case try to limit the use of those products due to the major disadvantages that go along with them (Fowler and Mikota, 2006b). To ease the physical examination, it should be executed in a consistent routine. All body systems should be included, aiming to do a thorough examination each time. Many diseases are multisystemic so any abnormality may play a role in diagnosing and cannot be ignored (Mikota, 2006c). When conducting a close exam start at the left side of the head continuing along the left side of the body to the rear of the elephant, followed by an examination of the right side of the elephant ending at the right side of the head. Although a body part may never be left out, thanks to thorough anamnesis and observation, specific body parts or vital signs can be emphasized.

Table 5. Physiological parameters & vital signs of the Asian elephant to Brattstrom et al. (1963); Fowler & Mikota (2008); Phuangkum et al. (2005); Sukumar (2006); Hile et al. (1997)

Elephant vital signs	**Value**
Height (meters)	2,0 – 3,5
Weight (Kg)	2.000 – 5.500 Wt = 18,0 x (HG) – 3.336
Dental formula	$\frac{1I \quad 0C \quad 3PM \quad 3M}{0I \quad 0C \quad 3PM \quad 3M}$
Temperature (rectal, °C)	36,0 – 37,0
Heart rate (beats per minute)	25 – 30 (Standing) 72 – 98 (Lateral recumbency)
Respiratory rate (Breaths per minute)	4 – 12
Wt: weight in kilogram *HG: heart girth* *I: incisor* *C: canine* *PM: premolar* *M: molar*	

1.3.1 The head

Upon the examination of the head**,** it is important to have a close look at **the skin**. Especially the forehead should be examined closely for wounds. Wounds in this area may indicate improper use of handling tools (Bansiddhi et al., 2019). After which, one would continue with the inspection of **the trunk**. First of all, observe any abnormal discharge (Mikota, 2006c). Secondly, if the elephant allows the trunk to be handled, check for symmetry of airflow between the two nares. Then move caudally to the base of the trunk. Listen if there are any audible respiratory sounds. At this location the two elongated nostrils enter the skull and air enters the trachea (Mikota, 2006c). Continue the examination

with a thorough inspection of the **tushes/tusks**. Any asymmetry of growth, discoloration or foul smell should be noted down (Dumonceaux, 2006; Mikota, 2006c). An injury as small as a fissure may be a side for infection leading to pulp decay, causing pain, inappetence and eventually loss of condition. Always inspect the base of the tusk/toosh by lifting the flap of skin overlying the base. Even if tushes or tusks seems absent this body part cannot be ignored. The base may be a site of infection or a site for parasite eggs. If the elephant is trained to lift up the trunk on demand, examine **the oral cavity**. The dental formula is given in Table 5 Note that not all 26 teeth will be visible at the same time as elephants are polyphyodonty, in contrast to most mammals who are diphyodonts. In most phases of their life only two teeth will be in wear at any one time (Dumonceaux, 2006; Mikota, 2006c). Age can be determined by dentition nevertheless this seems impossible to do so antemortem (Phuangkum et al., 2005). Observe the colour of the mucus membranes and the tongue (Mikota, 2006c; Firyal and Naureen, 2007). They should be rosy pink; pale colour may indicate anaemia and bright red may indicate intoxication or an allergic reaction. Capillary refill time may be checked at this point but comes with great risk as it requires the veterinarian's hand entering the elephant's mouth. Lastly check on the tongue for any injury, this may be an indication of abnormal teeth growth or bad feeding. Move forward to the temporal glands as they may be an entering port for infection (Mikota, 2006c; Firyal and Naureen, 2007). End the examination with **the eyes**. Many elephants get agitated if a close examination of the eyes is performed (Mikota, 2006c; Suedmeyer, 2006). A pupillary light reflex can only be conducted if the elephant is moved to a darkened area, as in normal conditions the pupil is constricted. The eyes should be checked for abnormal ocular discharges, corneal scars, cataract and the conjunctival area. The colour of the conjunctival area may indicate anaemia, icterus or cyanosis. A small number of tears rolling down onto the face coming from the corner of the eye is normal (Mikota, 2006c; Suedmeyer, 2006).

1.3.2 The (left & right) side

The examination should be continued by evaluating **the pulse**. The pulse can be measured at the auricular artery which is located on the caudal side of the ear (Mikota, 2006c). The normal pulse rate in a standing elephant is between 25-30 bpm (beats per minute). If the elephant is in a recumbent situation the pulse will elevate significantly up to 72-98 bpm (Mikota, 2006c). When examining the side of the elephant **the skin** should be inspected for any abnormalities or wounds. The normal healthy skin of an elephant should be almost black in colour, soft, wrinkled, uniform in temperature and free from scurf (Mikota, 2006b). External definition of the arm, the forearm or the *manus* is almost impossible to distinguish as the orientation of the bones is almost vertical (West, 2006). In case of **the limbs** pay attention to any wounds, asymmetry, swelling, heat or tenderness (Mikota, 2006c). As **foot** disorders are very common in captive elephants, extra emphasize should be placed on these body parts in the examination (Fowler, 2001b; Fowler and Mikota, 2006a; Mikota, 2006c). The elephant's front feet are rounded and semi digitigrade possessing five toenails, the hind feet on the other hand are elongated ovals, semi plantigrade and contain four toenails. Toenail numbers may vary individually and should be recorded. Although there are some anatomical differences between the front feet and the hind feet they should be approached in the same manner. Before examining the feet, they should be cleaned so small injuries in the sole can be seen. The cuticles should be moist. This can easily be tested by applying some dust and see if it sticks. Furthermore, the nails should be examined for overgrowth or cracks. The soles are covered in a thick keratinized pad with ridges and grooves leaving a distinctive footprint (Fowler, 2001b; Fowler and Mikota, 2006a; Mikota, 2006c). Later on, a detailed chapter will be provided discussing different foot abnormalities. At the left side of the thorax auscultation of **the heart** can be performed (Mikota, 2006c). Auscultation is not easily performed as the heart is located cranially in the thorax. To ease auscultation usage of an electronic stethoscope is

recommended. This will amplify the sound up to 18 times. Another method facilitating auscultation is commanding the elephant to move the left front limb forward or even lift the leg (Mikota, 2006c). Auscultation of **the lungs** is in most cases impossible. Therefore, to examine the respiratory system observe the character, the depth and the frequency of respiration by observing movements of the chest. When examining a cow have a closer look at the mammary glands which are located at the pectoral area. Any expansion or ventral oedema may alter the outline of the abdomen (Mikota, 2006c).

1.3.3 The rear

When arriving at the rear of the elephant, **the genitalia** should be examined. Bulls in musth dribble urine and the preputial rim may be pale or light green in colour (Rajaram, 2006). Any other discharge or change in colour is considered abnormal (Mikota, 2006c). Elephant's **urine** is clear or cloudy and straw-coloured (Miller, 2006). An elephant's **temperature** is best measured rectally, if the elephant refuses rectal examination, the temperature of fresh dung can be measured (Benedict and Lee, 1936; Dumonceaux, 2006; Mikota, 2006c; Firyal and Naureen, 2007). However, a small deviation of 0,5°C should be taken in consideration. Once the elephant's temperature exceeds 37,8°C, the elephant has a fever. Elephant defecate **faecal boluses** that are well formed but moist. Abnormal or absence of dung indicates gastro-intestinal problems. Rectal examination is not considered a part of a routine physical examination but should be executed if indicated (Dumonceaux, 2006; Mikota, 2006c; Firyal and Naureen, 2007).

2 Diseases and treatment

This chapter will focus on the most common diseases observed in captive elephants. While there are rural differences in prevalence of disease, many of the below mentioned do occur in all range countries (Mikota et al., 2006; Firyal and Naureen, 2007; Angkawanish et al., 2009; Oo, 2012; Mandal and Khadka, 2013; Miller et al., 2015). The goal of this chapter is to recognise particular symptoms and differentiate diagnose, in order to start a correct treatment. While a treatment might be started before a singularly diagnosis has been achieved. This is due to the remote location of many of the captured elephants (Angkawanish et al., 2009). Once the correct diagnosis has been achieved, adjustments to the threatment may be implemented. An important factor that one can not forget is that the labrotory facilities in Asian countries are not similar and as easaly accessible as in Europe (Mikota et al., 2006). This is mainly due to the fact that many of the range countries of the Asian elephant are third world countries[1]. Therefore, in many cases it will be impossible to reach a correct diagnosis, as eather the required materials to take culture swabs would not be available or the laboratory facilities would be inadequate. When these situations present themselves the best option is to use a trial and error technique. Starting of from the most likely diagnosis and adjusting treatment based on the results achieved. These are situations that will present themself in the field and it will be up to the treating vetrenarian to find the best solution.

2.1 Integument

2.1.1 Wounds

The skin is the biggest organ of the elephant, so it is predisposed to get injured (Barman et al., 2013). Integument ailments are one of the most common pathological conditions in captive elephants (Barman et al., 2013; Buragohain et al., 2019). The elephant's skin lacks subcutaneous glands making the skin dry and sensitive for UV rays (Mikota, 2006b). Elephants compensate this by daily dust and mud baths, making detection of small wounds difficult (Mikota, 2006b). Because of these, small wounds can fester to more severe conditions. Yet the elephant might show other **symptoms** indicating

[1] https://www.nationsonline.org/oneworld/third_world_countries.htm last referred on 28/04/2020

irritation or pain of the skin. If an affected area hurts or irritates, the elephant may blow air or dirt on this area (Phuangkum et al., 2005). Other symptoms of irritation or itch may be excessive scratching against trees or other items (Phuangkum et al., 2005). Wounds can be divided in different groups, such as abrasions, blunt-edge wounds, slice wounds, puncture wounds, etc. (Phuangkum et al., 2005; Mikota, 2006b; Bansiddhi et al., 2019). However, whilst **diagnosing,** the severances of the wounds should be evaluated. This contributes to determining a correct treatment. It is of the utmost importance to determine if the wound is infected or not. This can be done by sampling the affected area. Although it can also be determined by physical appearance of the wound (Dryden, 2010). In many cases sampling will be impossible due to the unavailability of proper laboratories in the neighbourhood or the elephant may be unmanageable (Ali et al.; Mikota et al., 2006). An infected wound will show signs of inflammation such as heat, redness, swelling, pain and in some cases even discharge (Dryden, 2010). If sampling of the wound is possible an antibiogram should be made. The use of correct antibiotics contributes to the minimalization of bacterial resistance (Stevens et al., 2014). **Treatments** of all wounds start the same. Depending on the wound an additional treatment should be administered. Any kind of wound needs to be cleaned thoroughly. Start cleaning the wound with clean water (Ali et al.; Barman et al., 2013; Hendrickson, 2013; Podhade and Harne, 2013; Stevens et al., 2014). Secondly remove all debridement in the wound because debridement creates a culture medium for bacterial growth and inhibits the host's defence mechanism (Haury et al., 1978). Removal of accumulated tissue debris in elephants can be a challenging task for various factors including anatomical features, individuals that are difficult to restrain, etc. A case report suggested bio-debridement by fishes feeding on dead tissues (Ali et al.). Once the wound is 'superficially' cleaned start with flushing the wound with an antiseptic (Sukklad et al., 2006; Barman et al., 2013; Hendrickson, 2013; Podhade and Harne, 2013). This can be a povidone iodine solution, potassium permanganate solution ($KMNO_4$) or any other suitable antiseptic. Lastly administer a topical antiseptic ointment in combination with a fly repellent ointment or powder. If possible, dress the wound to protect it from external dirt and organisms entering again. Execute this procedure at least once a day until the wound is completely healed (Sukklad et al., 2006; Barman et al., 2013; Hendrickson, 2013; Podhade and Harne, 2013). If a wound is bleeding excessively, aim to stop the bleeding before starting the wound care routine (Phuangkum et al., 2005). This can be done by applying pressure on the wound, using a tourniquet or any other measure that stops bleeding (Phuangkum et al., 2005). Depending on the size of the wound and if infection is suspected the elephant should be treated with antibiotics (Sukklad et al., 2006; Hendrickson, 2013). Antibiotics can be administered topically or systemically. Although topical treatment is not suggested as a curative treatment but more as a preventive measure (Sukklad et al., 2006). If you were able to make an antibiogram administer the antibiotic that is suggested. If not, studies proved that the most common bacteria found in wounds is *staphylococcus aureus*, a gram-positive bacterium (Barman et al., 2013; Senthilkumar et al., 2014; Buragohain et al., 2019). Nonetheless not every antibiotic, for treatment of gram-positive infections, will be suitable due to high bacterial resistance (Dryden, 2010). One study in elephants proved that *staphylococcus* isolates were in 86% sensitive for enrofloxacin, 69% gentamicin and 52% for norfloxacin and cefotaxime (Barman et al., 2013). Many case reports do suggest the use of enrofloxacin due to their positive results (Barman et al., 2013). Lastly a measure that should be taken if an elephant is affected by a deep wound, is administering a tetanus toxoid vaccine (Mikota, 2006b; Senthilkumar et al., 2014). Commercial vaccines produced for livestock and horses are proven to be effective in elephants (Lindsay et al., 2010).

2.1.2 Ectoparasites

As elephants mainly live in natural habitats, they will often encounter external parasites. Many ectoparasites can be observed in elephants, although many of them will not lead to direct clinical signs

(Phuangkum et al., 2005; Fowler and Mikota, 2008). They will annoy the elephant and may transmit diseases (Phuangkum et al., 2005; Fowler and Mikota, 2008). An irritated elephant will be less likely to eat and for this lose condition and become more susceptible to other diseases (Phuangkum et al., 2005). It is advised to keep the environment clean to reduce the presence of such parasites (Fowler and Mikota, 2008). The three most common ectoparasites leading to direct clinical symptoms are the elephant lice, fleas and maggots.

Firstly, the biting louse, that can be observed on elephants, is host specific. This *haematomyzus elephantis* is mostly seen behind elephants' ears and at the base of the tail (Evans, 1910; Phuangkum et al., 2005; Fowler and Mikota, 2008). The lice will cause an itch (Evans, 1910). **Symptoms** observed that go along with infestation of lice are excessive scratching leading to small wounds and in some cases even pruritis (Fowler and Mikota, 2008). **Diagnoses** can be made solely with the unaided eye. Lice will look like red or brown lumps the size of a rice grain attached to the elephant's skin (Phuangkum et al., 2005). If there is only a small infestation washing the elephant with insecticides should be sufficient as a **treatment** (Fowler and Mikota, 2008). If the elephant does not seem to improve ivermectin can be administered orally or subcutaneously (Phuangkum et al., 2005; Fowler and Mikota, 2008). Nearby elephants are most likely to be infested as well and should be treated despite showing no clinical signs (Phuangkum et al., 2005).

A not host's specific parasite that can lead to clinical signs are fleas (Phuangkum et al., 2005). Adult fleas will consume blood of the elephant leading to **symptoms** such as anaemia (Fowler and Mikota, 2008). Some elephants will react to the parasites saliva and an allergic reaction is observed. The **diagnosis** can be made with the unaided eye. Fleas will crawl all over the elephant. **Treatment** of fleas and lice are the same (Fowler and Mikota, 2008).

Lastly an ectoparasite that is quiet often seen, are maggots. Due to warm temperatures and a humate climate they seem to be more present in range elephant countries. For treatment and prevention of those I refer to the previous discussed topic; wound and abscesses. The removal of maggots specifically can be done mechanically or with products such as hydrogen peroxide (H_2O_2) (Fowler and Mikota, 2008).

2.1.3 Other integument ailments

Other ailments that can affect the elephant's skin are viral infections, fungal infections, tumours, cysts, etc. (Evans, 1910; Phuangkum et al., 2005; Fowler and Mikota, 2008). Most of those will not cause great harm, except for irritation and thus excessive scratching which can lead to wounds, dermatitis, pruritis, etc. Treatment depends on the ailment and if therapy seems necessary, research on the specific condition needs to be considered. However, skin lesions are often a secondary effect to other ailments such as exhaustion, compromised immune system, etc. If integument ailments are presented always conduct a thorough clinical examination to rule out any other conditions (Evans, 1910; Phuangkum et al., 2005; Fowler and Mikota, 2008).

2.2 Special senses

2.2.1 Eye problems

Elephants in captivity in comparison to wild elephants commonly have ocular abnormalities (Evans, 1910; Phuangkum et al., 2005; Kraiwong et al., 2016). **Symptoms** that often follow eye problems are excessive tearing, redness and swelling of the eye tissues, irritation (shown by rubbing the eye with the trunk), sensitivity to light, blurred vision, a cloudy or 'milky' eye and/or abnormal discharge (Phuangkum et al., 2005; Ahmed and Doley, 2016). Immediate and correct **diagnosing** is important to prevent temporary to permanent eye damage (Paul et al., 2018). The three main disorders affecting the elephant's eyes are conjunctivitis, corneal opacity and cataract (Phuangkum et al., 2005;

Suedmeyer, 2006; Kraiwong et al., 2016). Conjunctivitis, as pictured in Figure 1, is mainly caused by irritation of the eye by dust, smoke or other factors (Phuangkum et al., 2005). Trauma and vitamin A deficiency are the main etiologist leading to corneal opacity (Ahmed and Doley, 2016). To determine if the cornea is damaged a fluorescent staining can be performed (Wolfer and Rich, 1992; Suedmeyer, 2006). However, many elephants will not allow this treatment without sedation and local anaesthesia (Wolfer and Rich, 1992; Mikota, 2006c). Lastly cataract is most commonly found in elder elephants (Evans, 1910). **Treatment** for conjunctivitis and corneal opacity is similar. Prior to eye treatment, the surrounding area of the eye should be clean (Suedmeyer, 2006). First flush the affected eye with a saline solution (Phuangkum et al., 2005; Suedmeyer, 2006). Secondly, an antibiotic should be administered (Wolfer and Rich, 1992; Paul et al., 2018). This either prevents secondary infection or treats a current infection. The described antibiotics to treat eye infections are for example chloramphenicol and gentamycin (Suedmeyer, 2006). Medication for the eyes comes in two ways, drops or ointments (Phuangkum et al., 2005). Both have their own pros and cons. It is advised when using drops to administer them every hour. If the elephant easily accepts treatment, this should be your first choice. Ointments should only be administered two to three times daily. However, they attract dirt which has a negative effect on the healing process (Phuangkum et al., 2005). Thirdly, a corticoid eye drops can be given, although if cornea damage is suspected one should reconsider using corticoid eye drops (Kadmiel et al., 2016). This is due to the fact that glucocorticoids tend to slow down corneal healing (Kadmiel et al., 2016). Lastly, if vitamin A deficiency is suspected out of the anamnesis, treat the elephant with intramuscular vitamin A injections weekly. Unfortunately, prevention and/or treatment of cataract is to this date impossible in elephants (Ahmed and Doley, 2016; Kraiwong et al., 2016). Except for a few surgeries executed on zoo elephants replacing the elephant's lens (Ajitkumar et al., 2010).

Figure 1. Conjunctivitis and excessive tearing in an elephant's eye from Line Hansen

2.3 Foot disorders

Foot problems constitute to the single most important ailment of captive elephants (Fowler, 2001b; Fowler and Mikota, 2006a; Miller et al., 2015; Kido et al., 2018). Several predisposing factors make that elephants in captivity more often endure foot ailments than wild elephants (Fowler, 2001b; Miller et al., 2016). Elephants held in captivity often lack exercise, are kept on unsuitable surfaces, struggle with obesity, etc. (Fowler, 2001b) making foot problems a common ailment (Fowler, 2001b; Miller et al., 2016). Controlling or solving these predisposed factors seem to be challenging and to this point often impossible (Miller et al., 2016). Foot disorders are very challenging to manage even if aggressive treatment is assessed (Kido et al., 2018). However regular foot examination and foot care can prevent many common disorders (Roocroft and Oosterhuis, 2001). How to do regular footcare will be discussed in the chapter preventive measures.

In this section the most common foot ailments observed in captivity will be discussed. It seems that many different treatments are described to solve foot problems (Fowler and Mikota, 2006a; Csuti et al., 2008). To this date little to no research has been done to compare the effectiveness of each treatment. Therefore, it is hard to recommend specific treatments for each problem. Here the most common treatments will be provided, but a lot of treatments still rely on trial and error.

2.3.1 Skin ailments

Wounds and abscesses are common ailments of the elephant's foot (Fowler, 2001b; Fowler and Mikota, 2006a; Miller et al., 2016; Kido et al., 2018). The most striking **symptom** linked to any foot disorder is lameness (Csuti et al., 2008). If lameness is observed all four feet should be examined thoroughly (Mikota, 2006c). Prior to the physical examination the feet should be cleaned to remove excessive dirt. **Diagnosing** wounds in an early stage is of the utmost importance to prevent them from festering into worse conditions. **Treatment** of wounds and abscesses should be the same as described before for skin wounds and abscesses (Mikota et al., 2006). Whereas this is an easy task in trained elephants, this seems to be impossible in untrained elephants (Roocroft and Oosterhuis, 2001). In range countries many elephants are not trained to perform regular footcare, making lifting the leg for a longer period of time impossible. A solution for this problem is instead of cleaning the foot by hand, giving the elephant a footbath (West et al., 2001; Fowler and Mikota, 2006a; Mikota et al., 2006). Although it is important that the same cleaning routine is used. Firstly, the feet need to be cleaned with clean water, this can be done by a water hose while the elephant is walking on a clean surface. Next the affected foot should be put in a footbath with a disinfectant solution (Fowler and Mikota, 2006a). There is no solution that is universally accepted by elephant veterinarians. In Table 6 different solutions are compared and the indication of each is given (Fowler and Mikota, 2006a). Footcare can be a very time-consuming treatment because it is recommended to keep the wound in the footbath for at least 20 minutes (Boardman et al., 2000; Fowler and Mikota, 2006a). In addition to wound care, consideration to corrective trimming should always be given, if necessary. This procedure can take up to one hour a foot (Roocroft and Oosterhuis, 2001).

Table 6. Solutions used to soak elephant feet from Fowler & Mikota (2008)

Generic Name	Trade Name	Source	Indications	Mixing Directions	Comments
Magnesium sulfate, USP, $Mg\ SO_4\ H_2O$	Epsom salt	Any drugstore or pharmacy	A concentrated solution of Epsom salt is hypertonic and draws fluid from tissue; used for local inflammation, cellulitis, arthritis, and contusions	For an elephant foot, 225 g (0.5 lb) of Epsom salt in 2 l (2 quarts) hot water; allow water to cool	
Chlorhexidine diacetate	Nolvasan solution, 2% chlorhexidine	Fort Dodge Laboratories, 800 5th St., N.W. (P.O.B. 717), Fort Dodge, IA 50501	General disinfectant	250 ml (9 oz) of the 2% stock solution to 1.0 l (1 quart) of clean water = 0.5% chlorhexidine	Not effective against *Pseudomonas* spp., or gram-positive cocci
Povidone-iodine solution; other names include iodophore, tamed iodine	Vedadine, 10% stock solution	Vedco, St. Joseph, Missouri, USA	General disinfectant	May use undiluted or for irrigation or soaking; dilute stock solution 1:10 (400 ml to 3.79 l (1 gal)	May dilute up to 1:100
Copper sulfate	Copper sulfate	Veterinary supply companies	Disinfectant	50 g to 1 liter = 5% solution	Caustic in high concentrations
Sodium hypochlorite (NaOCl)	Clorox, 6% solution	Any grocery store	Powerful oxidizing agent and disinfectant	Use 0.25% solution for soaking; 155 ml bleach to 3.7 l (1 gal) water	Will bleach clothing

Formula for calculating dilution of a stock solution to a therapeutic solution:
the % of the active ingredient in the stock solution × X = the desired ultimate % × the volume desired.
5% × X = 0.25% × 1000 ml
X = 250/5 = 50 ml of 5% stock solution in 750 ml of water

Abscesses in the nails or footpad of the elephants occur due to insufficient blood supply (Roocroft and Oosterhuis, 2001). Insufficient blood supply knows many aetiologies, such as stereotypic behaviour, obesity, 'stone bruises', etc. First a sterile abscess will arise (Roocroft and Oosterhuis, 2001). This is often missed, because it lacks clinical **symptoms** (Hughes and Southard, 2001; Roocroft and Oosterhuis, 2001). As in every other animal, the elephant's body will try to get rid of this sterile abscess by protruding to the outside (Roocroft and Oosterhuis, 2001). The way of least resistance is followed, many abscesses like this will rupture at either the cuticle, interface between nail and footpad or at the backend of the foot. Once the abscess opened a rapid, thorough **treatment** should be implemented. It is important that the abscess is trimmed in this way that it can drain, and all necrotic tissue is removed. As in wounds the abscess needs to be held in a footbath for at least 30 minutes twice daily. If infection occurs the use of parenteral antibiotics is disputed. For this it is up to the treating veterinarian to decide the severity of infection and if antibiotic treatment is necessary (Roocroft and Oosterhuis, 2001).

Figure 2. 'Stone bruise' that leaded to a sterile foot abscess that eventually broke through from Line Hansen

Figure 3. Severe pododermatitis as a result from insufficient treatment of Figure 2 from Line Hansen

2.3.2 Pododermatitis

Any infectious process affecting the foot belongs to the term pododermatitis (Fowler and Mikota, 2006a). It can be as simple as an infected wound or as complex as an infection including all soft tissue structures (Gage, 2000; Fowler and Mikota, 2006a). Depending on the severity of the infection different **symptoms** can be observed (Keet et al., 1997; Fowler and Mikota, 2006a). Lameness or even reluctance to put weight on the foot is seen firstly (Fowler and Mikota, 2006a). In an up-close examination flaps or sloughing of the sole, redness, overgrowth of the keratinized structures, exudation and icky odour can be observed. During **diagnosis** the extend of the infection should be examined. It is important to determine if only the superficial structures are affected or also underlying structures. Depending on the extensiveness of the infection a more aggressive treatment should be considered (Mortenson, 2001; Fowler and Mikota, 2006a). Identical as to wounds, if possible, a sample should be taken and an antibiogram should be made. In contrast to skin wounds, infectious germs found in elephant feet are mostly gram-negative, non-spore-forming rods namely Enterobacteriaceae (Keet et al., 1997). For the **treatment** of pododermatitis a 20-minute footbath is essential. As discussed before there is no universal accepted disinfectant to do this (Fowler and Mikota, 2006a). Although Rutkowski et al. (2001) states that a 20-minute footbath in chlorhexidine seems to be the most effective. The removal of debris is really important (Csuti et al., 2008). Healthy lively skin should be aligned with other healthy lively skin to improve healing (Rutkowski et al., 2001). Bevelling of the infection area promotes drainage of dirt and exudate (Rutkowski et al., 2001). The usage of antibiotics in this case is up for debate (Mortenson, 2001). Local and parenteral administration of antibiotics can be considered. The veterinarian in charge should decide if an antibiotic treatment is effective or not. If the elephant is reluctant to get proper treatment the use of parenteral or local antibiotics can be justified. If it is impossible to control the infection it can fester into osteomyelitis (see further) which is the most serious condition in the elephants' foot (Mortenson, 2001). If an antibiogram is absent, consider giving antibiotics mainly affecting gram negative germs.

2.3.3 Toenails (overgrowth, onychia)

The elephant's toenail as the rest of the foot requires constant attention. Toenails grow approximately 0.5 cm to 1.0 cm a month (Fowler and Mikota, 2006a). If the nails are not worn out enough due to lack of exercise or the enclosure substrate not being abrasive, then it should be trimmed every two to three

months (Fowler and Mikota, 2006a). As mentioned before standard footcare is rarely executed in Asian countries (Roocroft and Oosterhuis, 2001). This often leads to overgrowth of the nails, initially this does not cause any harm on the elephant. Nonetheless more pressure will be put on the nail and so it is more prone to split (Fowler, 2001a). If it is considered a small split the elephant probably will not show any symptoms, if the split goes up to the cuticle, **symptoms** such as lameness will be seen frequently (Rutkowski et al., 2001). Even if the elephant shows no symptoms, the split should still be treated. This is done to prevent the split from further cracking to the top of the nail (Rutkowski et al., 2001). The bigger the split, and if the cuticle is involved, the more likely it is to get infected (Fowler and Mikota, 2006a). A few **treatments** are described for this. Acrylic patches or epoxy can be used to fill up the nail (Rutkowski et al., 2001; Seidon, 2001; Sampson, 2008). Although these treatments require some time and isn't always effective. Also, footbaths are recommended to prevent infection (Rutkowski et al., 2001). See Table 6. However, the most effective way to treat this ailment is by corrective trimming (Rutkowski et al., 2001; Sorensen, 2008). A split toenail should be trimmed in a way that the side where the split is growing to is shorter than the opposite side. Secondly the split should be cut in a V-shape, cutting the split the deepest and surrounding areas at an angle. This is done because not only do the nails grow longer, they also grow outwards. Creating the most stable way for the split to grow out naturally without any risk of further splitting. It should always be cut to the life area. By doing this a small bleeding can occur. Bleedings of toenails can be stopped by applying wonder dust®, for approximately three to four days to dry out the wound (Rutkowski et al., 2001; Sorensen, 2008). If wonder dust® or a similar powder is not available copper sulphate can be put on the bleeding as this is the main ingredient in wonder dust® causing the bleeding to stop. An alternative new treatment is suggested by Kido et al. (2018) to treat severe cases of pododermatitis. It suggests the usage of a modified mosh paste. The mosh paste makes sure the hyperplastic tissue clots and also prevents hyperproliferation. Due to this the hyperplastic tissue became less painful and could easily be trimmed so the disorder becomes manageable (Kido et al., 2018).

If it is impossible to clean behind the cuticle on a regular base, the toenail bed can get inflamed or infected (Fowler, 2001a; Fowler and Mikota, 2006a). This inflammation or infection on the toenail bed is named onychia. Typical **symptoms** are lameness, painful swelling that feels hot and a draining tract at the top of the nail. If the bottom of the nail is examined a black tract extending dorsally can be found. **Treatment** of such consist of trimming and packing the tract with disinfectant solutions. An ideal way to do this is by saturating gauze with disinfectant and then implementing it. This prevents further infection and the development of debris in the tract. This gauze should be changed at least twice daily (Fowler, 2001a; Fowler and Mikota, 2006a).

2.3.4 Musculoskeletal ailments

Trauma

Trauma of the elephant's foot bones is an unsolvable disease (Fowler and Mikota, 2006a). The elephant will show intermitted lameness or even refuse to put weight on the traumatised foot (Roocroft and Oosterhuis, 2001). Other symptoms can be swelling and heat, although this is not seen in every case (Fowler and Mikota, 2006a). A broken bone in the foot can only be diagnosed by radiography (Fowler and Mikota, 2006a). This is however often impossible in the field (Hittmair and Vielgrader, 2000). If an unresponsive lameness is noticed supportive treatment should be considered. The use of analgesics is described; however, this can affect the healing negatively (Mortenson, 2001). If the elephant is experiencing less pain it will be more likely to use the foot (Fowler and Mikota, 2006a). Make sure the elephant is put on rest and uses the limp the least amount possible without restricting other welfare factors (Fowler and Mikota, 2006a).

Osteomyelitis

An untreated or unsuccessful treated infection of the soft tissues of the foot can fester easily to osteomyelitis (Gage, 2000; West et al., 2001; Fowler and Mikota, 2006a). Osteomyelitis is the infection of the bones (Gage, 2000; Csuti et al., 2008). It is considered the most serious condition affecting the elephant's foot (Gage, 2000). If the elephant is affected with osteomyelitis a swelling locally around the nail of the affected digit or the complete foot can be seen. **Clinical signs** such as heat and lameness are observed as well. To confirm the **diagnoses** of osteomyelitis a radiography should be taken. If radiographic studies are possible, they should be at least taken weekly to observe the progression of the disease. **Treatment** of osteomyelitis is extremely challenging. Again, prevention is of the utmost importance. The prognosis of osteomyelitis is questionable, if observed high doses of general antibiotics should be administered (Gage, 2000). The most effective way of treatment is surgical removal of the infected area (Gage et al., 1997; Boardman et al., 2000). This is however an impossible treatment in the field. An alternative to surgical removal is regional perfusion with appropriate antibiotics (Mikota, 2006e). A tourniquet should be placed prior to administration of the antibiotic intravenously. After treatment the tourniquet should remain in place for another 20 minutes. The regional perfusion should be done daily. As many elephants will not allow this treatment without sedation, this treatment is very time-consuming (Mikota, 2006e).

Infective (septic) arthritis

Infective arthritis is described in elephants (Fowler and Mikota, 2006a). It can be caused by a proximally spread osteomyelitis or due to joint trauma making it susceptible to organisms causing another disease in elephants. As this is an extremely painful disease a common **symptom** is a recumbent elephant as it refuses to put weight on the limb. Also, pain, heat and swelling can be observed during palpation. If severe lameness is seen infective arthritis should always be on the differential diagnosis list. **Diagnosing** this disease can be done by aspiration of synovial fluid. It is important to do this aseptically so that the fluid can be cultured. The fluid may be cloudy, purulent or haemorrhagic and has a decreased viscosity. After cell count the white blood cells will be above 33 000 per mm^3. Start of **treatment** cannot wait for cultural results and should be done immediately. The aim of the treatment is to remove the infective organism and harmful products of synovial inflammation and fibrin. However, lavage is never described in elephants and so cannot be administered in the field. Regional perfusion can be tried but the effectiveness is unknown and so the prognosis doubtful (Fowler and Mikota, 2006a).

Degenerative joint disease (DJD, osteoarthritis)

Degenerative joint disease (DJD), also known as osteoarthritis, is thought to be the result of inadequate management practices (Fowler and Mikota, 2006a; Csuti et al., 2008; Miller et al., 2016). It is a progressive disease affecting the articular cartilage. It is a deterioration of the cartilage in combination with changes in the surrounding bones and soft tissues. This disease can be observed in every limb joint, however here the focus is given to foot joints. At the unset of DJD the first **clinical sign** is a subtle change in gait, or the elephant will be less active. Once advanced DJD is reached the elephant will show lameness. **Diagnosing** osteoarthritis in the field can be challenging. The only way to know it for sure is arthroscopy, however this is not yet described in elephants. Radiography can be used to suspected DJD. If radiography is impossible, the combination of symptoms and anamnesis may indicate towards this. A sole **treatment** is not yet described. Many treatments have been tried but none stand out. As this is a progressive disease, treatment will depend on the stage of DJD (Fowler and Mikota, 2006a; Csuti et al., 2008; Miller et al., 2016). One of the main factors in treatment is reducement of pain. This can be achieved by administering NSAID's (Mikota, 2006e). Note that the chronic use of NSAID's is negatively advised. In supplies, a list is provided describing the different NSAID's used in elephants and their dosage. Polysulfated glycosaminoglycan can be an alternative medicine in chronic cases of DJD. The medicine is especially good as it spares cartilage and has anti-inflammatory properties. Light exercise and/or swimming should be a part of the treatment plan. Lastly cold hydrotherapy is often used to reduce inflammation and swelling of the joint (Mikota, 2006e).

The different foot disorders have been examined separately above; it is important to note that rarely just one of the disorders presents itself. This is mainly due to the fact that the different disorders can cause each other. Meaning that if it is not noticed straight away and allowed to fester, instead of treating a small wound, one has to resolve a pododermatitis. This is but a short example to express that immediate treatment and preventive healthcare are extremely important.

2.4 Musculoskeletal system

Musculoskeletal ailments are described frequently in elephants, especially logging elephants (Evans, 1910; Phuangkum et al., 2005; West, 2006). These can go from a small sprain to severe fractures. If an elephant is affected with a musculoskeletal ailment it will show **clinical signs** such as changed gait, reluctance to walk, lameness or even be recumbent. **Diagnosing** the specific musculoskeletal ailment is in most cases impossible. The enormous body mass of the elephant prevents taking radiography making diagnosing difficult. The prognoses for many of these ailments is poor. The main **treatment** exists out of supportive treatment. The elephant should be put to rest, although light exercise should be allowed. NSAID's can be administered to reduce swelling and pain, if present. Depending on the ailment other supportive matters can be taken (Evans, 1910; Phuangkum et al., 2005; West, 2006).

2.5 Digestive system

2.5.1 Tusks/tushes

The tusks, tushes are two incisive (sort teeth) that protrude from the maxilla (Phuangkum et al., 2005; Dumonceaux, 2006). As they are out of the body, they are prone to injury. The main problem that occurs is infection and should at all times be prevented (Phuangkum et al., 2005; Dumonceaux, 2006). **Symptoms** indicating infection are foul odour, purulent discharge and a small black spot on the end of the tusk (Dumonceaux, 2006). **Diagnosing** can be done by collecting an aseptic cultural swab (Fowler and Mikota, 2008). **Treatment** at an early stage is really important. First of all, if a small fissure or an opening to the pulp canal is seen it should be treated immediately (Evans, 1910; Phuangkum et al., 2005; Dumonceaux, 2006). At all times the aim should be to protect the pulp canal from environmental contamination. This can be done by administering caps. If a serious infection is observed an aggressive

treatment should start immediately to prevent septicaemia. Flush the pulp canal excessively with an antiseptic such as diluted iodine. In combination start administering antibiotics working against aerobic and anaerobic species. In between treatment the tusk should be protected with a cap (Evans, 1910; Phuangkum et al., 2005; Dumonceaux, 2006).

2.5.2 Endoparasites

A great amount of endoparasites can be distinguished in the digestive system of elephants (Fowler and Mikota, 2008). Many of them are not accompanied with clinical signs and cause no great harm to the elephant, if the infestation number remains low (Phuangkum et al., 2005; Fowler and Mikota, 2008). Prevention of high infestation is recommended and will be further discussed in the chapter preventive care. High infestation and/or specific endoparasites however will lead to disease and are discussed here.

The first and commonly seen endoparasite of the liver is liver fluke (Fowler and Mikota, 2008). Two species have been described in elephants. The species specific, *Fasciola jacksoni* and the common liver fluke, *Fasciola hepatica*. Both giving the same **symptoms**, differentiation in the field is unnecessary. Acute and chronic forms have been described, but the chronic form is seen more often (Fowler and Mikota, 2008). The acute form is characterised by anorexia, constipation, diarrhoea, anaemia, icterus and sudden death (Caple et al., 1978; Islam, 1996; Phuangkum et al., 2005; Fowler and Mikota, 2008). Chronic forms have a steadier progress. The elephant becomes anorectic followed by weight loss. The mucous membranes may be pale or icteric and pendant oedema is described. Infestation can either lead to diarrhoea or constipation (Caple et al., 1978; Islam, 1996; Phuangkum et al., 2005; Fowler and Mikota, 2008). **Diagnosis** can be done by a faecal flotation test. If not available, elevated liver enzymes combined with symptoms may be a good indication (Caple et al., 1978). If infestation is suspected **treat** the elephant with an anthelmintic (Mikota, 2006d). Clorsulon, albendazole, triclabendazole and oxyclozanide have shown to be effective (Islam, 1996).

Nematodes, also referred to as roundworms, are extensively described in elephants. Many different species have been observed in the elephant's digestive system (Abhijith et al., 2018). Depending on the species a different part of the gastro-intestinal tract is infested, but mainly they infest the large intestine and cecum (Fowler and Mikota, 2008). However, most of them will show similar symptoms and therefore no distinction will be made here. Depending on the number of roundworms infesting the elephant's GI-tract per acute, acute and chronic forms has been seen. Infestation with endoparasites, in most cases, only leads to debilitation of the elephant. This leads to the body being more susceptible to secondary infections (Fowler and Mikota, 2008). A **symptom** that goes along with this weakening of the elephant's body is an unhealthy skin (Mikota, 2006b). The skin will become rough and the hairs become brittle due to poor nutrition utilisation (Mikota, 2006b). If the elephant is infected for a longer period of time emaciation is seen (Fowler and Mikota, 2008; Jani, 2008). In very severe cases, diarrhoea, anaemia and in some cases, hypoproteinaemia can be seen. In small animals a growth lag is observed due to the inappetence and the poor nutritional intake. If one of the above symptoms is observed parasitic infestation should be on the differential diagnosis list (Fowler and Mikota, 2008; Jani, 2008). Different **diagnostics** are described. First of all, adult worms can be, in some cases, found in the dung. The length of the adult worm is between 2.6 mm and 35.6 mm (Phuangkum et al., 2005). Secondly the presence of nematode eggs can be shown by a flotation-sedimentation test or other centrifugation test (Lynsdale et al., 2015). Lastly the response to treatment is a good indication if the elephant was infested or not (Fowler and Mikota, 2008). **Treatment** should always start with the administration of an anthelminthic (See: supplies). As many are not yet described in elephants it is advised to use equine doses and dosing intervals as a model (Mikota, 2006d). Depending on the clinical status of the elephant a supportive treatment should be considered.

Diarrhoea, as in other animals, does not always mean infection. Nutritional diarrhoea, diarrhoea from stress and 'self-deworming' diarrhoea is described in elephants (Phuangkum et al., 2005; Dumonceaux, 2006). It is advised to elephant handlers to call a veterinarian if the diarrhoea persist for over three days. This because 'self-deworming' diarrhoea may not exceed this three-day period. Also, the food will pass the gastro-intestinal tract in 24 to 50 hours. So, if the elephant only ate one bad thing a single period of diarrhoea is observed. So, the main principle concerning diarrhoea is, 'if it exceeds three days, measures need to be taken' (Phuangkum et al., 2005; Dumonceaux, 2006).

2.5.3 Disorders of the intestines (infectious agents / intestinal obstructions)

Two major infectious diseases of the gastroenteric infections (GI) tract are described in Asian elephants, namely salmonellosis and colibacillosis (Phuangkum et al., 2005; Fowler and Mikota, 2008).

Salmonellosis caused by *salmonella spp.* will present as a gastroenteritis, although in some cases it becomes systemic causing septicaemia (Andrews-Polymenis et al., 2010). This disease is mainly seen after an immune depression. Immune depression can be caused by several causes such as stress, viral diseases, parasitic infections, failure of passive transfer, post-surgery, etc. (Fowler and Mikota, 2008). Initial **symptoms** of gastroenteritis are colic, loss of appetite, lethargy and diarrhoea. To **confirm** salmonellosis a culture of the faeces needs to be made (Fowler and Mikota, 2008; Oludairo et al., 2013). However, *Salmonella spp.* are shed intermittent and for this may be difficult to detect. If septicaemia is present a blood culture can be taken as well (Fowler and Mikota, 2008; Oludairo et al., 2013). **Treatment** of GI is similar for each germ. Two major things need to be taken into account. First of all, the electrolyte imbalance needs to be corrected as quickly as possible (Mikota, 2006a). Intravenous fluids containing sodium bicarbonate, potassium chloride or other electrolytes and minerals are crucial. Keep in mind that overdoses of some can happen, so always calculate the amount that should be given (Mikota, 2006a). Secondly, try to control the diarrhoea (Fowler and Mikota, 2008). To control diarrhoea the germ needs to be killed by administering parenteral antibiotics (Mikota, 2006d; Fowler and Mikota, 2008). If the germ is unknown administer a broad-spectrum antibiotic. Keep in mind by doing this the natural habitat of the intestines can be killed as well, leading to dysbiosis. Neomycin orally is also described to concur infection. However, this is not absorbed into the elephant and only acts locally (Mikota, 2006d; Fowler and Mikota, 2008).

Various forms of colibacillosis have been described (Fowler and Mikota, 2008). One can cause a simple enterotoxin diarrhoea, whilst another shows generalised infection with septicaemia. **Symptoms** will vary but, in most cases, diarrhoea is an indicative sign. **Diagnosis** is very challenging and in most range

Figure 2. Saw-horse stand: movements to relief pain & gas from Govindan et al. (2019)

countries impossible. To confirm diagnosis an isolation and identification of the organism and strain is necessary (Fowler and Mikota, 2008). **Treatment** is the same as described in salmonellosis.

Elephants lacking in nutrients are inclined to eat dirt, clay or sand (Dumonceaux, 2006). If ingested in high amounts those can become impacted in the GI tract. A second cause to GI tract obstructions is the consumption of large amounts of high fibrous food in a short period of time. Partial or total obstruction of the intestines may lead to colic (Dumonceaux, 2006). **Clinical signs** aligned with colic are restlessness, stretching, rolling or assuming a bowing posture (saw-horse stand as seen in Figure 4), abdominal distension, lack of defecation, biting the tip of the trunk, groaning and tenesmus (Phuangkum et al., 2005; Dumonceaux, 2006; Govindan et al., 2019). The earlier the treatment is started, the better the prognosis. This due to the fact that intestinal obstruction rapidly leads to dehydration of the elephant, due to reluctancy to drink. Dehydration on its term leads to intestinal stasis, worsening the disorder, electrolyte imbalance, endotoxic shock and circulatory collapse. In severe cases the patient will rapidly evolve to recumbency and eventually die. A specific symptom associated with total obstruction is the absence of faeces (Phuangkum et al., 2005; Dumonceaux, 2006; Govindan et al., 2019). **Diagnosing** intestinal obstructions in elephants, is unlike in horses, impossible with ultrasound or rectal examination (Dumonceaux, 2006). However, it is suggested to perform a rectal exam to examine if faecal boluses are present and can be removed by hand. The decisive factors in determining whether or not an obstruction is present is the combination of anamnesis and symptoms (Dumonceaux, 2006). **Therapy** of elephant's colic is similar to those in horses (Phuangkum et al., 2005; Dumonceaux, 2006; Mikota, 2006d; Govindan et al., 2019). Administering a pain-relieving medication and Hyoscine butyl bromide (Buscopan®) will comfort the elephant. Secondly if the elephant is willing to eat a laxative, such as a mixture of mineral oil and bran or tamarind fruit, may stimulate the evacuation of the obstruction. Walk the elephant frequently so the intestinal tract is stimulated. Lastly, warm water enemas are especially helpful in distal obstructions. This will partly resolve dehydration and may soften the impaction. Depending on the dehydration status of the elephant a supportive treatment should be considered (Phuangkum et al., 2005; Dumonceaux, 2006; Mikota, 2006d; Govindan et al., 2019).

2.6 Respiratory system

2.6.1 Tuberculosis (TB)

Tuberculosis rarely shows symptoms in elephants, it is discussed here, as it is a significant zoonotic disease (Phuangkum et al., 2005). If **symptoms** are present, they are vague. Anorexia, chronic weight loss, weakness, exercise intolerance, decreased water intake, depression, tremors and abnormal discharge from the trunk can be seen (Phuangkum et al., 2005; Fowler and Mikota, 2008; Miller et al., 2018). The best **diagnostic** tool for detecting TB in elephants is trunk washes (Miller et al., 2018). Unfortunately, most elephants in range countries are not trained to perform this procedure. As a result, the spread of tuberculosis is unknown. If TB does occur a long intensive **treatment** with antituberculotic drugs should be administered (Rosen et al., 2019). The treatment should last for at least twelve months (Fowler and Mikota, 2008; Rosen et al., 2019).

2.7 Infectious diseases

2.7.1 Elephant Endotheliotropic Herpesvirus (EEHV) infection

Kochagul et al. (2018) stated that EEHV is one of the most devastating viral diseases in elephants worldwide. To this date it is mostly confirmed in captive elephants (Fowler and Mikota, 2008). Clinical signs in adult elephants are rarely seen, but they are suspected carriers (Hayward, 2012). The exact number of affected elephants is unknown due to lack of appropriate **diagnostic** tools (Stanton et al., 2012). Symptoms and outbreak of this infection is mainly seen in elephant calves from the age of one

to four (Hayward, 2012). Symptoms suddenly appear and the disease progresses quickly (Fowler and Mikota, 2008; Long et al., 2016; Kochagul et al., 2018). Typical **symptoms** seen in EEHV is cyanosis of the tongue, as seen in Figure 5, (starting at the tip progressing distally), oedematous swellings, lethargy and anorexia. An effective **treatment** is not yet found. This makes the prognosis poor and clinical affected elephant will in most cases die. If diagnosed early, an anti-herpesvirus medication in combination with an aggressive supportive treatment can be tried. Also, broad-spectrum antibiotics should be administered to prevent secondary infections (Fowler and Mikota, 2008; Long et al., 2016; Kochagul et al., 2018). This disease is a major threat to the young elephant captive population (Hayward, 2012).

Figure 3. Tongue cyanosis (dark blue) and mucosal haemorrhages due to EEHV from Fowler and Mikota (2008)

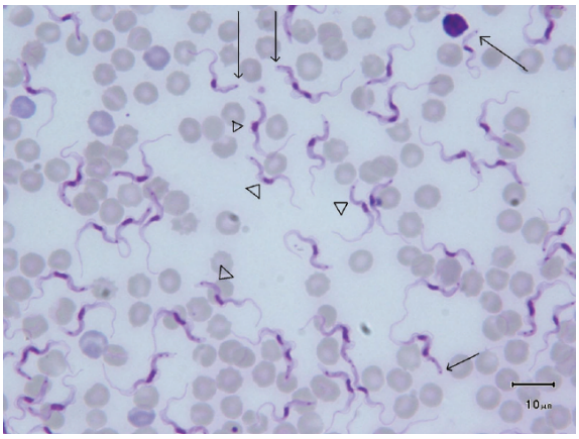
2.7.2 Tetanus

Although tetanus is preventable by vaccination, it is still observed in range country elephants (Evans, 1910; Phuangkum et al., 2005; Fowler and Mikota, 2008; Lindsay et al., 2010). Tetanus is caused by the anaerobic germ *Clostridium tetani* (Evans, 1910; Phuangkum et al., 2005; Fowler and Mikota, 2008). The Disease occurs when deep wounds are contaminated with soil or faeces containing C. tetani spores. Tetanus can be recognised by specific **symptoms** such as hypersensitivity to noise and touch, elevated temperature, tension, raising the tail, reluctance to open the mouth and eventually tetanic spasms (Evans, 1910; Phuangkum et al., 2005; Fowler and Mikota, 2008). **Diagnosing** the bacteria is a difficult task, diagnoses should be done by anamnesis and symptoms (Burke, 1975; Fowler and Mikota, 2008). Supportive care is an extremely important part of the **treatment**. High doses of penicillin can be administered or broad-spectra antibiotic, if deep wounds are still present. Secondly Tetanus antitoxin can be given, nonetheless little to no research proves the effectiveness in elephants. In most cases the prognosis remains unfavourable and the elephant will die (Burke, 1975; Fowler and Mikota, 2008).

2.7.3 Trypanosomiasis (Surra)

In Asian elephant only one protozoon has been described excessively, namely *Trypanosoma evansi (Phuangkum et al., 2005; Mikota, 2006a; Desquesnes et al., 2013)*. Local population may refer to this disease by 'Surra' (Evans, 1910). The parasite is spread by blood sucking insects, mechanically or true

the environment (Evans, 1910; Mikota, 2006a; Desquesnes et al., 2013). The geographic distribution of the parasite is massive (Desquesnes et al., 2013). Disease caused by this protozoon is not uncommon (Mikota, 2006a). Vague **symptoms** can be linked to this infestation (Fowler and Mikota, 2008). Both acute and chronic forms exist. Acute Surra is associated with high fever, depression, weakness and general oedema. Death will follow within a few weeks. Chronic Surra on the other hand is associated with intermittent fever, anaemia, dependant oedema and maceration. Depending on the care, the elephant may live for several more years (Fowler and Mikota, 2008).



Diagnosing can be done by a microscopic test (Mikota, 2006a; Desquesnes et al., 2013). A blood smear will show trypanosomes, as shown in Figure 6 However, they do not 'live' constantly in the peripheral blood and thus can be absent in this blood smear. Unfortunately, no other laboratory tests have been tested in Asian elephants. **Treatment** to this date seems a challenging task with different responses. The use of trypanocide agents is described (Mikota, 2006a; Desquesnes et al., 2013).

Figure 4. Morphological features of Trypanosoma evansi in a Giemsa stained blood smear: with thin posterior extremity (head of arrows), together with truncated forms (arrows) whose posterior extremities are truncated just below the kinetoplast location from desquesnes et al. (2013)

3 Medical Preventive healthcare

The best way to prevent many ailments in captive elephants would be creating the same living conditions as in the wild (Buckley, 2008; Turesson, 2014; Miller et al., 2016; Bansiddhi et al., 2018; Williams et al., 2018; Bansiddhi et al., 2019; Mumby, 2019; Bansiddhi et al., 2020; Veasey, 2020). However, this seems to be impossible. Up until a few decades ago little to no attention was given to the husbandry of elephants held in captivity (Riddle and Stremme, 2011). Nowadays, the welfare of animals becomes more and more important, making the aim creating similar circumstances as in the wild essential. This is a very difficult task, especially due to the limitations of space and equipment. Experts are in many cases at their wits end trying to create similar circumstances (Riddle and Stremme, 2011). However, by taking other medical preventive measurements those difficulties can be countered (Buckley, 2008; Turesson, 2014; Miller et al., 2016; Bansiddhi et al., 2018; Williams et al., 2018; Bansiddhi et al., 2019; Mumby, 2019; Bansiddhi et al., 2020; Veasey, 2020).

3.1 Foot care

As cited in diseases and treatments, foot problems are one of the major concerns in captive elephants. Regular footcare may be a solution to the extension of those disorders. There are two major aspects contributing to regular footcare (Hughes and Southard, 2001; Roocroft and Oosterhuis, 2001; Buckley, 2008).

First of all, elephant feet should be inspected and cleaned daily. To clean the foot a hard brush, water and soap is used. The footpad, as well as the interspace between nails should be cleaned thoroughly. Those areas are predisposing places for dirt to get stuck and so lead to infection. Captive elephants do not have the ability to walk away of their own faeces and urine, because they are chained for longer period of times. Both faeces and urine often contain infectious agents and have an erosive effect on the foot. Foot cleaning in combination with daily cleaning of the elephant's living area prevents infection.

Secondly, the elephants' feet should be lifted and trimmed at least every three months. As captive elephants do not perform the same exercise as in the wild, foot structures tend to overgrow easily. When trimming the elephants' feet three structures should be targeted. Firstly, the nails should be trimmed in a way that if the elephant stands on a flat surface the nails do not touch the ground. Secondly the space between each nail should be one finger as illustrated in Figure 7, except for the lateral nail on the back feet, there the space can remain smaller. Secondly, the cuticles should be trimmed as well. Although this procedure seems more challenging due to the sensitivity of them, it cannot be skipped. If it is skipped, the drainage of the sweat glands is blocked and painful fluid pockets form. Lastly, the footpad of the elephant shouldn't be either too thick or too thin. In Figure 7 a healthy foot is illustrated. Thick footpads can be rasped with a hoof rasp. For thin footpads not many things can be done, except for allowing the elephant to stay on a non-rocky soft surface so puncture wounds and 'stone-bruises' are prevented (Hughes and Southard, 2001; Roocroft and Oosterhuis, 2001; Buckley, 2008). In Figure 8 a picture of a good-looking footpath is illustrated.

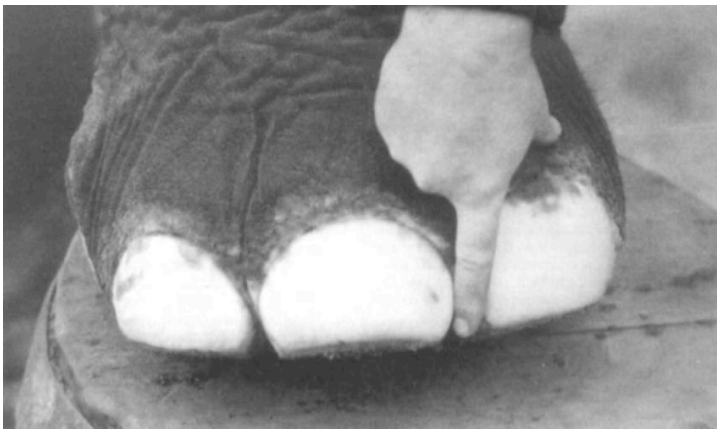


Figure 6. A healthy elephant's foot with sufficient space between the nails from Roocroft and Oosterhuis (2001)

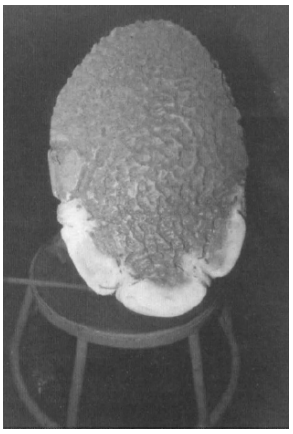


Figure 5. A good footpath of an employed elephant that has never been trimmed from Roocroft and Oosterhuis (2001)

3.2 Vaccinations

Depending on the area where the captive elephant population is situated as well as previous history records, vaccinations can be given to prevent diseases (Mikota, 2006c). One of the most common used vaccinations in captive elephants is tetanus toxoid. As mentioned before, the tetanus commercial vaccines produced for livestock and horses are proven to be effective (Lindsay et al., 2010). Other vaccinations that may be considered are rabies vaccine, anthrax vaccine, foot and mouth disease and lastly leptospirosis vaccine if endemic (Mikota, 2006c; Fowler and Mikota, 2008). For more information I refer to Elemotion Foundation [2], where a medical protocol can be downloaded.

3.3 Deworming

Although 'self-deworming' has been described in elephants, it is strongly suggested to deworm every six months (Phuangkum et al., 2005). This will prevent a high infestation of parasites. Anthelmintic that can be used are given in the chapter supplies. In contribution to this, faecal screening for parasites should be executed, including direct, flotation and sedimentation tests (Fowler and Mikota, 2008; Abeysinghe et al., 2012).

[2] http://www.elemotion.org/our-programs/completed-projects/welfare last referred on 13/05/2020

3.4 Blood sampling

It is strongly advised to develop what is normal in an individual elephant or group of elephants by regular blood testing. This is because many resources do not meet the basic principles for the development of reference intervals (KLINHOM et al., 2017). One of the commonly used databases to interpret haematological and biochemical results is the International Species Information System (ISIS) Reference Ranges for Physiological Values in Captive Wildlife (System, 2002). Results in this system can be broken down in different groups namely males, females, both sexes and age classes. More common valuables are reliable, but some parameters in groups are not reliable due to the small sample size. Another concern to this database is that not only healthy elephants' parameters are included but also sick animals. This results in that parameters can be unreliable (System, 2002). Others tried to combine different references values (Mikota, 2006a). However, they may not be reliable as well because they didn't take environmental influences, such as nutrition, into account. Lastly handling and storage of samples is another factor that influences the usefulness of many results. Poor quality blood smears, haemolysis of the blood sample due to bad storage are no exception. It is advised to at least take an annual sample of each healthy individual or more frequently if possible. This resulting in a record of reference values of a specific elephant group or individual (Mikota, 2006a). Blood samples can be taken from the auricular, saphenous and cephalic veins (Phuangkum et al., 2005; Mikota, 2006a).

4 Supplies

The previous chapters have been focused on how to diagnose and treat an animal, while this is of crucial importance to the mobile health clinic, an equally crucial part is the medication that is required to treat the animal. Definitely in the range countries of the Asian elephant, one cannot depend that the medications that are required will be available locally. The tables do not provide all medication but instead only include the medications of which scientific research has been done in regard to their pharma-dynamics and -kinetics. If any further information on this topic would be requested, please go to 'Elephant Care International'[3].

4.1 Medications

Administering medications can be done by many methods. In the tables below (Table 7, 8 and 9) are cited the following; per oral, per rectum, subcutaneous, intramuscular and intravenous. Subcutaneous injections will likely be followed by a swelling due to the low absorption rate of the used medication (Phuangkum et al., 2005). The preferred areas are the front leg and the side of the neck.
Intramuscular injections can be given in three areas, namely the shoulder, the top of the neck and the rump. If administering medication intramuscular attention should be given to the length and thickness of the needle due to the thick elephant skin. Lastly when administering intravenous injections preference is given to the auricular vein, because there the skin is very thin, and the vein is easily accessible. However, the saphenous and cephalic veins are attainable as well (Phuangkum et al., 2005).

[3] www.elephantcare.org last referred on 19/05/2020

Table 8. Most commonly used Nonsteroidal anti-inflammatory drugs in elephants to 'Elephant Care International' [3]

Name	Dose (mg/kg)	Administration route	Indications
Albendazole	2.5	PO	Endoparasites
Clorsulon	1	PO	Immature (8 weeks+) & adult forms of Fasciola Hepatica Other Fasciola spp., most cases single dose not effective
Fenbendazole	5	PO	Strongylus spp.
Ivermectin	0.059 - 0.087	PO	Re-treat at 5 - 6 weeks Lice (Haematomyzus elephantis)
	0.1	SQ	Strongylus spp. & other helminths
Levamisole	2.5 - 3	PO	Strongylus spp. ! May give toxicity in combination with Tetramisole !
Mebendazole	2.5 - 4.0	PO	Helminths
Morantel Tartrate	2.0 - 4.0	PO	Helminths
Oxibendazole	2.5	PO	Helminths
Oxyclozanide	3.4 - 7.5	PO	Helminths & Fasciola spp.
Praziquantel	2.5 - 4.0	PO	Cestodiasis
Thiabendazole	20.0	PO	Helminths
	32	PO	Strongylus spp.

Abbreviations
SQ: subcutaneous
PO: per oral
spp.: species

Table 7. Most commonly used anthelmintic in elephants to 'Elephant Care International'[3]

Name	Dose (mg/kg)	Administration route	Indications
Flunixin Meglumine	1,1	IV; IM; PO	Alleviation of inflammation and pain ~ musculoskeletal disorders Alleviation of visceral pain ~ colic Control of fever ~ respiratory disease & endotoxemia Do not exceed 5 days of consecutive therapy Every 12 - 24 hours (~ severity of pain)
Ibuprofen	6	PO	Alleviation of inflammation & pain ~ musculoskeletal disorders Every 12 hours (b.i.d.)
Ketoprofen	1-2	PO; IV	Alleviation of inflammation & pain ~ musculoskeletal disorders Every 24 - 48 hours
Phenylbutazone	3	PO	Alleviation of inflammation & pain ! NOT IV ~ sloughing of the ear ! Every 48 hours

Abbreviations
IV: intravenous
IM: intramuscular
PO: per oral
b.i.d.: bis in die

Table 9. Most commonly used antibiotics in elephants, separated by their classes to 'Elephant Care International'[3]

Name	Dose (mg/kg)	Administration route	Indications
Penicillins			**Gram positives (aerobes + anaerobes)**
Amoxicillin			Gram positives & negatives (aerobes + anaerobes)
	5.5	IM	As a starting dose Every 24 hours (s.i.d.)
	11	IM	Every 24 hours (s.i.d.)
Ampicillin			Gram positives & negatives (aerobes + anaerobes)
	8	PO	Every 8 - 12 hours (b.i.d. - t.i.d.)
Penicilling G + benzathine penicillin			Gram positives (aerobes + anaerobes) & gram negative anaerobes
	4.545 IU/kg	IM	Every 24 - 96 hours depending on the bacterium
	2.273 IU/kg	IM	Every 48 hours
Cephalosporines			**Gram positives & negatives; decreased activity gram positive cocci**
Ceftiofur			
	1.1	IM	Every 8 - 12 hours (b.i.d. - t.i.d.)
	1.1	IV	Every 24 hours (s.i.d.) ~ MIC of the pathogen
Ceftiofur crystalline-free acid (CCFA)			
	6.6	SQ	Every 7 - 10 days
Macrolides			**Anaerobes (Gram positives + negatives) & Gram positive aerobes**
Tylosin	12.0	IM	Every 24 hours (s.i.d.)
Aminocyclitols			**Aerobe gram negatives**
Amikacin	6.0 - 8.0	IM	Antituberculosis Every 24 hours (s.i.d.)
Gentamicin	4.4	IV; IM	IV: dilute with 10% saline Every 24 hours (s.i.d.)
Neomycin Sulfate	See doses prescription for horses	IM; IV; PO	No specifics for elephants
Tetracyclines			**Gram positives & negatives (aerobes + anaerobes)**
Oxytetracycline	18.0	IM	No information about efficacy against specific pathogens in elephants Every 48 - 72 hours
Sulfonamides			**Gram positives & negatives (aerobes + anaerobes)**
Trimethoprim Sulfa	22.0	PO	Every 12 hours (b.i.d.)
Sulfadimethoxine	See doses prescription for horses	PO; IV	Every 12 - 24 hours (s.i.d. - b.i.d.)
Quinolones			**Gram negatives & positives (aerobes)**
Enrofloxacin	2.5	PO	Every 24 hours (s.i.d.)
Anti-tuberculosis			
Ethambutol	30.0	PO	! Never administrate rectally ! Monitor serum drug level ~ adjust dose as needed
Isoniazid	5.0	PO; per rectum	Starting dose ~ adjust dose till serum drug levels of 3-5 µg/ml
Pyrazinamide	30.0	PO; per rectum	Starting dose ~ adjust dose till serum drug levels of 20-60 µg/ml
Rifampin	10.0	PO	! Never administer with food; not absorbed rectally! Single dose ~ adjust dose till serum drug levels of 8-24 µg/ml

Abbreviations
IM: intramuscular
s.i.d.: semel in die
IV: intravenous
PO: per oral
b.i.d.: bis in die
t.i.d.: ter in die
MIC: minimal inhibitory concentration
SQ: subcutaneous

5 Discussion

This master thesis represents the first step in creating a well-founded health care system for the Asian elephant. The main function of this document is to create the first layer of a foundation that needs to be built upon by experience and a more in-depth knowledge of veterinarians currently working with the captive population. This would allow their experience and knowledge to become part of the blueprint. The large scale of the range countries is a limiting factor. While one could find information about one of the countries that falls within this area, it would not make this information applicable to other range countries. In order to define the general information that can be applied for all range countries, further research is required. In the scope of this thesis there are a number of limitations that need extra consideration.

5.1 Limited availability of information

The most difficult obstacle that this master thesis faced is the lack of research and the availability of knowledge in regard to the Asian elephant. While this has been briefly touched upon in the introduction it is a very important matter and therefore it should be discussed in more detail. While there has been some research done in the past, it has always been on a very limited scale and with a very limited number of available subjects. This of course results in a lack of reliable results and useable data. Another important note to consider is that the available research is only applicable to the area where the research has been conducted. If one would want to have data applicable to all range countries, larger and more in-depth studies would have to be performed.

Another major issue that comes from the limited available knowledge is that there is a chance that there are many undiscovered factors and diseases. This means that if the blueprint of the mobile health clinic is implemented, non-discussed issues could appear. Therefore, it is important to note that the current work is based upon the available data and is most likely still incomplete. The mobile health clinic blueprint is supposed to be a constant work in progress. To say that it would ever be complete would be wrong. As in every situation that it would be applied different issues would present themselves and should be added in the future. Allowing it to grow and become a sound basis to increase the living conditions and general health care of the Asian elephant.

5.2 Financial impact and requirements

One major topic that has not been touched upon is the Financial side of the mobile health clinic. While it is one of the most important aspects of the mobile health clinic, there are multiple reasons why this has not been discussed in the master thesis.

Firstly, in order to create a full picture of the financial requirements to set-up and operate a mobile health clinic is a challenging task. This is due to the different economies in the range countries, meaning that one product could cost double in one area compared to another area. Another reason that it is impossible to define the financial needs of a mobile health clinic is that the exact scope of it would only become available once it has been set up and the exact materials and products that would be required reveal themselves. One could try and create a rough outline of the requirements based upon previous papers and cases, yet this is also not feasible to achieve as there is a very limited amount of cases touching upon this and the ones that do, rarely allow a comparison to be drawn.

5.3 Preventive care/ general health care

While in this master thesis there has been brief touches upon preventive health care there are some major factors that need to be considered upon this. First and foremost is that there is still a major lack of knowledge with the mahouts (elephant handlers) and owners in regard to this. Many small health issues are not noticed and are allowed to grow and fester. This is an issue that needs to be resolved over time in order to ensure that a quicker intervention can be taken with small health issues and prevent them from growing in to major health risks. Yet it is not as easy to do this as one would think. The first reason for this is the language barrier. English is rarely spoken by the mahouts, meaning that only the local tong can be spoken with them. Often the mahouts have their own version of the local tong making communicating with them even more difficult. Another drawback that needs to be considered is the fact that the mahout job is usually given on from father to son, making that the knowledge they use is based upon old methods and superstitions. Creating a situation where they would be accepting to learn new knowledge from an outsider would be very time consuming and difficult. Something that could only be achieved once a great deal of trust has been build.

Another major factor that needs to be discussed in regard to preventive health care is that it is bound to the local countries within the range countries of the Asian elephant. While one could try to create a general outline that would be applicable for all range countries, there would be some major obstacles in regard to this. Due to the fact that most countries discussed are third world countries[1], the availability of medicine and specific equipment would be limited in specific areas. Another factor that needs to be considered in this regard is the limitations of the local knowledge in regard to health care and preventive health care. Making that implementing a similar basis of preventive health care over all range countries would be impossible. Instead the first stages would have to be a case by case implementation and would be up to the veterinarian in this situation to decide what would be possible to implement and what would not be achievable.

While the general health care has been discussed before, there are certain aspects that have not been examined closer.

The first aspect that needs to be discussed is the use of plants and herbs instead of medicine. As mentioned before the mahouts learn their knowledge from their fathers. Part of this knowledge is the use of local plants and herbs to treat symptoms presenting themselves in the elephant. While there has been no actual research done upon their effectiveness. The fact that they have been using them for hundreds of years and do form some kind of positive effect upon the health of the ill animal, makes it impossible for it to be completely dismissed. However, if one would want to include the use of these products in the blueprinting for the mobile health clinic, further research upon the effectiveness and exact working of these products would be required.

Another major factor that needs to be discussed is the limited available knowledge of the use of medication in the Asian elephant. While for many animals there is a sound basis of medication and their effects, thanks to large amounts of research and development for individual species, the Asian elephant does not have this luxury. Meaning that due to a lack of research in the past upon diseases and their treatments, the current available knowledge of what medication to use and the effects it would have is very limited. Therefore, it is very difficult to say what treatment should be used and this is why it is not always specified in the master thesis. However, this is something that can easily be expanded upon in the future with the aid of experience of veterinarians working with Asian elephants and further research.

While the unknown treatment options are a major drawback in creating sustainable health care for the Asian elephant, another aspect that cannot be overlooked is the lack of available equipment, more specifically the non-availability to preform culture swaps at times. Forcing local veterinarians to rely on a trial and error technique. While it is not scientifically sound, there have been many cases where it has worked and due to the fact that it is the only option in most cases with treating elephants in remote areas, it is important to give notice to this method. While in an ideal world this should never be used and instead a correct diagnosis can be made, followed up with the correct treatment. When working in the field it is rarely an ideal world. An important note that one cannot forget is that even though the trial and error technique might not always lead to the best result, it does allow for an improved health of the elephant and a better life, which after all is still the most important goal.

One final note that should be discussed in regard to health care is the use of euthanasia. In most local cultures of the range countries of the Asian elephant, euthanasia is not used due to a clash with their believes. While in Europe it has become a tool to end the suffering of an animal when there are no treatment options left. In most cases in Asia this will not be possible. Therefore, it is important to note that one could often not consider using this and will have to resort to find other methods to ease the animals suffering. It is also another reason why supportive and preventive health care should be improved upon. This needs to be done in order to prevent and/or limit the suffering of the animal.

6 Conclusion

This mobile health clinic blueprint is a sound first step in creating an integrated available health care system in the range countries of the Asian elephant. Allowing not only the captive population to become self-sustainable and flourish but help prevent the extinction of the wild population. As stated in the problem and goal, currently the captive population has a higher mortality rate than the wild population. By improving the available preventive care and the general health care, the life expectancy will increase. This then will subsequently increase the birth rate of the captive population. While looking at them separately these might look like insignificant changes, when combining them it would create the perfect circumstances for a self-sustainable captive population. This would consequently mean that there would be no further need to capture elephants from the wild population and therefore one of their largest threat to their further existence is taken away. By improving the health and life expectancy of the captured elephant, a trust would be built between the veterinarians and the owners/ mahouts (elephant handlers). This would allow the veterinarians to teach them about preventive health care and together they could find ways to improve the living conditions without the loss of profit. Once this is done on a large enough scale, the groundwork is laid for governmental oversight and the implementation of protective laws for the Asian elephant. While this is something that can only be achieved in the long run, it is important to remember that every beginning is humble, and the current blueprint is but the mere beginning of a lifetime goal.

7 References

Abeysinghe, K.S., Perera, A. end Fernando, P., 2012. Developing a practical and reliable protocol to assess nematode infection in Asian elephants. Research Article Gajah 37, 22-26.

Abhijith, T., Ashokkumar, M., Dencin, R.T. end George, C., 2018. Gastrointestinal parasites of Asian elephants (Elephas maximus L. 1798) in south Wayanad forest division, Kerala, India. Journal of Parasitic Diseases 42, 382-390.

Ahmed, N. end Doley, S., 2016. Successful management of corneal opacity in Asian elephants (Elephas maximus). International Journal of Agricultural Science and Research 6, 433-6434.

Ajitkumar, G., Narayanan, P.H., Sreejith, R., Abraham, D. end Alex, P., 2010. Prevalence of ocular problems among captive Asian Elephants of Kerala. Zoos' Print 25.

Ali, S., Basumatary, P., Choudhury, B. end Boruah, B., Clinical management of traumatic injury in captive Asian elephants by BIO-debridement (Elephas Maximus) – CASE REPORT of four captive Asian elephants.

Andrews-Polymenis, H.L., Bäumler, A.J., McCormick, B.A. end Fang, F.C., 2010. Taming the elephant: Salmonella biology, pathogenesis, and prevention. Infection and immunity 78, 2356-2369.

Angkawanish, T., Boonprasert, K., Homkong, P., Sombutputorn, P., Mahasawangkul, S., Jansittiwate, S., Keratimanochaya, T. end Clausen, B., 2009. Elephant health status in Thailand: the role of mobile elephant clinic and elephant hospital. Gajah 31, 15-20.

Bansiddhi, P., Brown, J.L., Thitaram, C., Punyapornwithaya, V. end Nganvongpanit, K., 2020. Elephant Tourism in Thailand: A Review of Animal Welfare Practices and Needs. Journal of Applied Animal Welfare Science 23, 164-177.

Bansiddhi, P., Brown, J.L., Thitaram, C., Punyapornwithaya, V., Somgird, C., Edwards, K.L. end Nganvongpanit, K., 2018. Changing trends in elephant camp management in northern Thailand and implications for welfare. PeerJ 6, e5996.

Bansiddhi, P., Nganvongpanit, K., Brown, J.L., Punyapornwithaya, V., Pongsopawijit, P. end Thitaram, C., 2019. Management factors affecting physical health and welfare of tourist camp elephants in Thailand. PeerJ 7, e6756.

Barman, N.N., Nath, A.J. end Sarma, B., 2013. Bacterial infection, antibiogram and wound treatment in domesticated asisan elephants. Gajah 39, 40-43.

Benedict, F.G. end Lee, R.C., 1936. Studies on the body temperature of elephants. Proceedings of the National Academy of Sciences of the United States of America 22, 405.

Boardman, W.S., Jakob-Hoff, R., Huntress, S., Lynch, M., Reiss, A. end Monaghan, C., 2000. The medical and surgical management of foot abscesses in captive Asiatic elephants: case studies, In: The elephant's foot: Prevention and care of foot conditions in captive Asian and African elephants, pp. 119-126.

Brattstrom, B.H., Stabile, A.J., Williams, F.R., Des Lauiers, J. end Pope, D., 1963. Body temperature of Indian elephants. Journal of Mammalogy 44, 282-282.

Buckley, C., 2008. Captive elephant foot care: natural habitat husbandry techniques, In: The Elephant's Foot: Prevention and Care of Foot Conditions in Captive Asian and African Elephants (B. Csuti, EL Sargent and US Bechert, eds.), Iowa State University Press, Ames, USA.

Buragohain, A., Mahato, G., Das, B., Phukan, A., Sarma, K. end Barman, N., 2019. Prevalence of wound infection in wild and captive elephants (Elephas maximus) of Assam.

Burke, T.J., 1975. Probable tetanus in an Asian elephant. The Journal of Zoo Animal Medicine 6, 22-24.

Caple, I., Jainudeen, M., Buick, T. end Song, C., 1978. Some clinico-pathologic findings in elephants (Elephas maximus) infected with Fasciola Jacksoni. Journal of wildlife diseases 14, 110-115.

Choudhury, A., Choudhury, D., Desai, A., Duckworth, J., Easa, P., Johnsingh, A., Fernando, P., Hedges, S., Gunawardena, M. end Kurt, F., 2008. Elephas maximus. The IUCN Red List of Threatened Species. Report on the Global Conservation Status of the Asian Elephant. http://dx ….

Chusyd, D.E., Brown, J.L., Golzarri-Arroyo, L., Dickinson, S.L., Johnson, M.S., Allison, D.B. end Nagy, T.R., 2019. Fat mass compared to four body condition scoring systems in the Asian elephant (Elephas maximus). Zoo Biology 38, 424-433.

Cohn, J.P., 2006. Do Elephants Belong in Zoos? BioScience 56, 714-717.

Council, F.A.W., 1979. Farm animal welfare council press statement, In: FAWC.(8 August 2013).

Csuti, B., 2006. Elephants in captivity, In: Biology, Medicine, and Surgery of Elephants, pp. 15-22.

Csuti, B., Sargent, E.L. end Bechert, U.S., 2008. The elephant's foot: prevention and care of foot conditions in captive Asian and African elephants. John Wiley & Sons.

Desquesnes, M., Holzmuller, P., Lai, D.-H., Dargantes, A., Lun, Z.-R. end Jittaplapong, S., 2013. Trypanosoma evansi and surra: a review and perspectives on origin, history, distribution, taxonomy, morphology, hosts, and pathogenic effects. BioMed research international 2013.

Dryden, M.S., 2010. Complicated skin and soft tissue infection. Journal of antimicrobial chemotherapy 65, iii35-iii44.

Dumonceaux, G.A., 2006. Digestive system, In: Biology, Medicine, and Surgery of Elephants, pp. 299-307.

Evans, G.H., 1910. Elephants and their diseases. Government Printing, Rangoon, 1-343.

Firyal, S. end Naureen, A., 2007. Elephant as a veterinary patient. Pakistan Veterinary Journal 27, 48.

Fowler, M. end Mikota, S.K., 2008. Biology, medicine, and surgery of elephants. John Wiley & Sons.

Fowler, M.E., 2001a. Elephant foot care: concluding remarks, In: The Elephant's Foot. Prevention and Care of Foot Conditions in Captive Asian and African Elephants, pp. 147-148.

Fowler, M.E., 2001b. An overview of foot conditions in Asian and African elephants, In: The elephant's foot: Prevention and care of foot conditions in captive Asian and African elephants, pp. 3-7.

Fowler, M.E., 2008. Behavioral clues for detection of illness in wild animals: models in camelids and elephants, In: Zoo and Wild Animal Medicine. Elsevier, pp. 33-cp33.

Fowler, M.E. end Mikota, S., 2006a. Foot disorders, In: Biology, Medicine, and Surgery of Elephants. Ames, IA: Blackwell Publishing, pp. 271-290.

Fowler, M.E. end Mikota, S.K., 2006b. Chemical restraint and general anesthesia, In: Biology, Medicine, and Surgery of Elephants. Blackwell Publishing Professional, Ames, Iowa, pp. 91-118.

Gage, L.J., 2000. Treatment of osteomyelitis in elephant feet, In: The elephant's foot: Prevention and care of foot conditions in captive Asian and African elephants, pp. 117-118.

Gage, L.J., Fowler, M.E., Pascoe, J.R. end Blasko, D., 1997. Surgical removal of infected phalanges from an Asian elephant (Elephas maximus). Journal of Zoo and Wildlife Medicine, 208-211.

Govindan, V.P., Dhakate, P.M. end Uniyal, A., 2019. Ethnomedic treatment of colic in captive safari Asian Elephants Elephas maximus (Mammalia: Proboscidea: Elephantidae) with classical symptoms-an update, In: ZOO'S PRINT, pp. 35-40.

Haury, B., Rodeheaver, G., Vensko, J., Edgerton, M.T. end Edlich, R.F., 1978. Debridement: an essential component of traumatic wound care. The American Journal of Surgery 135, 238-242.

Hayward, G.S., 2012. Conservation: clarifying the risk from herpesvirus to captive Asian elephants. The Veterinary record 170, 202.

Hendrickson, D.A., 2013. Principles of wound management and the use of drains, In: Turner and McIlwraith's Techniques in Large Animal Surgery, p. 93.

Hile, M.E., Hintz, H.F. end Erb, H.N., 1997. Predicting body weight from body measurements in Asian elephants (Elephas maximus). Journal of Zoo and Wildlife Medicine, 424-427.

Hittmair, K.M. end Vielgrader, H.D., 2000. Radiographic diagnosis of lameness in African elephants (Loxodonta africana). Veterinary Radiology & Ultrasound 41, 511-515.

Hughes, J.A. end Southard, M., 2001. Preventive foot care for an Asian elephant at Mesker Park Zoo and Botanic Garden, In: The elephant's foot: prevention and care of foot conditions in captive Asian and African elephants., pp. 73-77.

Islam, S., 1996. Studies on some aspects of fascioliasis in Asian elephants (Elephas maximus). ZOO'S PRINT 11, 11.

Jackson, J., Childs, D.Z., Mar, K.U., Htut, W. end Lummaa, V., 2019. Long-term trends in wild-capture and population dynamics point to an uncertain future for captive elephants. Proceedings of the Royal Society B: Biological Sciences 286, 20182810.

Jani, R., 2008. Prevalence and Haemato-Biochemical Studies of Gastro-intestinal Parasites of Indian Elephants (Elephas maximus). Veterinary World 1, 296.

Kadmiel, M., Janoshazi, A., Xu, X. end Cidlowski, J.A., 2016. Glucocorticoid action in human corneal epithelial cells establishes roles for corticosteroids in wound healing and barrier function of the eye. Experimental eye research 152, 10-33.

Keet, D., Grobler, D., Raath, J., Gouws, J., Carstens, J. end Nesbit, J., 1997. Ulcerative pododermatitis in free-ranging African elephant (Loxodonta africana) in the Kruger National Park.

Kido, N., Tanaka, S., Omiya, T., Shoji, Y., Senzaki, M., Hanzawa, S., Ando, M., Osaki, T., Hatai, H., Miyoshi, N., et al., 2018. Novel treatment for chronic pododermatitis in an Indian elephant (Elephas maximus indicus) with Mohs' paste. Journal of Veterinary Medical Science 80, 1834-1838.

KLINHOM, S., LOYTHONG, J. end THITARAM, C., 2017. Hematologic and biochemical reference intervals for captive Asian elephants (Elephas maximus) in Thailand. Kafkas Univ Vet Fak Derg 23, 665-668.

Kochagul, V., Srivorakul, S., Boonsri, K., Somgird, C., Sthitmatee, N., Thitaram, C. end Pringproa, K., 2018. Production of antibody against elephant endotheliotropic herpesvirus (EEHV) unveils tissue tropisms and routes of viral transmission in EEHV-infected Asian elephants. Scientific reports 8, 1-12.

Kraiwong, N., Sanyathitiseree, P., Boonprasert, K., Diskul, P., Charoenphan, P., Pintawong, W. end Thayananuphat, A., 2016. Anterior ocular abnormalities of captive Asian elephants (Elephas maximus indicus) in Thailand. Veterinary ophthalmology 19, 269-274.

Laohachaiboon, S., 2010. Conservation for whom? Elephant conservation and elephant conservationists in Thailand. Japanese Journal of Southeast Asian Studies 48, 74-95.

Laukkanen, N., Yanes, G.A. end Borrero, A., 2016. The Case for Responsible Travel: Trends & Statistics 2016.

Leimgruber, P., Senior, B., Uga, Aung, M., Songer, M.A., Mueller, T., Wemmer, C. end Ballou, J.D., 2008. Modeling population viability of captive elephants in Myanmar (Burma): implications for wild populations. Animal Conservation 11, 198-205.

Lindsay, W.A., Wiedner, E., Isaza, R., Townsend, H.G.G., Boleslawski, M. end Lunn, D.P., 2010. Immune responses of Asian elephants (Elephas maximus) to commercial tetanus toxoid vaccine. Veterinary Immunology and Immunopathology 133, 287-289.

Long, S.Y., Latimer, E.M. end Hayward, G.S., 2016. Review of elephant endotheliotropic herpesviruses and acute hemorrhagic disease. ILAR journal 56, 283-296.

Lynsdale, C.L., dos Santos, D.J.F., Hayward, A.D., Mar, K.U., Htut, W., Aung, H.H., Soe, A.T. end Lummaa, V., 2015. A standardised faecal collection protocol for intestinal helminth egg counts in Asian elephants, Elephas maximus. International Journal for Parasitology: Parasites and Wildlife 4, 307-315.

Mandal, R.K. end Khadka, K.K., 2013. Health Status of Captive Asian Elephants in Chitwan National Park, Nepal. Tuberculosis 14, 6.5.

Mason, G., Burn, C.C., Dallaire, J.A., Kroshko, J., Kinkaid, H.M. end Jeschke, J.M., 2013. Plastic animals in cages: behavioural flexibility and responses to captivity. Animal Behaviour 85, 1113-1126.

Mikota, S.K., 2006a. Hemolymphatic system, In: Biology, medicine, and surgery of the elephant. Blackwell Publishing, Ames, IA, pp. 325-345.

Mikota, S.K., 2006b. Integument system, In: Biology, Medicine, and Surgery of Elephants, pp. 253-262.

Mikota, S.K., 2006c. Preventive health care and physical examination, In: Biology, Medicine, and Surgery of Elephants, pp. 67-73.

Mikota, S.K., 2006d. Therapeutics. Biology, Medicine, and Surgery of Elephants, 211-231.

Mikota, S.K., 2006e. Therapeutics, In: Biology, Medicine, and Surgery of Elephants, pp. 211-231.

Mikota, S.K., Fowler, M.E., Toit, J.G.d., Cheeran, J.V., Chandrasekharan, K., Martelli, P., Fahrimal, Y., Sudarwati, R., Subramanian, V. end Mar, K.U., 2006. Veterinary problems of geographical concern, In: Biology, Medicine, and Surgery of Elephants, pp. 439-473.

Miller, D., Jackson, B., Riddle, H.S., Stremme, C., Schmitt, D. end Miller, T., 2015. Elephant (Elephas maximus) health and management in Asia: variations in veterinary perspectives. Veterinary medicine international 2015.

Miller, M.A., Finnegan, M., Storms, T., Garner, M. end Lyashchenko, K.P., 2018. Outbreak of Mycobacterium Tuberculosis in a herd of captive Asian Elephants (Elephas Maximus): Antemortem diagnosis, treatment, and lessons learned. Journal of Zoo and Wildlife Medicine 49, 748-754.

Miller, M.A., Hogan, J.N. end Meehan, C.L., 2016. Housing and demographic risk factors impacting foot and musculoskeletal health in African elephants [Loxodonta africana] and Asian elephants [Elephas maximus] in North American zoos. PloS one 11.

Miller, R.E., 2006. Urinary system, In: Biology, Medicine, and Surgery of Elephants. Blackwell Publishing Ltd., Oxford, United Kingdom, pp. 389-391.

Morfeld, K.A., Lehnhardt, J., Alligood, C., Bolling, J. end Brown, J.L., 2014. Development of a body condition scoring index for female African elephants validated by ultrasound measurements of subcutaneous fat. PloS one 9.

Morfeld, K.A., Meehan, C.L., Hogan, J.N. end Brown, J.L., 2016. Assessment of body condition in African (Loxodonta africana) and Asian (Elephas maximus) elephants in North American zoos and management practices associated with high body condition scores. PloS one 11.

Mortenson, J., 2001. Determining dosages for antibiotic and anti-inflammatory agents, In: The elephant's foot: Prevention and care of foot conditions in captive Asian and African elephants, pp. 141-144.

Mumby, H.S., 2019. Mahout Perspectives on Asian Elephants and Their Living Conditions. Animals 9, 15.

Oludairo, O., Kwaga, J., Dzikwi, A. end Kabir, J., 2013. The genus Salmonella, isolation and occurrence in wildlife.

Oo, Z.M., 2012. Health issues of captive Asian elephants in Myanmar. Gajah 36, 21-22.

Paul, P., Hasan, T. end Rahman, M.M., 2018. Medical management of bilateral corneal opacity in an Asian elephant (Elephas maximus): A case report. Journal of Advanced Veterinary and Animal Research 5, 98-100.

Phuangkum, P., Lair, R.C. end Angkawanith, T., 2005. Elephant care manual for mahouts and camp managers. FAO Regional Office for Asia and the Pacific.

Podhade, D.N. end Harne, R.J.R., 2013. Management of incised wound of trunk in Asian elephant (Elephus maximus). Journal of Wildlife Research 1, 08-09.

Pokharel, S.S., Seshagiri, P.B. end Sukumar, R., 2017. Assessment of season-dependent body condition scores in relation to faecal glucocorticoid metabolites in free-ranging Asian elephants. Conservation physiology 5.

Rajaram, A., 2006. Musth in elephants. Resonance 11, 18-27.

Riddle, H.S. end Stremme, C., 2011. Captive elephants-an overview. Journal of Threatened Taxa, 1826-1836.

Roocroft, A. end Oosterhuis, J., 2001. Foot care for captive elephants, In: The elephant's foot: Prevention and care of foot conditions in captive Asian and African elephants, pp. 21-52.

Rosen, L.E., Olea-Popelka, F., Deem, S.L., Isaza, R., Schmitt, D. end Miller, M., 2019. Survey of antituberculosis drug administration and adverse effects in elephants in North America. Journal of Zoo and Wildlife Medicine 50, 23-32.

Rutkowski, C., Marion, F., Hopper, R., Csuti, B., Sargent, E. end Bechert, U., 2001. Split nails, abscesses, and cuticular fluid pockets, In: The elephant's foot: prevention and care of foot conditions in captive Asian and African elephants., pp. 85-86.

Sampson, J., 2008. Foot care at the Indianapolis Zoo: A comprehensive approach, In: The elephant's foot: Prevention and care of foot conditions in captive Asian and African elephants, p. 57.

Schiffmann, C., Clauss, M., Hoby, S. end Hatt, J.M., 2020. Weigh and see-Body mass recordings versus body condition scoring in European zoo elephants (Loxodonta africana and Elephas maximus). Zoo Biology 39, 97-108.

Schmidt-Burbach, J., Ronfot, D. end Srisangiam, R., 2015. Asian elephant (Elephas maximus), pig-tailed macaque (Macaca nemestrina) and tiger (Panthera tigris) populations at tourism venues in Thailand and aspects of their welfare. PloS one 10.

Seidon, A., 2001. Procedure for nail reconstruction and treatment for an Asian elephant (Elephas maximus), In: The elephant's foot: prevention and care of foot conditions in captive Asian and African elephants., pp. 89-91.

Senthilkumar, K., Senthilkumar, A. end Jayathangaraj, M.G., 2014. Clinical management of chronic abscess in an Asian elephant (Elephas maximus). Journal of Advanced Veterinary and Animal Research 1, 73-74.

Sofranko, D.M., 2006. Laws and Legislation, In: Biology, Medicine, and Surgery of Elephants, pp. 23-33.

Sorensen, D., 2008. A history of elephant foot care at the Milwaukee county zoo, In: The elephant's foot: Prevention and care of foot conditions in captive Asian and African elephants, p. 65.

Stanton, J.J., Nofs, S.A., Peng, R., Hayward, G.S. end Ling, P.D., 2012. Development and validation of quantitative real-time polymerase chain reaction assays to detect elephant endotheliotropic herpesviruses-2, 3, 4, 5, and 6. Journal of virological methods 186, 73-77.

Stevens, D.L., Bisno, A.L., Chambers, H.F., Dellinger, E.P., Goldstein, E.J., Gorbach, S.L., Hirschmann, J.V., Kaplan, S.L., Montoya, J.G. end Wade, J.C., 2014. Practice guidelines for the diagnosis and management of skin and soft tissue infections: 2014 update by the Infectious Diseases Society of America. Clinical infectious diseases 59, e10-e52.

Suedmeyer, W.K., 2006. Special senses, In: Biology, Medicine, and Surgery of Elephants, pp. 402-403.

Sukklad, S., Sommanustweechai, A. end Pattanarangsan, R., 2006. A retrospective study of elephant wound, wound management from thai veterinarians. Proceedings of AZWMP. Chulalongkorn University, Faculty of Veterinary Science, Bangkok, Thailand. pp16.

Sukumar, R., 2006. A brief review of the status, distribution and biology of wild Asian elephants Elephas maximus. International Zoo Yearbook 40, 1-8.

System, I.S.I., 2002. Physiological data reference values. International Species Information System Apple Valley, Minnesota.

Turesson, V., 2014. On the back of an Asian elephant (Elephas maximus)–the backside of the elephant tourism with focus on welfare.

Veasey, J.S., 2020. Assessing the Psychological Priorities for Optimising Captive Asian Elephant (Elephas maximus) Welfare. Animals 10, 13.

Vries, d.L., 2014. An Elephant is Not a Machine, A Survey into the Welfare of Private Captive Elephants in Sauraha, Chitwan National Park, Animal Nepal, Kathmandu, Nepal. by Animal Nepal PO Box 23066, Kathmandu, Nepal www. animalnepal. org ….

West, G., 2006. Musculoskeletal system, In: Biology, Medicine, and Surgery of Elephants. Ames, IA: Blackwell Publishing, pp. 263-270.

West, G., Csuti, B., Sargent, E. end Bechert, U., 2001. Occurrence and treatment of nail/foot abscesses, nail cracks, and sole abscesses in captive elephants, In: The elephant's foot: Prevention and care of foot conditions in captive Asian and African elephants, pp. 93-116.

Williams, E., Chadwick, C.L., Yon, L. end Asher, L., 2018. A review of current indicators of welfare in captive elephants (Loxodonta africana and Elephas maximus). Animal Welfare 27, 235-249.

Wolfer, J. end Rich, P., 1992. Persistent corneal erosion in an Asian elephant. The Canadian Veterinary Journal 33, 337.