FACULTY OF VETERINARY MEDICINE
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Kangaroo: Meat of the Future?

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Foreword

I would first like to thank my supervisors Prof. dr. Geert Opsomer and Prof. dr. Stefaan De Smet Janssens for their support and guidance of the last two years.

Furthermore I would like to express my sincere thanks to my younger sister Hannelore. She helped my countess hours correcting my English grammar, almost to the point of her insanity. However she kept on going!

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Finally, I want to thank my parents for giving me all the amazing chances in life and supporting me throughout my years of study. Because of their love and amazing support I am who I am today.

Index

Summary

This thesis examines whether kangaroo meat has the potential to compete with beef in the future. It starts with discussing the zoology of the kangaroo, mainly focussing on his reproductive characteristics. In addition, some kangaroo are covered.

To evaluate the potential of kangaroo meat, the kangaroo industry should be examined. Kangaroo farming involves a completely different process than the traditional beef farming. Kangaroos live in the wild and are killed there. The hunters must comply with the national code written by the government. This regulates the amount of kangaroos that can be shot in each year in order to keep the kangaroo population in balance. Additionally the code describes the type of kangaroos that can be shot, the hunting process and what has to happen with the carcasses. Although this code must minimize the suffering of the animals, there is still controversy about the kangaroo harvesting.

When we compare kangaroo and beef in terms of environmental profits and nutritional values, there are also some remarkable findings. The kangaroo's emission of methane is remarkably lower compared to cows. Methane is a gas that plays an important role in global warming. Furthermore, a kangaroo's daily consumption of food and water is significantly lower. Because kangaroos are actually living on the Australian lands in large numbers, the harvesting of these animals ensures that the biodiversity of the landscapes is not destroyed by them. Considering all these factors, kangaroo meat is more environmentally friendly than beef.

The good nutritional value is also strongly emphasized by the kangaroo industry. Kangaroo meat would be high in proteins, low in fat, high CLA and high in iron. The statements are true, but must sometimes be nuanced.

If the wild kangaroo population no longer satisfies the demand, or the harvesting of kangaroos is not further recognized by the consumer as an acceptable way of slaughtering, building kangaroo farms can be an option. At the moment kangaroo meat is not yet popular enough, resulting in the low price of the kangaroo meat which makes it impossible to start a kangaroo farm. However, the demand for kangaroo meat is rising slightly in both in Australia as internationally, but the negative image that Australians have about this meat, affects the perception of other countries, makes their food still a bit controversial. Now that the pressure rises to eat more environmentally friendly and healthier, kangaroo meat may be gaining importance, but the chance that it will become an all-day type of meat seems almost non-existent.

Introduction

In recent years, people are becoming more aware of their diet and how their food sources affect, the environment. The search for diet alternatives that are balanced and healthy, whilst trying to reduce the impact on nature to supply our ever-growing global population, remains a challenging one. Although there are several factors to be considered when looking at the causes of global warming, one of the most discussed ones is the impact of livestock farming.

Due to eating meat and other animal products, a person's ecological foot print increases. Does this mean we should all resort to vegetarianism and veganism to save our planet? Is this kind of diet healthy and balanced to fulfil our dietary needs? Is this a viable solution? There has been a lot of discussion, research and some controversies about this subject but in this thesis, another alternative will be proposed: kangaroo meat. The pros and cons of vegetarianism and veganism have been pointed out by many. So have those of consuming meat and more specifically beef. But what if you could present people a meat source that has a lower impact on the environment and is healthier than other red meats. That's what the kangaroo Industries Association of Australia (KIAA) is offering its consumers as they are promoting the use of kangaroos as an alternative meat supply.

Of course, the use of kangaroo as an alternative meat has both advocates and opponents. There are questions about the ethical side of harvesting kangaroos, the hygiene, the actual environmental impact and if the meat is indeed healthier. Because these questions are asked by the consumer today and will help to determine if kangaroo meat can be the meat of the future, this thesis will try to answer them.

But if everyone would replace beef by wild kangaroo meat, is not a realistic option because the current wild population supply isn't endless. To keep the harvest sustainable, there is a quota set on 15-20% of the kangaroo population. However, generally, the harvest is much lower. So, this market still has to grow significantly. Nevertheless, at some point this quota will be reached. The most accessible solution for a higher demand of kangaroo meat is kangaroo farming, but is it possible? There a lot of factors to be considered. The three main ones are: land and its infrastructure, nutrition and reproduction. By evaluating these data will provide an indication of the feasibility of kangaroo farming.

Study of Literature

1. Zoology of the kangaroo

1.1 General

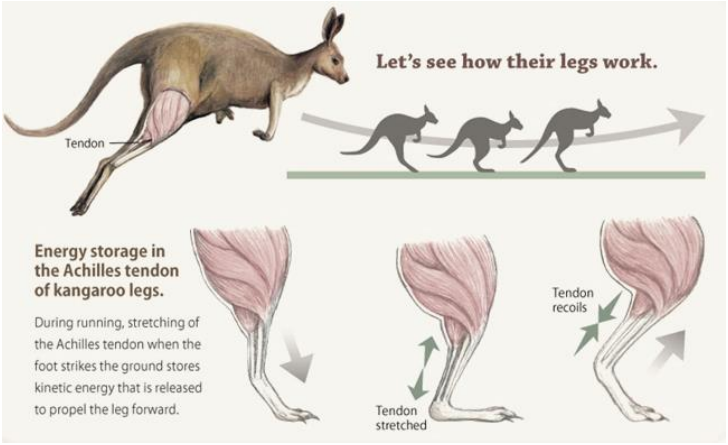
Classification

The kangaroo and the wallaby are both members of the *Macropodidae* or kangaroo family. The members of this family are plantigrade. This means that the bones from the metatarsea down are positioned flat on the ground. The foot of human is formed the same way. The feet of a kangaroo are long and narrow and support their very muscled hind legs. These limbs, together with their long and powerful tail, are used in their way of moving: hopping(Jackson, 2003).[1] In this mechanism the tail is also used for balance and stabilisation. Although most of the macropods use their tail and hind legs for this movement, there are a few exceptions who don't, like the tree kangaroo. Additionally, macropods have two smaller front arms they use for walking, grip and climbing into their mother's pouch when they are born.[2] The members of this family have an adult size between 500g and 90 kg (Jackson,2003). The *Macropodinae,* which is a subfamily of the *Marcopodidae*, is the group that consists of kangaroos, wallaroos and wallabies (Wilson and Reeder, 2005). The four largest species in size are called kangaroos, the intermediate size wallaroos and the smaller size wallabies.

The kangaroo family is the second largest family of the Marsupials that in his turn is an infraclass of the Mammalia. (Wilson and Reeder, 2005) Marsupials are famous in the animal kingdom for their way of reproduction. They give premature birth after which the new-born attaches itself to a nipple. These are located in the open or in a pouch. Positioned like this, the new-born continues his growth (Hume et al, 1989; Dawson, 1995).

Anatomy

Kangaroos, wallaroos and wallabies are the only large animals that use hopping as a way of locomotion. This is shown by their body shape. Their hindquarters and tail are highly specialised. They contain a number of tendinous structures that help to conserve high levels of energy as shown in figure 1. This energy conservation is the same concept as the storage of energy in a spring. This makes hopping highly sufficient once begun but starting costs a lot of energy. Kangaroos usually have a speed between 20-25km/h but they reach 40-45km/h. In case of emergency kangaroos can even reach 65-70km/h, but they can only hold this speed for a few hundred meters (Dawson, 1995; Roberts et al., 2011).



Figuur 1: Mechanisme of the Achilles tendon [2a]

Pentapedal walking is a term used to describe speeds below 6km/h. In this movement, kangaroos use their tail to support their arms while moving their hindlegs forward (Dawson, 1995; Connor et al., 2014).

Another important but lesser known fact about kangaroos is their unique digestive system. It is adapted to their herbivore diet of primarily grass and little water. Although there are a lot of similarities with ruminants, like the for-gut fermentation, merycism and compartmentation of the stomach, the kangaroo isn't sorted in this group. This is because they don't actually ruminate (Dawson, 1995). Ruminating is essential for the digestive process of ruminants unlike merycism which isn't. During merycism, the for-gut makes involuntary contractions, often taking the animal by surprise, shortly after a feeding period.

[1] See: Macropodidae.http://animaldiversity.org/accounts/Macropodidae (accessed 18/02/18)
[2] See : Why kangaroos evolved small arms and long legs. http://news.bbc.co.uk/earth/hi/earth_news/newsid_8754000/8754412.stm(accessed 4/12/17)
[2a] See: Kangaroo's legs. http://haru.co/portfolio.html (accessed 18/02/18)

This causes the animal to regurgitate the food back into the oral cavity after which he rechews it and swallows it back in. The frequency, rhythm and length of this events differs from kangaroo to kangaroo and also causes distress for the individual (Vendl et al., 2017). The exact mechanism that triggers merycism isn't exactly known yet but there is a hypothesis that this process occurs after a kangaroo has swallowed its food fast without first chewing it thoroughly (Vendl et al., 2017). This way merycism should occur more in captivity because those kangaroos often receive pelleted feed which are easier to eat fast. But also, on this topic scientists made different observations and so more research should be done.

Obviously the most noticeable anatomical difference that separates marsupials and therefore also kangaroos is there way of reproduction. But this will be discussed in more detail further on in this thesis.

1.2 Natural habitat

Macropods are native to the Australian continent which includes the main land, Tasmania, New Guinea and the island around. The area where one lives depends on the species. The eastern grey kangaroo can be found at the eastern side of the Australian coastline and some parts of Tasmania. His habitat ranges from forest and tall woodland to inland scrubs. They feed in the open field during nights and early mornings and seek shelter by the threes during the middle of the days. The areas they live in usually have more than 250mm of rain a year (Dawson, 1995).[3] The western grey kangaroo lives in the southern/western part of the mainland of Australia where they prefer to live in low woodland near heathland and scrubs. The name southern grey kangaroo has been suggested because they have more association with the south. Nevertheless, this name isn't yet accepted. These kangaroos have a high tolerance for plant toxins. This is probably because the scrubs of southern Australia contain a lot of fluoroacetate which is a toxic organic fluor compound (Russell, 1974; Dawson, 1995). The red kangaroo which is the largest kangaroo of all kangaroos occurs mostly in the central part of Australia. They inhabit grassland, scrubland, desert, open forest but are most commonly found in open savanna woodland. They maybe not the highest in number on the Australian continent but because they are found in open savanna they are the most present and known by people (Russell, 1974; Dawson, 1995). We have three more species in the kangaroo family that are important in this thesis: the common wallaroo, the Bennetts wallaby and the Tasmanian pademelon. The first one is found near rock formations in scrublands in most of the Australian inland. These rocks can provide shelter from the burning sun during the day. They also stay near streams to use it as a water source. The second one, the Bennetts wallaby, can be found on the south- eastern shores and highlands of Australia and throughout Tasmania. They reside in the eucalypt forests of shrublands and always close to open areas (McKenzie et all., 2016). The last one is the Tasmanian pademelon. This one can be found in the rainforests and wet forests of Tasmania. They feed into open areas at night but never too far from the safety of the trees.[4] The members of the kangaroo family can thus be found all around the Australian continent in different environments and landscapes that sometime overline and sometimes differ a lot.

1.3 Reproductive organs

Males

The reproductive system of the male kangaroo is not as widely known as that one of a female kangaroo, yet on the outside it already has a distinguished difference as compared to placentals. The penis of a male kangaroo is positioned behind the testes (Dawson, 1995). The testes are as in placentals positioned outside of the body cavity in the scrotum, connected by a narrow neck. This, together with sweat glands on the scrotum and a counter current system of the blood vessels, helps keeping them a few degrees lower than the body temperature which is necessary for an optimal spermatogenesis. The male kangaroo starts producing spermatozoa when he reaches puberty and keeps doing this continuously. The exceptions are animals that live in regions with long droughts or high temperatures (Jones, 1989). The penis of the kangaroo is S-shaped and stocked in a preputial sac right at the base of the cloaca. When starting sexual intercourse, the preputial sac will evert through the cloaca and the penis will come out in an erected position. In figure 2 the reproduction organ of a male tammar wallaby is shown. The overall view is quite similar to the one in placentals. However, the accessory glands are

[3]See: Macropus giganteus. http://animaldiversity.org/accounts/Macropus_giganteus (accessed 22/03/18)
[4] See: Tasmanian Pademelon, Thylogale billardierii. http://www.parks.tas.gov.au/index.aspx?base=4863 (accesed 22/03/18)

different. Generally, mammals are in the possession of four accessory glands on or near the urethra: the prostate, the Cowper's or bulbourethral glands, the ampullary glands, and the seminal vesicles but in *Marcopodidae* the last two are missing and only the prostate and 3 pairs of Cowper's glands are present (Hume et all, 1989; Jones, 1989).

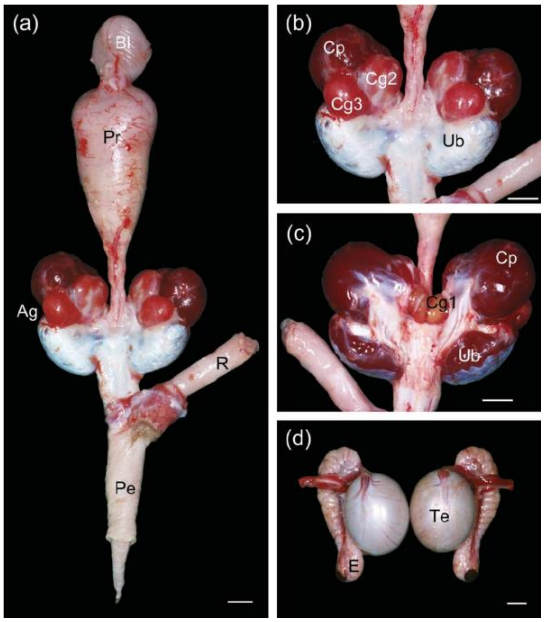


Figure 2: Anatomy of the reproductive tract of the male tammar wallaby. (a) Dorsal view of whole tract, (b) dorsal and (c) ventral view of accessory glands, and (d) testes and epididymides. Ag, accessory glands; Bl, bladder; Cg, Cowper's gland; Cp, crus penis; E, epididymis; Pe, penis; Pr, prostate; R, rectum; Te, testis; Ub, urethral bulb (Adapted from Paris et al, 2005).

Females

Marsupials, with as flagship the kangaroo, give birth to their young prematurely. The way of reproducing is thus completely different from other mammals. Figure 3 shows the reproductive system of a female macropod. It consists out of 2 uteri who merge into a vaginal cul-de-sac which develops into 3 separate vaginae. The two lateral and median vaginae then come together in a urogenital sinus in which the bladder also fuses. The urogenital sinus and the rectum then end together in the cloaca (Dawson et al, 1989; Dawson, 1995; Mitchell and Tully, 2009). The reproductive cycle of the marcopodinae generally lasts between 33 and 50 days. The changes that happen to the reproductive tract during that time are similar to the changes in most mammals. The cycle starts off with the pro-oestrus. One or several follicles start to grow along with the epithelium of the uterus and in the vagina the secretory glands activate. Around oestrus or heat, the oestrogen levels that the growing follicles produce reaches a peak level. During this time, the female will allow the male to mate with her and copulation may take place. One to two days after heat has occurred the ovulation will take place. This happens alternating, each cycle the ovulation takes place on another ovarium where one egg is released. The post-oestrus or di-oestrus phase is categorised by the corpus luteum. This is a residue of the ovulated follicle that will now produce progesterone. The time that the corpus luteum stays on the ovaria vary from species to species and ends in a regressive phase. After this the animal can either go in anoestrus or start another cycle as there are as well continuous breeders as seasonal breeders in kangaroos (Hume et al, 1989; Dawson, 1995).

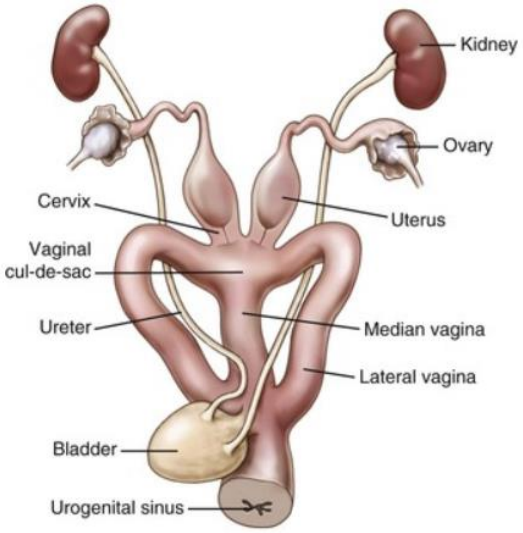


Figure 3: The urogenital tract of a female macropod (Adapted from Vogelnest and Woods, 2008).

1.4 Reproduction

Like many other animals, kangaroos have courtship activities. Male kangaroos will sniff and touch the cloacal region of the female to check if the female is receptive and ready to mate. The female will move away if this is not the case. Sometimes, when a young or small male is involved, the female will use aggression to show she is not interested. Especially with seasonal breeders, it is important that the male checks out the female regularly to increase his chances to breed. When a female is receptive, it often occurs that she urinates when the male is checking her out. In this event the male will start to flehm and he will be able to determine the exact status of the female's cycle. When the female is near oestrus, she will extend her living area in the hope to find and attract the largest male possible. She will often be followed by multiple candidates but the dominant male will be the one to copulate with her (Kauffman, 1975; Dawson, 1995). The spermatozoa will be deposited in the urogenital sinus during copulation and travel to the cervices afterwards. A part of them, however, will coagulate and form a seminal plug throughout the female's reproductive track. The exact function of the plug isn't known yet but there are different theories. Scientists suggest that the plug functions as a barrier to keep spermatozoa close to cervix and in the reproductive track, as a sperm reservoir or to prevent the migration of the sperm of other males (Dawson, 1995; Paris et all, 2005).

The fertilisation of the egg by the spermatozoid takes place in the oviduct. From there on, the egg will rapidly go to the uterus and slowly start to develop (Dawson, 1989). Although kangaroos have a very short gestation and are often called aplacentae, they have a fully functional placenta that is essential for the gestation process (Dawson et al, 1989; Renfee, 2006). A kangaroos yolk sac fulfils one of the most important parts in the formation of the placenta. Its blood vessels will grow in parts of the chorion which will then form a choriovitelline placenta. A fusion with the uterine wall does not occur, it is just an adherent connection that makes gas and additional nutrients exchange possible between mother and foetus (Hume et al, 1989; Dawson, 1995).

After a gestation period that last between 25- 35 days, the young will be born (Tyndale-Biscoe, 2005). Two days prior to the birth, the mother will start cleaning her pouch and will take on the birth position to higher the chances of the foetus getting to the pouch. This position is different for each species, but their ultimate goal however is to get the cloaca in an upright position. This position usually involes kangaroos rotating their pelvis forward by putting their tail in between their legs and extending their hind legs forth. They may use their tail or an object to support themselves (Dawson, 1995; Tyndale-Biscoe, 2005).

The medial vaginal canal will form a connection with the urogenital sinus around the time of birth. With most marsupials, this connection will disappear after birth and will form again with each birth. However, most macropods develop a permanent connection after the birth of the first young (Hume et al, 1989; Mitchell and Tully, 2009). The young is born still enclosed in the amnion. After it makes its way out of the cloaca, it will start to climb to the pouch using his forelimbs in a swimming motion. The young will only take a few minutes. The inner ear of the young is well developed in comparison to the rest of his body and helps him finding his way to the pouch. In addition, smelling and touching help him find his way. It will attach itself to the nipple when it arrives (Dawson, 1995).

Other than with other mammals, the lactation of the young, not the pregnancy, will interrupt the oestrus cycle. This means that during pregnancy a new cycle will start. With kangaroos and wallabies, the oestrus cycle is longer than the gestation period and a new ovulation will take place post-partum. This can occur a few hours or a few days post-partum, depending on the species. As a result, soon after birth, the female kangaroo will go back in oestrus and a new fertilisation can take place. A fertilised egg will consequently develop into a blastocyst and make its way to the uterus. The suckling of the new born joey will then initiate embryonic diapause (Renfree, 1981, Dawson 1995). Embryonic diapause is a physiological state in which the blastocyst will stop its development for a certain period. The cell division will start again after the body releases progesterone. With continuous breeders, this will happen around the time that the joey leaves the pouch and the frequency of the suckling diminishes. As a consequence the suckling stimulus will decline and progesterone will be released. The embryonic diapause of seasonal breeders, on the contrary, can be prolonged for several months when the breading season is over. The blastocyst will consequently be reactivated by stimuli of the next breeding season. Finally with western grey kangaroo's diapause, doesn't occur at all (Renfree, 1981; Renfree, 2006).

During the first months of the new born joey's existence, the little kangaroo will continuously feed on his mother's nipple. This will change over the next few months. The more it grows both in length and in confidence, the longer its trips out of the pouch will last. The actual weaning happens gradually and ends when the young is about one year old. Mother and young will usually stay close to each other for feeding, drinking and resting. At sexual maturity they will separate. Male kangaroos will reach sexual maturity when they are one to four years of age. Female kangaroos reach this stage between 14 months and 2 years old. Female young are prone to stay in the same home range as their mothers wile male young leave to find suitable females to mate with (Hume et all, 1989; Dawson, 1995).

2. Kangaroo diseases

In the wild, the lack of nutrition is a more common cause of mortality for kangaroos than disease. Especially in times of drought, joeys and older kangaroos die of starvation. They also have a higher chance of becoming a target of predation, mostly by dingo's. Predators will mostly hunt rabbits or other small rodents. If those are scares, they turn their focus to kangaroos. If disease outbreaks do occur, sickness will often lead to death. Kangaroos in captivity usually don't face lack of nutrition or predation. However with kangaroos in captivity, disease will be one of the mean cause of death. (Dawson, 1995).

2.1 Lumpy jaw

Lumpy jaw or oral necrobacillosis is the most fatal disease for macropods in captivity (Canfield et al, 1993, Rendle, 2017). This disease causes inflammation and infection of the jaw bone. In more sever stadia, eating becomes difficult and painful for the kangaroo. The two main bacteria that evoke lumpy jaw are *Dichelobacter nodosus* and *Fusobacterium necrophorum*. As the pathogenesis of the oral necrobacillosis is considered to be multifactorial, factors as husbandry and diet should also be taken into account when trying to manage the disease (Dawson, 1995; Mitchell and Tully, 2009). When treating an infected animal, surgery is usually required to drain and remove infected tissue, where after an antibiotic treatment of 6 months or more will be necessary to completely cure the animal. An oral dosage of clindamycin 11mg/kg twice a day has occasionally shown effective results but the disease often reoccurs. Therefore, keepers should take strict preventive measures, like cleaning the enclosure regularly and keeping food dry and clean (Mitchell and Tully, 2009; Rendle, 2017).

2.2 Respiratory diseases

Another deadly disease macropods in captivity are often diagnosed with, are respiratory diseases (canfield, 1993; Staker, 2006). Especially pneumonia makes a lot of casualties among macropods, mostly as a secondary disease. Most of the time, the primary diseases that weaken the kangaroo and make him more receptible to pneumonia, haven't even fully developed yet when the latter takes over and kills the animal (Canfield et al.,1993; Mitchell and Tully, 2009).

Pneumonia can be detected by listening to the kangaroos lungs with a stethoscope. When examining healthy lung, no breading sounds should be audible, when this is the case, pneumonia can be suspected. Injectable antibiotics are the best way to treat the disease (Staker, 2006). Since bacterial infections of the lungs are mostly caused by gram-negative bacteria, antibiotics such as amikacin, gentamycin and enrofloxacin can be used for treatment (Mitchell and Tully, 2009).

2.3 Kangaroo blindness syndrome

The kangaroo blindness syndrome or epidemic blindness, has been a treat to the wild kangaroo population for the last twenty years. The disease is caused by an obrivirus that will induce chorioretinitis and sometimes uveitis in the infected kangaroo. Epidemic blindness, that is transmitted by midges, only causes blindness in severe cases. These clinically blind kangaroos will stumble around especially when they are startled. Apart from the stumbling the disease is hard to detect. Especially in periods when the food supplies are getting scarcer and infected kangaroos consequently have more difficulties to find food, the disease will cause high number of deaths. The western grey kangaroos seem to be the most vulnerable but epidemic blindness has also been observed in eastern grey's, reds and euro's species (Mitchell and Tully, 2009; Reddacliff et al, 2009).

2.4 Zoonoses

Zoonotic diseases are diseases that can transferred from animal to human and visa versa. They occur in both small animals and livestock, as well as in kangaroos. These zoonotic diseases can be caused by bacteria, viruses or parasites. Bacteria like *Leptospira*, *Microsporum sp.* and *Coxiella burnetti* are often transferred in human-kangaroo encounters. Infection through *Escherichia coli* and *Salmonella spp.* is also possible, but this is mostly the result of ingestion of kangaroo meat. The most common parasites are *Leishmania sp*. and *Echinococcus granulosus* (ladds et al., 2010).

The zoonotic disease that has the major impact on kangaroos is Toxoplasmosis. This disease is caused by the parasite *Toxoplasmosis gondii* and has a wide spectrum of clinicals signs. For captive animals toxoplasmosis can even result in death without any preceding clinical abnormalities. Treatments do exist, but they are not always effective and they involve the difficult process of capturing kangaroos. Therefore, prevention is essential. The most important prevention measure is ensuring cats cannot enter the premises, because they are the only distributor of the disease. Humans can be infected by contamination of the environment. Especially pregnant women and immunocompromised people should be careful, since this infection can cause abortion and encephalitis respectively (Jackson, 2003)

3. The kangaroo industry

3.1 Concept

Instead of being kept on a farm like cattle, sheep and other farm animals, kangaroos are rooming the vast lands of Australia and are shot in the wild for their meat and skin. Each Australian state has different regulations about killing kangaroos for commercial purposes, including which kangaroo species can be shot. In total, there are 6 macropods that can be killed on the Australian continent.

The shooting of kangaroos is part of a state's management plan. In general, 15% of the estimated kangaroo population can be shot. This way the population remains in balance. If by disease or weather the population would drop drastically, this percentage will be altered (Cooney et all, 2012). In order to hunt kangaroos in the wild, one must become a licenced commercial kangaroo harvester. Before getting the licence, the applicant must undergo training considered adequate by the Australian government. An test at the end of the training asses if the candidate has suitable knowledge and has practiced enough to kill kangaroos in a human way(NSW, 2018). This means the kangaroo is immobilized by an headshot and is consequently bled dry and finally, 20 minutes later, eviscerated (NRMMC,2008). Here after, the carcasses will be stored in refrigerated facilities and the processing can start.[5]

[5] Exporting Kangaroo Meat. http://www.agriculture.gov.au/export/controlled-goods/kangaroo (accessed 3.15.17)

3.2 Kangaroo species

Of more than 50 species of Macropods living on the Australian continent, only 4 kangaroo and 2 wallaby species can be used for commercial harvest namely the red kangaroo, the eastern grey kangaroo, the western grey kangaroo, the common wallaroo, the Tasmanian pademelon and the Bennett's wallaby. Other species are protected. 90% of the harvested species consist out of red, eastern grey and western grey kangaroos (Frawley, 2010).

Red kangaroo

The red kangaroo or *Marcopus rufus* is the largest marsupial on the planet and therefore the largest of kangaroos. Males can grow up to 140cm in height and weight up to 92kg. Females are half this size. Although they are named red kangaroos, only males are red (more rusty brown). Females are rather smoky blue. They both have white and black patches on their cheeks and a white stripe running from their mouth to their ears. These markings distinguished them from other kangaroo species (Dawson,1995).

The eastern grey kangaroo

The eastern grey kangaroo or *Macropus Giganteus* can grow up to 130cm. Females are smaller, about half of the male's size. Apart from their size, males and females look quite similar. Their fur has a light grey-brownish colour. The head is darker than the rest of the fur, as well as the paws, tips of the hind feed and tip of the tail. They can even be black. Their belly has a much lighter grey colour, occasionally even white. The eastern grey kangaroo exists in many shades of grey, depending on where the animal lives. Inland kangaroos are a darker shade of grey than those living on the coast (Dawson,1995).

The western grey kangaroo

The western grey kangaroo or *Macropus fuliginosus* was long considered a subspecies of the eastern grey kangaroo. However after more research in 1960, it was made a full species on his own. These kangaroos are grey-brownish with lots of regional differences. They can be distinguished from the eastern grey kangaroo by their darker face and white patches on their upper thighs (Russell, 1974; Dawson, 1995).

The common wallaroo

The common wallaroo, also known as *Macropus robustus,* is closely related to the kangaroos mentioned above. Their length ranges from 100cm up to 140 cm. Despite this length, they don't weigh more than 50kg. Females, again, are only half the males size. Wallaroos have a sturdier body shape and shorter limbs than kangaroos. These adaptation make climbing rock easier in the rocky habitat they live in. They have black nostrils and their noses are hairless (Dawson, 1995).

The Bennett's wallaby

The Bennett's wallaby or *Macropus rufogriseus* is smaller than kangaroos and wallaroos. They can grow up to 80-90cm and weigh between 10-16kg. In this species, females are just a little bit smaller. Bennett's wallabies have a grey-brown fur and a white belly. They can be recognised by their silvery tail with a black top. Other characteristic include their black snout, ears and paws. In some parts of the world, they are nicknamed the red-necked wallaby because of the reddish fur on their shoulders (Jackson, 2003)

The Tasmanian pademelon

The Tasmanian pademelon or *Thylogale billardierii* is the smallest of these hunted kangaroos. Males weigh on average 7kg, female 4kg. They live, as discussed before, in the rainforest of Tasmania. This habitat has a very dense vegetation and this is reflected in their body adaptations. They have a shorter tail and shorter limbs which makes moving through this landscape easier. They are grey-brown on their dorsal side and red-brown on the ventral side (Jackson, 2003) [4]

3.3 Products

A kangaroo is the source of two animal products: kangaroo leather and kangaroo meat. Kangaroo leather is made from the hide of the kangaroo and is the result of multiple processes, including tanning. Tanning will change the protein structure, making the hide less susceptible to decomposition. The result

of the whole process will transform the hide to long-lasting leather that is ready to use in different items. Kangaroo leather is the strongest and lightest of all leathers.. Along with these two qualities, it is still flexible. That is why the leather is used in high performance sporting equipment such as cycling gloves, football shoes (Looney et al, 2002)[6].

Kangaroo meat was, before the Europeans arrived, one of the main sources of proteins for the Australian Aborigines (Dawson,1995). The European settlers would continue this practice out of necessity, due to the lack of other red meats like cattle or pork. However, since the nineteen thirties, the interest in kangaroo meat has diminished and until today 70% of the kangaroo meat is exported (Braddick, 2015). For this reason, the Kangaroo industries association of Australia (KIAA) tries to promote the meat yet again, emphasizing all the benefits kangaroo meat has.[7] Kangaroo meat can be bought in many different cuts from neck to tail and there are even manufactured products like sausage's and hamburgers.

3.4 Criticism

Hygiene is a thorny issue in the kangaroo industry. The evisceration and bleeding of the kangaroos happens in their natural habitat, were they are shot. These places don't reach the hygienic standards of a slaughterhouse. Additionally the period between the death of the kangaroo and storage of the carcasses in a refrigerated facility can rise up to several hours because the harvester has to shoot around 40 animals to be profitable. The pour hygienic standards as well as the delayed storage encourage the growth of bacteria such as E-coli and salmonella. Although the meat is inspected, critics have been heavily debating whether this method of slaughter is hygienic enough to be certified for daily human consumption (Ben-Ami et al. 2014). The kangaroo industry denies the public health is at risk, stating that it is compliant with all the regulations put in place by the government. The Esam report (E. coli and salmonella monitoring) confirm these statements.[8]

Another point of criticism is animal welfare. Kangaroos should be killed with a single headshot to minimise pain and suffering. However, critics doubt this always happens. Shooting happens at dusk and during the night and kangaroo are agile and fast. They think that many kangaroos are getting away injured. Others suffer a horrible and slow death because they are accidently shot in the abdomen and consequently left behind because harvesters cannot sell them for human consumption. Third, the slaughter of kangaroos with joeys causes a lot of controversy. If a female kangaroo with a joey is shot, the latter is clubbed to death or if it escapes, left to die from exposure. This is shown in a 2017 documentary "Kangaroo: A love-hate story" and seen by critics as evidence of the lack of animal welfare in the kangaroo industry (Ben-Ami et al. 2014). The KIAA on the other hand, draws attention to the fact that the moviemakers didn't take a neutral position. They claim that their harvesters are trained killers with a high success rate and that the kangaroo carcasses are checked for other wounds than the headshot when they are delivered. The KIAA has also set a ban on the killing of female kangaroos in 2013. There taken number has declined to 5% since.[9]

4. Kangaroo meat vs beef

4.1 Environmental impact

The human population has grown rapidly over the last decade and with her our livestock. This expansion of livestock has an immense effect on our water and land supplies, especially in areas where scarcity already prevails. These effects include, amongst others, Grassland degradation, deforestation and water and air. Additionally livestock contribute to global warming by the emission of greenhouse gases. The livestock sector represents 14,5% of all human induced emissions, with the beef and dairy sector accounting for the majority.[10]

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[6] See: Leather. http://www.kangarooindustry.com/products/kangaroo-leather.aspx (accessed 18/03/17)
[7] These topics will be discussed further on in this thesis, see chapter 4.
[8] See: Kangaroo meat deemed a healthy choice by consumers. https://www.globalmeatnews.com/Article/2016/06/15/Kangaroo-meat-deemed-a-healthy-choice-for-consumers (accessed 18/03/18)
[9] See: Male only. http://www.kangarooindustry.com/industry/animal-welfare.aspx (accessed 18/03/17)
[10] See:Tackling climate change through livestock.
http://www.fao.org/ag/againfo/resources/en/publications/tackling_climate_change/index.htm (accessed 20 march 2017)

Methane is one of the reasons that our consumption of beef has been ethically questioned. On short terms methane is 84 times more potent to contribute to global warming than carbon dioxide.[11] Methane is a by-product of the digestive systems of cattle and ruminants in general. It is formed by the microbes breaking down the digested feed during fermentation in the rumen and is released in the atmosphere by flatulence and belches. Although the digestive system of the kangaroo also includes a fermentation process, the produced methane is of a lower quantity compared to ruminants. Scientists used to think that the kangaroo's methane emission was even lower than all the other herbivore's emission and this was a result of their unique digestive microbiome. However, recent research has shown that their mean methane emission is 27% of the body-mass specific volume (m^3/kg) of a cow (Vendle et al., 2015) which is similar to the emission of hind-gut fermenters like horses. This results in a cow having a mean methane production of 0,63±0,111l $kg^{-1}dag^{-1}$ (Dittmann et al., 2014) and kangaroos on average having one of 0,14l $kg^{-1}dag^{-1}$ (Vendle et al., 2015). However, a kangaroo's methane yield is higher than could be expected and lies in between the yield of ruminants and other non-ruminants. Thus, Vendle et al. (2015) are suggesting that there is no difference in microbiome but merely a difference in metabolic state (Madsen and Bertelsen, 2012; Vendle et al., 2015).

Additional problems with our traditional livestock are the high percentage of cropland they feed and the large amounts of water they consume. To feed our livestock today, we need one third of the available croplands.[12] Beef cattle has the lowest feeding efficiency of all farm animals (Smil, 2002). Feeding efficiency or feed conversion ratio is the efficiency by which an animal puts its intake into an amount of desired output. So, beef cattle has to eat more to get the same amount of muscle growth in comparison to other farm animals

The amount of water that is consumed by farm animals is also much higher than the amounts of water needed for other eatable products. According to the institution of mechanical engineers (2013), beef cattle is the largest water consumer. They need 15415 litre of water to produce 1kg of meat which is a lot in comparison to sheep(10412 l/kg), pork(5988 l/kg) and chickens(4325 l/kg) (Mekonnen and Hoekstra, 2012; institution of mechanical engineers, 2013).

These are high numbers, especially for areas where croplands or water are scarce. The kangaroo on the other hand, is adapted to the harsh dusty environment of Australia. In comparison to sheep, kangaroos have a lower energy life style. This variation in metabolic energy makes it possible for a kangaroo to eat less from the same food source compared to sheep and keep a good body condition (Munn et al., 2008). Kangaroos also have a much lower water turnover than sheep. The water turnover is the replacement of water that the body consumed during a certain period. Kangaroos only have 27% of the water turnover of sheep, with their urine being 3 times as concentrated (Munn et al., 2014).
Because we already established that sheep have a higher feeding efficiency and need to drink less than cattle, we can assume that a kangaroo also has a lower food and water requirement then a beef cow.

Apart from the croplands and water efficiency, there is another environmental factor to consider. At the moment kangaroos live in the wild, in some area's there are too many of them and they bring damage to the biodiversity of the Australian lands by eating all the grass. There used to be barriers that kept the number of kangaroos stable like predation by dingo's, hunting by aborigines and drought. However, in many areas these barriers have declined or even vanished and as a result, the number of kangaroos has risen over the years. Howland et al. (2014) has proven this by looking at the insects in certain areas in Australia. Insects play a crucial role in the food chain for all kinds of animals. So, a high number of insects implies there is enough food for these animals. Howland et al. (2014) found that in areas where there were too many kangaroos, the insect population as a consequents the biodiversity were much lower. So, managing the number of kangaroos can contribute to the protection of the delicate biodiversity of the Australian lands (Howland et al., 2014).

[11] See: Methane, the other important greenhouse gas. https://www.edf.org/methane-other-important-greenhouse-gas (accessed 10 April 2017)
[12] See: Livestock and animal production.
http://www.fao.org/ag/againfo/themes/en/animal_production.html(accessed 19 march 2017)

4.2 Health and nutrition

Apart from the effects on the environment, nutritional value and the effects on our health are considered important by consumers when choosing what to eat. In meat, four major components can be analysed: moisture, proteins, fat and ash. Moisture is the primary component (75%) followed by proteins (18%), fat (6%) and ash (1%) (Vanhaecke, 2013). Proteins and fats are macronutrients that are important when looking at the daily dietary requirements.

When comparing beef and kangaroo meat, beef shows a slightly higher amount in protein. Beef has 20.83g protein/100g and kangaroo 20,30g protein/100g. Even when kangaroo meat is compared to other common red meat sources like pork and sheep, kangaroo meat is still slightly lower in proteins (Hoffman and Cawthorn, 2012).The last few years, the consumption of red meat has been questioned due to the possible negative effects on human health. Especially the high-fat content of these meats has been said to cause different types of cancer (Biesalski, 2005) but their consumption in lower amounts remains important. Kangaroo meat has a low-fat content of around 2% (Beiilken and Tume, 2008; Hoffmann and Cawthorn, 2012), while beef and sheep circle around 5% (Mcafee et al., 2010). Certainly, not only the percentage of fat in the muscle should be taken into account. The kind of fatty acids they are made out of and in which quantities they are present, is equally important.

The two main types of fatty acids are the mono/polyunsaturated fatty acids (MUFA/PUFA) and the saturated fatty acids (SFA). The ratio of PUFA/SFA should be 0.4 or higher to have a desired dietary ratio. For beef, the ratio is around 0.11(Mcafee et al., 2010). This low number is a result of the partial biodegradation of unsaturated fatty acids in the rumen (Engelke et al., 2004; Mcafee et al., 2010). In kangaroo meat, the amount of unsaturated fatty acids is relatively high and the saturated fats relatively low (Engelke et al., 2004). This results in a ratio of around 1,2 (Beiilken and Tume, 2008). These numbers can be significant because products high in saturated fatty acids can contribute to carcinogenesis. (Biesalski, 2005).

Another ratio to keep in mind is the ω-6/ω-3 polyunsaturated fatty acid ratio. This ratio is generally very high in today's western. This is stimulating factor in the start and development of various diseases, like cancer and cardiovascular diseases. The meat of farmed animals contains a lower ω-6/ω-3 ratio than animals who live in the wild. The reason for this difference is due to the fact that the feed of domesticated animals contains grains with a high content of ω-6 and a low content of ω-3, while plants eaten by the wild animal have a higher content of ω-3 (Simopoulos, 2002). (lagere omega 3)

Finally, another important unsaturated fatty acid is the conjugated linoleic acid (CLA). This fatty acid is assumed to have health benefits, like anticarcinogenic properties and lowering the chances of obesity (Engelke et al., 2004; Lehnen et al., 2015). They are predominately found in the fats from ruminants, where they are produced through the process of fermentation in the rumen. Other meats like chicken and pork have lower levels of CLA in their fat tissue. Beef contains is high in CLA containing round 1.7 to 10,8mg of CLA per g of fat (Lehnen et al., 2015). Engelke et al. (2004) found out that the amount of CLA in the adipose tissue of a kangaroo is almost four times higher than the amount found in lambs. The investigated lambs had an CLA of around 10mg/g fat and kangaroos around 38mg/g fat.

After all these comparisons between kangaroo meat and other red meats, it is important to nottice that the fatty acid composition of meat is depending on many factors like age, breed, diet, sex and the cut of meat (Mcguire and Mcguire, 1999; Mcafee et al., 2010). So, deviations in measured numbers between countries, regions and, in the case of cattle, neighbouring farms, could be present.

Apart from these macronutrients, red meat is also rich in many micronutrients like zinc, iron, and vitamin B12 which are less available in other food products and essential for many processes in the body (Biesalski, 2005).

	Zink	Iron	Vit B12
Beef steak cuts, raw	3.6g	1,4 g	2mcg
Standard kangaroo meat	3.05g[13]	4.1g^2	?

The comparison micronutrients beef and kangaroo per 100g meat ((Adapted from Pereira and Vicente, 2013)

Finally, kangaroos are wild animals. The meat contains by consequence no residues of antibiotics, hormones or other chemicals.

5. Kangaroo farming

Today, kangaroo meat is not on the weekly menu in many households. This chapter will investigated the factors to be considered for kangaroos farming that will be necessary if one day the wild population can sustain the demand. We will focus on the largest of all kangaroos: the red kangaroo.

5.1 Land and infrastructure

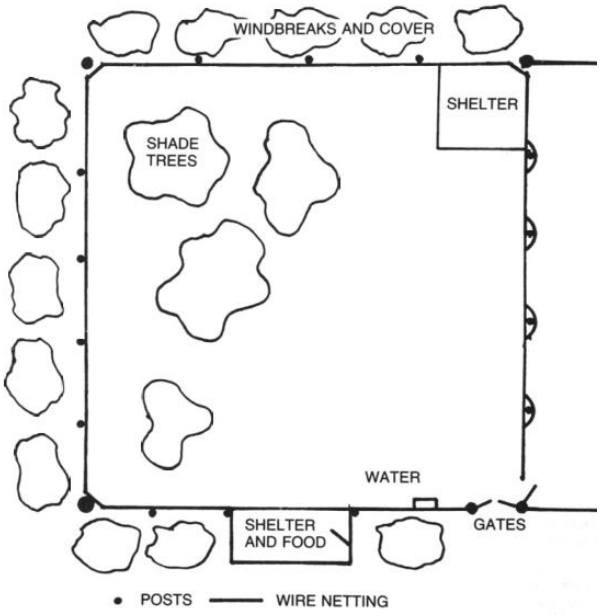
In the wild, kangaroos live in a certain home-range. This in an area in their habitat were they will stay on short term and do their day to day activities like feeding, breeding and raising a joey. For red kangaroos the home range will be located in grasslands, open forests, scrubs, deserts but most of the time open savanna. Unlike other animal's territories, these home-ranges will not be defended by its population and other kangaroos can join in. Red kangaroos are rarely nomadic and once they settle in a certain home-range, they will stay there for the rest of their life. However, in case of drought, poor vegetation or natural disasters, they will move out and establish their home range elsewhere. The red kangaroo has a home-range between 259-516 ha with areas that are more actively used than others (Croft, 1991; Dawson, 1995). Kangaroos live in social groups of 2-4 kangaroos, most of the time mothers and their joeys. Nonetheless, when they go grazing, they will often merge in larger mobs. A number of 50 kangaroos is not unusual (Caughley,1964, Dawson, 1995).

When keeping kangaroos in captivity, it is at their best interest to mimic their natural environment and keep in mind that they are prey animals with a predominant instinct to flee. This is of particular importance when installing the fencing. The enclosure should be formed in straight lines with curved turns because freighted kangaroos will keep close to the fences and just ran at high speeds against it. This can cause serious injuries and even death. The fence should be made out wire netting (50*50mm) and metal posts. The wire netting should be so narrow that when the kangaroos run into them, they don't get stuck. Kangaroos can jump quite high so, an 1.8m high fence is appropriate. It is also advised to bury the rest of the wire 30cm into the ground so kangaroos cannot dig their way out either. If there are predators in the area, applicable precautions should be made. Additionally, it is import to put the supporting and holding materials, like the posts, on the outside of the wire netting, yet again so kangaroos can't hurt themselves (Calaby and Poole,1971; Williams, 1989; Jackson, 2003).

Red kangaroos need a space of 250 m^2 for a pair of kangaroos and for every extra kangaroo another 20m^2 (Jackson, 2003). When putting kangaroos together, it is important to realise that male kangaroos will fight each other for females in oestrus. So, it is generally advised to 1 male per group of females. Putting male kangaroos together on an all-male bachelor group however, is not a problem (Williams, 1989; Jackson, 2003). The area inside the enclosure should be filled with grass, sand, soil or leaf litter and any unnecessary obstacle should be avoided. As seen in figure 4, there should be some threes and sheds for shelter. It is also advised to feed the kangaroo inside the shelter and put the food in height so it remains dry and clean. Furthermore, if red kangaroos are kept in cold weather, a form of heating should be present, like warming plates. To help them control parasites, dustbathes are needed. Finally, it is useful to build a holding or catching area where you can herd the kangaroo in and throw a net. For

[13] See: Beef vs Kangaroo Meat for NUTRITIONAL benefits. http://www.daleynutrition.com/beef-vs-kangaroo-meat/ (accessed 15/05/18)

intensive farming, it is recommended to regularly handle the animals. Otherwise this will cause too much stress and this can lead to capture myopathy (Shepherd, 1989; Jackson, 2003).



A plan and picture of an kangaroo enclosure (adapted from Williams, 1989)

5.2 Nutrition

Red kangaroos are primarily grass eaters. In the wild they will try and find grazing areas but they will also eat numerous plants (Dawson, 1995). In captivity, red kangaroos should be put on grasslands if these are available, so they have an ad liberum source of grass. When moving the animals from one grazing area to another, it is always important to ensure that the grass is of an equal quality. For example, if kangaroos go from a low quality enclosure to high quality grass enclosure, the bacteria in their stomach will have to change too rapidly. This makes them more susceptible to bacteria like salmonella and clostridium which in turn can cause sudden and great amounts of losses amongst the animals. Giving the captive animals some high value grass every day whilst they are still on the low quality grass, can help easing the adaptation process.

Additionally it is important to check is if the new area is free from toxic plants. If grass isn't available, a daily portion of grass hay or Lucerne is also an option (Williams, 1989; Jackson, 2003). Kangaroos have the good habit of only eating their needed requirements and obesity is rare. So, hay and Lucerne can be given at liberum (Shepard, 1983; Jackson, 2003). In some holding facilities for kangaroos, only the chaff of the Lucerne is given. The stalks of the plants can surely cause wounds in the mouths which in turn eases the manifestation of necrobacillose (Jackson, 2003). Apart from grass, grass hay or Lucerne, kangaroo should also be given 350 g pasture replacement pellets, 60 g maize, 1 carrot piece, 1 Browse: eucalypt/acacia/native mint bush branches daily, according to Jackson (2003). An ad liberum water source should be present as well.

5.3 Reproduction

In general red kangaroos are not difficult to breed in captivity (Jackson, 2003). Female kangaroos become sexually mature between 15 -20 months and males between 20-24 months of age (Sharman and Calaby, 1964). To achieve the best breeding results one males should be put together with five to six females (Jackson, 2003).

The female red kangaroo has a gestation period of 33 days which is followed by a post-oestrus. If she mates again with a male during this period, this can result in another pregnancy. The suckling of the

joey will stop the embryonic development at a 80 cell stage (Shaman and Calaby, 1964). The embryonic diapause will stop when the last 30 days of the pouch life of the joey starts. This pouch life will take around 235 days and during the last ones, the birth of the second joey will occur and two young kangaroos will be present in the pouch. The older joey will leave the pouch, but continue to suckle for another 4 months before it can stand on its own. The kangaroo can actually have three offspring at once. One outside the pouch, one inside the pouch and one in an embryonic state (Russell, 1974). Although the care for different joeys may overlap, the mother will still need approximately a year to produce a young that is independent. Females are fertile their whole life which lasts about 10-15 years in captivity. However, their fertility may decline when getting older (Shepherd, 1983).

Discussion and conclusion

Of course, much more information can be gathered on the general question: Can kangaroo meat be the meat of the future? However, in this discussion, we try to form an answer based on the information gathered above. The environmental factors of kangaroo meat, that are taken into account in my assessment, are factors that are of growing importance to people, are quit satisfying.

The opinions about the low methane production of the kangaroo took a bit of a turn the last few years when Vendle et al. (2015) questioned the unique microbiome of the kangaroo and revealed a higher methane yield than first expected. Still, if we compare it with the methane production of cows, it is four times lower. Although they probably don't have a unique microbiome in their stomach (Vendle et al., 2015), producing much less methane is a big advantage. The lower consumption of water and food is an environmental factor that hasn't a direct effect on the global warming and maybe does not really bother consumers at the moment, but the growing human population will make it more of an issue in the future. There will be a larger demand for food and fresh water, supplies that are consumed by cows in large quantities at the moment. If we want to be able to feed the entire population without pressuring the planet, we should use our resources more efficiently. Replacing a part of the sheep and cattle population by kangaroos seems an evident choice[14].

The kangaroo industry claims that besides the fact that kangaroo meat and products are more sustainable than any other animal products, the meat is also high in protein, low in fat and the highest CLA source[15]. The good nutritional features could guide even more people towards the kangaroo industry. However, we should have a critical attitude toward these claims. Kangaroo meat is high in protein compared to other edible products, but not in comparison with other red meats. Still, these analyses were done on raw meat with kangaroo meat having the highest percentage of moisture (Hoffman and Cawthorn, 2012). So, when the kangaroo meat would be baked and there is loss of moisture, the percentage of protein might actually appear than the other pieces of red meat.

Kangaroo meat is also low in fat. The 2% is indeed the lowest of the common red meats. Nonetheless this has an effect on the CLA content of the meat. Kangaroos have 38mg/g fat CLA in their meat and beef has 10,8mg/g fat (Engelke et al., 2004; Lehnen et al., 2015). When we look at a 100g piece of meat of both species we can conclude out that kangaroo meat contains 76mg CLA/100g and beef contains 54mg CLA/100g. Kangaroo meat is still higher than beef but not three times as high as one would think. In addition to the high CLA, kangaroo meat has better ratios of fatty acids and can be considered healthier to other red meat when it comes to fat content.

When considering all these benefits, kangaroo meat will most likely have a smaller environmental impact than beef, with an additional advantage of being healthier. So, why hasn't it managed to become the number one meat? In Australia, kangaroo meat has a slightly of a negative image that reflects on the international markets. The kangaroo is the national emblem of the country and with skippy still in mind, Australian are hesitant to eat an animal that has been considered cute and fluffy for the last 50 years. Apart from the emotional link, Australian consumers have another concern. They see kangaroo meat as

[14] See: Total grazing pressure.http://thinkkangaroos.uts.edu.au/issues/total-grazing-pressure.html. (accessed 4.5.18)
[15] See: .Kangaroo meat. http://www.kangarooindustry.com/products/meat.aspx (accessed 16.4.18)

an unhygienic source of meat because it is shot in the wild. Thus, around 70% of the kangaroo meat is exported and a large amount of the remaining meat is just used in pet food (Braddick, 2015). [16] The meat that is sold for consumption is 30% cheaper than beef. As a consequence of this lower price, kangaroo meat is seen by some as a lower quality meat. The Australians that do eat kangaroo meat, save it mostly for special occasions, so it is not yet integrated in their daily lives (Braddick, 2015). Internationally, kangaroo meat is seen as good piece of game meat with the Netherlands being one of the main international buyers. However, not everyone agrees kangaroo meat is worth importing. Russia and California already put a ban on it, questioning the hygienic standards of the meat, although some sources say the ban is more political.[17][18] Depside all these controversies, the demand for meat is slowly growing, both in Australia and internationally. Nonetheless, the perception that many Australians have, reflects toward other countries. This perception will have to change if the kangaroo industry wants to continue his growth.

The hygiene is one of the bigger concerns when the consumer looks at kangaroo meat. So, why not farm these kangaroos? On a farm, hygienic circumstance can better be managed. Furthermore, female kangaroos with joey's can be separated and so no harm will be befall the young kangaroos. Finally, kangaroo farming could be a solution when the shooting of wild kangaroos reaches its quota.

Starting an intensive kangaroo farm in Australia cannot be done at the moment, because is not economically viable, based on the information gathered in this thesis. Furthermore, Shepherd (1983) did a more thorough came to the same conclusion. Although this study is dates from 1983 many factors have remain the same. However, if the price of kangaroo meat would rise because of the higher demand and the production cost could consequently be covered, intensive kangaroo farming could be a possibility.

The probability of kangaroo meat ever replacing beef, is almost non-existent. However, it is an alternative that people may consider to eat more regularly in the future and still has the possibility to expand without resorting to kangaroo farming. Especially in Australia, this is a good sustainable foodsource that should be promoted more.

[16] See: Eating Skippy: Why Australia has a problem with kangaroo meat. http://www.bbc.com/news/magazine-23086541. (accessed 16.4.18)

[17] See: Kangoeroevlees is een risico voor de volksgezondheid. http://www.gezondheidskrant.nl/kangoeroevlees-risico-volksgezondheid (accessed 16.4.18)

[18] See: Russia bans kangaroo meat due to unacceptable levels of E.coli. http://www.abc.net.au/news/rural/2014-08-18/kangaroo-meat-ban/5677656 (accessed 10.04.17)

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Appendix

Nederlandse samenvatting

In deze thesis wordt nagegaan of kangoeroevlees in de toekomst de potentie zou kunnen krijgen om met rundvlees te concurreren. Daarom wordt eerst dieper ingegaan op de zoölogie van de kangoeroe, waarbij dan vooral gefocust wordt op zijn reproductieve kenmerken. Daarnaast worden ook enkele ziektes in kangoeroes overlopen.

Om de potentie van het kangoeroevlees na te gaan, moeten we ook kijken naar de kangoeroe industrie. Deze is volledig anders dan het traditioneel rundsvlees. Kangoeroes leven in het wild en worden daar dan ook gedood. De jagers moeten zich houden aan een nationale code opgesteld door de overheid. Deze reguleert de hoeveelheid kangoeroes dat per jaar geschoten mogen worden, zodat de kangoeroe populatie in evenwicht blijft. Ook de soort kangoeroes, het jachtproces zelf en wat er vervolgens met de karkassen moet gebeuren, staat beschreven. Ondanks dat deze code het lijden van de dieren moet minimaliseren, is er nog steeds controversie over deze aanpak.

Wanneer we kangoeroe- en rundvlees dan vergelijken op vlak van milieuvriendelijkheid en nutritionele waarden zijn er ook enkel opmerkelijke bevindingen. Kangoeroes stoten opmerkelijk minder methaan uit dan koeien, een gas dat een belangrijke rol speelt in de opwarming van de aarde. Verder zijn hun dagelijkse behoeften aan water en grondstoffen ook noemenswaardig lager. Omdat kangoeroes eigenlijk in grote getalen aanwezig zijn, zorgt de jacht op deze dieren ervoor dat ze de biodiversiteit van de landschappen minder verstoord worden, waardoor kangoeroe vlees eigenlijk op alle vlakken milieuvriendelijker is dan rundvlees.

De goeie nutritionele waarde wordt ook uitgesproken benadrukt door de kangoeroe industrie. Kangoeroevlees zou hoog zijn in proteïnen, laag in vet, hoog CLA en hoog in ijzer. De uitspraken zijn waar, maar moeten soms in de juiste context gezien worden.

Dan is er natuurlijk ook nog de gedachtegans, om indien de wilde kangoeroe populatie niet meer voldoet, of het jachtproces achter het huidige kangoeroevlees maar niet verder erkend wordt door de consument, als een acceptabele manier van slachten, er nog altijd kangoeroe boerderijen kunnen gebouwd worden. Op dit moment is kangoeroevlees nog niet doorgebroken ondanks de talkrijke voordelen en is het door de lage prijs van het kangoeroe vlees niet rendabel om een kangoeroe boerderij op te starten. De vraag naar dit vlees is echter zowel in het buiten-als in het binnenland lichtjes aan het stijgen maar het negatieve beeld dat vooral Australiërs hebben over dit vlees, en zo reflexteren naar de andere landen, maakt het eten ervan nog altijd een beetje tegenstrijdig. Nu de druk om

milieuvriendelijker en gezonder te eten echter stijgt, zal kangoeroevlees misschien zo aan belang winnen maar de kans dat het een alle daagse vleessoort wordt, lijkt klein.