Deering to be Different

An evaluation of RFID technology within velvet-focused farm systems and velvet value chains

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Executive Summary

New Zealand (NZ) has the largest population of farmed deer worldwide and the invention of deer farming is a great innovative agricultural success (Anselmi, Taylor, Good, Hansen, & McHugh, 2012). Recently, NZ velvet has developed a premium product reputation and prices have been high. However, on the 1st March 2016 the National Animal Identification and Tracing (NAIT) scheme will require all mature deer to be NAIT tagged and registered.

This imposes a compliance cost, but equally creates new opportunities from the adoption of Radio Frequency Identification (RFID) technology. RFID has revolutionised NZ dairy farm production systems and is seen by many premium markets, as *"a necessity for food safety procedures and requirements"* (Anselmi, et al., 2012, p. 15).

"RFID is a generic term that is used to describe a system that transmits the identity (in the form of a unique serial number) of an object or person wirelessly, using radio waves" (Kaur, Sandhu, Mohan, & Sandhu, 2011, p. 151). RFID or electronic identification (EID) animal tagging "is a means of automatically identifying individual products or livestock via a unique numbered tag which has the ability to be scanned and recorded onto an external database" (Anselmi, et al., 2012. p. 7). RFID could be thought of as a replacement to barcode technology, but with a number of additional capabilities, including its ability to operate in some environments without direct line of sight.

The majority of NZ velvet is sold in South Korea within private medicine shops, by highly trained Oriental Medicine Doctors who "prescribe velvet in combination with a number of herbs, according to the treatment required" (Fraser, 2009, p. 6). This market is changing and young Koreans are time poor, but still believe in the health properties of velvet. They require velvet in a capsule and extract form, which creates new opportunities within velvet-focused farm systems and velvet value chains.

The purpose of this study was to add to the existing literature available to the Deer Industry New Zealand (DINZ) and its stakeholders on RFID. The goal of this study was to fill the gap by completing: *an evaluation of RFID technology within velvet-focused farm systems and velvet value chain*s. A case study approach was used as defined by Perry (1998) and a thematic analysis technique was used to analyse the data as described by Fereday, (2006). The study's interviewees were made up of industry professionals who have specific knowledge and viewpoints on either RFID, velvet supply chains, the NZ deer industry or velvet-focused farming systems.

It can be concluded that there are opportunities for RFID technology within velvet-focused farm systems. Seven main opportunities were identified from the adoption of RFID technology by the NZ velvet industry. All seven of these opportunities were shown to be interlinked through the adoption of RFID technology, but were shown to provide different impacts depending on the adopter's position within the supply chain. These seven opportunities are:

1. Ultra-High Frequency (UHF)
2. Traceability
3. Supply chain management
4. Data handling
5. Individualised management
6. Live data analysis
7. Industry data hub

The biggest opportunity for the velvet industry is the industry-wide adoption of UHF RFID technology. UHF is the preferred RFID frequency for supply chains, but it also creates additional opportunities for NZ velvet producers. UHF appears to better adhere to the behaviour of deer, which enables more applications in the animal management systems of producers compared to low frequency. UHF's key benefits were its animal handling, information storage and increased operator safety capabilities.

The traceability capability of RFID was seen as the biggest opportunity across all RFID frequencies. The benefits of RFIDs traceability capability are created through RFIDs ability to improve supply chain management, data handling, individualised management and live data analysis through the use of an industry data hub. This requires the integration of on-farm and supply chain RFID technologies, which is needed to create relatively seamless electronic information transfer between entities. This integration would enable the opportunities that have been identified to be implemented and would be beneficial for all parties within the NZ velvet industry.

In the long term, the potential opportunities of RFID for the NZ velvet industry will outweigh the limitations to adoption as the adoption of RFID has the potential to benefit all parties within the NZ velvet industry. The main limitations of the uptake of RFID technology within the NZ velvet industry are a lack of useful information sharing and time for user familiarisation. These limitations will be ongoing as more innovative RFID opportunities are created for velvet-focused farm systems and velvet value chains. Some of these opportunities we have yet to imagine, let alone recognise.

Based on this study, it has been recommended:

1. That further research is conducted into understanding the full potential of RFID technologies within the NZ velvet industry.

2. That NAIT urgently revisits and reassess its decision to exclude the use of UHF technology from the NZ velvet industry for animal identification and tracing.

3. That DINZ makes the further exploration of UHF RFID velvet tag technology as a suitable alternative to paper-based velvet traceability systems a priority.

4. That DINZ enables innovative customers, marketers and producers to freely experiment with RFID and identify their own tangible opportunities, limitations and benefits.

5. That DINZ does not immediately make a new RFID technology compulsory and instead enables the extension, support and time needed for users to become familiar with RFID.

6. That entities involved within RFID technology development, NZ velvet production and velvet value chains come together to communicate and collaborate in order to create:

    a. An improved extension framework for RFID within the NZ velvet industry.
    b. A development plan for the utilisation of data created through RFID.
    c. A strategy of enablement, which allows commercial entities both on-farm and in the velvet value chain to benefit from the opportunities that RFID can create.

7. That NZ livestock industries come together on RFID research and development to create and exploit mutually beneficial opportunities.

8. That visionary leadership is utilised for decisions regarding RFID within the NZ velvet industry. To ensure that RFIDs long term potential to create new opportunities is not wasted.

9. That a strategy for the creation of a national industry good livestock data hub is created. A hub that would enable the transfer of information between entities, the creation of powerful big data analysis and a framework for RFID data transfer and analysis technology developers.

Preface

I was required to prepare this document for the Kellogg Rural Leadership Program (Kellogg's) at Lincoln University in New Zealand (NZ). It has been a privilege to complete this study which has combined my greatest passions of deer, agribusiness, farm management and innovation.

This study along with other recent events, has made me realise that I can apply my knowledge and skills commercially while simultaneously improving the lives of others. I hope that this study will provide valuable insights to readers on the potential of RFID within the NZ velvet industry.

I became interested in this topic whilst learning what is possible through RFID technology on robotic dairy farms during my Masters of Agricultural Science studies. After discussions with the Deer Industry of New Zealand my raw idea was moulded into this study. This report is solely my work and perspective on the topic. Whilst I am an optimistic thinker and early technology adopter, I have endeavoured to create a document which is both critical and balanced.

I would like to personally thank all the individuals and organisations which contributed their time and freely shared their insights into RFID technology, the NZ velvet industry and a great deal of other topics which were beyond the scope of this study. Their thoughts have given me new insights into an industry that I'm incredibly passionate about and have helped me to identify a number of opportunities for my future beyond university. My deepest thanks go to all of you and your teams.

I'd like to take the time to thank the team; family, friends, peers, supporters, fellow Kelloggers, guest speakers and course coordinators. Thank you for creating the opportunity for me to be a part of this environment. It has improved my life in more ways than I have room to describe with adequate justice. My recommendation to other young rural leaders regarding Kellogg's is simple, if the opportunity arises to complete the course, grasp it tight with both hands. Upon reflection, I have realised that the connections, reputation and inspiration that Kellogg's has given me are simply priceless. I would sincerely like to thank everyone that made this experience possible.

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1.0 Introduction

Radio Frequency Identification (RFID) tagging within the dairy industry has revolutionised New Zealand (NZ) dairy farm production systems. Its use has given rise to individual cow management, which has led to a host of new technologies, including automated milking, weighing and drafting systems. This development of new electronic farming tools available to NZ dairy farmers poses the question, how could RFID be utilised in a similar way for velvet-focused deer farmers (velvet producers)?

A cost-benefit study by Anselmi, Taylor, Good, Hansen, & McHugh (2012) identified that there is the potential for financial rewards to result from the adoption and adaption of RFID technologies by deer farmers. This is supported by Deer Industry New Zealand (DINZ), who believes that the compulsory RFID tagging of deer under National Animal Identification and Tracing (NAIT) creates an opportunity for improved productivity measurement. In 2015, few NZ deer farmers seem to be adopting RFID technologies (Deer Industry New Zealand, 2015), but the compulsory RFID tagging of all mature farmed deer on the 1st March 2016 has reduced the opportunity cost of adopting RFID.

RFID technologies are not limited to just animal tagging. In the rapidly growing world of e-commerce RFID is being continually evaluated for its attributes within supply chains. It can replace paper-based documentation systems and has the ability to enable automation of physical processes. DINZ has recognised that RFID has the potential to create benefits within velvet supply chains, but the velvet industry still needs a greater understanding of the potential of RFID technology. It needs a clearer picture of the opportunities that RFID technologies could provide to NZ velvet-focused deer farmers and their velvet value chains, and what is currently limiting the adoption of these technologies.

Variety within NZ deer industry exists and there are differences "from farmer to farmer about the way they farmed and what their enterprise meant to their farming operation" (Anselmi, et al., 2012, p. 2). This means that a variety in the capabilities, resources and goals of the velvet industry will exist. A reader should consider that the findings might not apply to some entities in the NZ velvet industry, as certain technologies or technological concepts may or may not apply to certain situations.

The purpose of this study is two-fold. Its first purpose is to push the boundaries of the current literature and evaluate new and futuristic RFID technology concepts to identify what opportunities exist that could benefit NZ velvet producers and marketers. The second purpose is to further evaluate and examine the findings of these opportunities, by identifying and examining what may assist and limit the uptake of these ideas by NZ velvet producers and velvet marketers.

2.0 The NZ Velvet Industry

NZ has the largest population of farmed deer worldwide. The creation of the NZ deer farming industry is one of the great innovative success stories of agriculture (Anselmi, Taylor, Good, Hansen, & McHugh, 2012). It is claimed by Drew (2012) that the domestication of deer in NZ was the first case of an animal being fully domesticated for over 5,000 years. However, the domestication of deer in NZ did not occur overnight, it was a serious of fortuitous and fortunate events.

The first event was the introduction of multiple species of deer to NZ for hunting as game animals in 1851. The main species of deer introduced was red deer *(*Cervus *elaphus)* (Fraser, 2009). Red deer thrived in the NZ environment and by the early 1900's NZ's wild red deer population had expanded rapidly. This population boom made the NZ government initiate control measures to limit the negative impacts the species were having on the natural flora and fauna (Yerex, 1979).

In the 1960's a group of innovative Kiwis established a trade from NZ into Asian markets for the pizzles, tails, sinews and velvet of the wild deer being culled in NZ (Yerex, 1979). These Asian markets were then complimented by the establishment of lucrative trade with West Germany for venison. The high demand for wild deer products and the earlier control (culling) measures had led to the reduction of the NZ wild deer herd by more than one million animals by 1971 (Yerex, 1979).

By 1971, the harvesting of wild deer out of the NZ's mountainous landscapes had developed and evolved into an efficient but costly system through the utilisation of helicopters. Helicopters were a multi-purpose tool in venison recovery. They were used as both a shooting platform and for initial carcass transportation purposes out of difficult terrain (Yerex, 1979). The systems efficiency and success put pressure on NZ wild deer resources, which generated growing competition between recovery teams (Yerex, 1979).

The venison recovery pilots and other members of the wild deer industry recognised a looming crisis. They recognised three things: that wild deer numbers in NZ were decreasing rapidly, there would be a conclusion to the NZ wild deer harvest and they would lose their ability to supply the lucrative markets which they had worked hard to develop (Fraser, 2009). In the late 1960's, they explored and perfected the art of how to capture live wild deer and how to farm deer in NZ (Fraser, 2009) to combat this looming supply crisis. They invented deer farming systems that were successful and deer farming became recognised as a viable opportunity for NZ farmers.

The first deer farming licence was issued to M. P. Giles of Rahana Station (near Taupo) in 1969 (Drew, 2012). In these early days of deer farming in NZ, it was recognised that an organisation was needed "to assist in maximising sustainable benefits for all deer farmers and to provide a linkage to the agricultural industry and the public" (Deer Industry New Zealand, 2014, p. 1).

In 1975, the New Zealand Deer Farmers Association (NZDFA) was formed. It was made up of 25 founding members and Sir Peter Elworthy was its first president. Four years later in 1979, promotional work by the NZDFA prospered and there were around 800 deer farms in NZ. However, interest in deer farming reached a climax in 1979 and by 1980 there were around 1,540 deer farms remaining with around 120,000 deer being farmed (Drew, 2012). The majority were red deer (85%) and fallow deer (14%), with the balance being wapiti, sika, rusa, and white-tailed deer (Drew, 2012).

During these early stages of the NZ deer industry, it was velvet rather than venison which was the early driver of profitability (Wallis, 1989). However, venison was still an important co-product of deer farming in these early years (Fraser, 2009). Venison and velvet are still the two main focuses of NZ deer farmers, but venison rather than velvet has become the main focus of today's NZ deer industry.

In 2015, deer are most commonly farmed as part of a larger livestock portfolio, most commonly with sheep and beef cattle (Anselmi, et al., 2012). In 2014, there were 3,000 farms in NZ that ran a total of approximately 950,000 deer (Deer Industry New Zealand, 2014). These farms are spread throughout NZ, but the majority of deer are farmed in the Central North Island and South Island on large hill and high country stations.

In 2014, NZ velvet export revenue was valued at $28 million with NZ remaining the largest producer of farmed velvet in the world (Deer Industry New Zealand, 2014). NZ velvet markets are predominantly in Asia, with the majority (estimated at around 80%) consumed in South Korea (Anselmi, et al., 2012). China is the other traditional market for NZ velvet, which continues to be a valuable customer of an increasing proportion of NZ's velvet (Anselmi, et al., 2012).

Recent NZ velvet market prices have been high and NZ velvet has cemented its place as a premium product, which is buffering some of the below average returns of venison (Proudfoot, 2015). Proudfoot (2015) recognised that the NZ deer herd is declining at an annual rate of 3.7% since 2009. This is predominantly due to a conversion of deer finishing farms to dairy or dairy support properties.

3.0 Food Safety, Traceability and NAIT

The NZ deer industry has the opportunity to differentiate its products from others in the market place, which is essential to its ongoing success in a rapidly changing and globalising food market (Anselmi, et al., 2012). Food safety has become recognised by international food consumers as the most important attributes of food supply chains (Anselmi, Taylor, Good, Hansen, & McHugh, 2012). There is a general recognition and acceptance that our international customers and trading partners are placing an increasing importance on the existence of credential data systems to provide farmer to consumer tracing of animal products (Hartley, 2013).

Consumer awareness of food safety has been created through the world becoming connected though new communication systems and by multiple scares in food products worldwide (e.g. BSE scare in the UK beef industry in the 1990's). These events have necessitated the need for tightened food safety standards around the world and raised the importance of food safety standards within food supply chains and traceability (Anselmi, et al., 2012). Traceability is now recognised as an important product attribute by many premium food markets worldwide (Anselmi, et al., 2012).

'The Food Business Forum' defines traceability as *"the ability to trace the history, application or location of an entity by means of recorded identifications"* (Drew, 2012, p. 4). The "fundamental requirement of any traceability system is some form of unique identification" (Hartley, 2013, p.3). Traceability systems within supply chains enable: transparency, control of livestock epidemics, increasing due diligence and withdrawing government interventions (Anselmi, et al., 2012).

Traceability is best achieved when near real-time information transfer in an online format is combined with the capability for constant information transfer up and down the supply chain. This creates almost instantaneous traceability, which allows sellers to effectively position, identify and recall contaminated or harmful products (Hartley, 2013). Therefore "*in many premium markets, radio tagging traceability systems will become a necessity, especially as the level of food safety procedures and requirements lift and increase the credence value of products which are perceived as valuable by customers"* (Anselmi, et al., 2012, p. 15).

In 2005, a Foot and Mouth disease hoax on Waiheke Island made it clear that the NZ livestock industry (including the velvet industry) needed an enhanced animal identification and traceability scheme (Young, 2011). NZ was ill-prepared for the consequences of the disease outbreak. Agricultural exports would have been blacklisted by international markets and the NZ economy would have potentially lost billions before the damage could be mitigated (Young, 2011).

In November 2009, the NZ agricultural industry approached the NZ Government with a business case to establish a mandatory National Animal Identification and Tracing (NAIT) scheme (Young, 2011). In December 2009, it was agreed that the NZ Government would fund the development of NAIT.

The NAIT Bill was set down to be passed into law in early 2012. The purpose of the act has been described by Young (2011), as to establish an animal identification and tracking system that:

- *Provides for rapid and accurate tracing of individuals or groups of NAIT animals from birth to death or live export.*
- *Provides information on the current location and movement history of individuals or groups of NAIT animals.*
- *Improves biosecurity management.*
- *Manages risks to human health arising from residues in food, food-borne diseases and diseases that are transmissible between animals and humans.*
- *Supports improved animal productivity, market assurances and trading requirements.*

(Young, 2011)

Today in 2015, NZ's NAIT act has been implemented and NAIT LTD (2015) states that under the NAIT Act NZ deer farmers are required by NZ law to:

1. Tag new-born deer, born on the property with an approved orange NAIT ear tag (low frequency RFID tag), before they are six months old or before they move off farm (whichever occurs first). Apart from the following exemptions:
   - Deer which a farmer considers too dangerous to tag and are destined for transport to a venison processor.
   - Fallow deer & trophy stags.

2. Register their animals in the NAIT system within one week of being tagged or before they move off farm (whichever occurs first). This requires the following details:
   - The animal's NAIT RFID or Visual ID number.
   - Animal type.
   - Production type.
   - Animal date of birth.
   - NAIT number of birthplace.

3. Record animal movements on and off farm within the NAIT system. With the exception of movement to (not from) an accredited sale yards and meat processors.

4. At the 1st March 2016, all mature deer must be NAIT tagged and registered.

4.0 Adoption Framework

Adoption is a process of technological change or technology substitution for improvement (Marra, Pannell, & Ghadim, 2003). This process "involves the acquisition of information and the process of learning" (Marra, Pannell, & Ghadim, 2003, p. 222). Adoption is dynamic in nature and involves decisions that require changes in "perceptions and attitudes as information is progressively collected" (Ghadim & Pannell, 1999, p. 145). Ghadim & Pannell (1999) "emphasise the personal subjective perceptions of the innovation's profitability and riskiness" (Ghadim & Pannell, 1999, p. 149). During the assessment of new technologies for adoption there is "a trade-off between profit and risk" (Ghadim & Pannell, 1999, p. 149).

Within an agricultural context, adoption is a "multi-stage decision process involving information acquisition and learning-by-doing" (Ghadim & Pannell, 1999, p. 146) by individuals that "vary in their risk preferences and their perceptions of riskiness of an innovation" (Ghadim & Pannell, 1999, p. 146). The rate of adoption and the ultimate adoption level are "determined primarily by the actual benefits of adoption to the potential adopters" (Ghadim & Pannell, 1999, p. 150).

When an innovation can be adopted in a stepwise manner, the decision to adopt includes "a decision regarding the intensity of adoption at any given time period along the adoption time path" (Marra, et al., 2003, p. 222). In these scenarios "it is important to consider and account for the relationships between the components of the innovation package" (Marra, et al., 2003, p. 221). Due to the perceived risk associated with the new technology with complex adaptions, the "potential adopters initially have a cautious approach toward adopting the innovation" (Marra, et al., 2003, p. 222).

RFID technology in the NZ velvet focused farm systems poses a risk to adopters, as it may not be possible to recover the costs of a failed technology investment. To manage this type of risk adopters "often attempt to trial an innovation without investing in the 'correct' machinery. They instead make do with their existing machinery and make allowances for imperfections when they evaluate trial results" (Ghadim & Pannell, 1999, p. 152). In these situations, "learning and imitation are central to adoption" (Marra, et al., 2003, p. 222) as further gains are made through experience (learning-by-doing) (Marra, et al., 2003).

To reduce an industry-wide risk perception of RFID, improved information about the performance of the innovation is needed. Research provides an opportunity to reduce adoption uncertainty (Marra, et al., 2003). This is explained by Bayes' theorem, which "provides a logical mechanism for the consistent processing of additional information" (Ghadim & Pannell, 1999, p. 150).

> *"Bayes' theorem allows us to revise probabilities based on new information and to determine the probability that a particular effect was due to a particular cause. This allows us to refine the optimal decision and to calculate the expected value of benefits from this refinement"*.
>
> *(Ghadim & Pannell, 1999, p. 150)*

Farmers gather information on a new technology from a variety of sources and as *"more information is gathered the decision-makers are able to increase their knowledge about the overall attractiveness of the innovation. Through the improvement of their knowledge on the best use of the innovation, there is a reduction in their uncertainty about its potential benefits"* (Marra, et al., 2003, p. 222).

Results of an innovations performance "reduce a farmer's uncertainty for future years and allow better decision making" (Ghadim & Pannell, 1999, p. 149). Long term case studies or on-farm trials increase the rate of adoption of a technology and lead to the development of the adopter's skill base by demonstrating the uncertainty of innovation's long-term profitability" (Ghadim & Pannell, 1999).

When accurate information is provided, the potential adopter is able to revise their subjective beliefs about the profitability of the technology and create a more accurate perception of the innovation (Ghadim & Pannell, 1999). This enables them to revise their thinking to a more accurate perception of the innovation (Ghadim & Pannell, 1999), allowing for better adoption decisions to be made when assessing the risk vs benefit profile of the new technology.

Figure 1: Velvet stags in the Waikato during a summer drought.

5.0 Goals and Objectives

Previous work had been conducted on RFID technology in deer farming systems and a large study was conducted prior to the introduction of NAIT by Anselmi, Taylor, Good, Hansen, & McHugh (2012). It was identified in the following literature review, that there are still many gaps within the literature on RFID use in the NZ deer industry.

The purpose of this study is to add to the literature available on RFID technology for the DINZ and its stakeholders. The goal of this particular study is to complete: *an evaluation of RFID technology within velvet-focused farm systems and velvet value chains*.

The focus of this study is to provide DINZ and its stakeholders with a quality report, which is based on accurate and relevant information on the opportunities and limitations of RFID technology within velvet-focused farm systems and velvet value chains. This will be achieved through creating a report which answers the following research questions.

6.0 Research Questions

To fill in the gaps in the literature that was identified in the previous section, the following three research questions have been identified:

1. What RFID based technologies would be beneficial to the NZ velvet industry?
2. How could these new RFID-based technologies be beneficial to the NZ velvet industry?
3. What is limiting the adoption of RFID technologies within the velvet industry?

7.0 Literature Review

7.1 Velvet

Velvet is the immature stage of the growth of deer antlers (Fraser, 2009). Deer antlers are unique to cervids and are two bone outgrowths from the skull (similar to horns), that regenerate and cast (falls-off) annually through a natural cycle in temperate climates. Due to its annual cyclic pattern of growth, velvet can only be seasonally produced and harvested in NZ. The annual harvesting of velvet is essential, as antlers when fully developed are used by mature male deer as dangerous fighting and attacking weapons during mating (known as the rut or roar) (Provelvo, 2015). If left on the animal, antlers pose a high risk of human and animal injury or even death.

Velvet is the immature form of antler and its growth is a naturally occurring tissue regeneration cycle, which occurs only in the male deer of the species farmed in NZ (red, elk and fallow). Unlike antler, which is a bone structure and contains no living tissues, velvet is only cartilage and has a blood supply and nerves which form as a part of the covering skin (Fraser, 2009). This living tissue is covered by a layer of dense but fine hairs, which the name 'velvet' is derived from (Fraser, 2009).

For the transition from velvet to antler to occur, the velvet cartilage is gradually replaced by bone through calcification. When velvet growth concludes, the antler development is complete and the antler is then exposed through the death of the living velvet skin tissue and nerves through the drying up of its blood supply. The remaining dry skin is then rubbed off by the animal (referred to as stripping), which exposes the antler underneath (Fraser, 2009).

The capacity of deer to undertake full organ regeneration is unique among the animal world (Fraser, 2009). "In red deer this shedding and regeneration follows a seasonal pattern closely linked to the events of the sexual cycle and testosterone levels" (Fraser, 2009, p. 4). New velvet growth begins when testosterone levels are low in the spring, and velvet development concludes in the autumn when testosterone levels are rising prior to the rut (Fraser, 2009).

Deer 'velveting' is a process where the antlers are removed when there is maximum soft tissue and minimal calcification of the bony core (typically occurs 55-60 days after growth begins) (Provelvo, 2015). The antlers are carefully cut off and a short portion of each antler is left in place. This remaining short portion naturally hardens into an antler 'button', which is cast off in the same way as a full antler stick in the following spring (Provelvo, 2015).

“Velvet removal benefits the welfare of the stags by reducing the risk of injury from fighting during the mating season” (Provelvo, 2015, p. 11). In NZ the velveting process meets with NZ national legislation, which is managed by the DINZ. Velveting *“can only be carried out in accordance with rigorous mandatory protocols that require a trained operator to use approved procedures. These procedures are designed to ensure the welfare of the stags and it is important to note that pain control during velvet removal is ensured by use of a tourniquet, local anaesthetic and/or general anaesthetic”* (Provelvo, 2015, p. 10).

When a stick of velvet is removed it is labelled immediately with individual, authorised and unique identifications labels, which assist with monitoring systems that ensures traceability and compliance with velveting standards (Provelvo, 2015). *“It is then frozen on farm and subsequently handled and processed as required by the Ministry for Primary Industries (MPI). Processing is subject to inspection of MPI and audits are performed at least every three months depending on the plant’s performance”* (Provelvo, 2015, p. 11).

Three attributes of velvet are considered important by traditional velvet markets. These are: circumference, blood retention and texture. Velvet is commonly sold in a sliced state and variations in the circumference of the slice are perceived differently, based on the idealism that velvet size is related to the health of the animal that it came from, which has a relationship with the potency of the consumed product (Fraser, 2009). Blood retention and texture of a stick of velvet are related to the level of calcification of the velvet stick (Fraser, 2009).

To meet the requirements of the traditional Korean market “the product should be a dull rosy pink in colour tending slightly to a dull brown to indicate high blood retention” (Fraser, 2009, p. 8). There are three main ways that the NZ supply chain ensures the quality of final sliced velvet products. These three factors are the velvet phenotype (genetic merit and environment) of the stag, the growth stage at which it is removed and the way the velvet is processed (particularly during drying) (Fraser, 2009).

Velvet is graded based on its characteristics and then the producers are paid on a weight basis for velvet in each grade. Producers often face a dilemma around the timing of harvest as the same stick of velvet will reduce in quality (calcification), but will increase in quantity (weight) with a longer growth period. DINZ has overcome this dilemma through the creation of specific velvet stick guidelines.

Velvet sticks are graded (for grouping for sale) under nationwide industry recognised guidelines. Sales and grading are based on:

- Individual stick weight (kg).
- Thickness of beam.
- Number of tynes.
- Total length (calcification level indicator).
- Top length (calcification level indicator).
- The presence or absence of damage.

(Fraser, 2009).

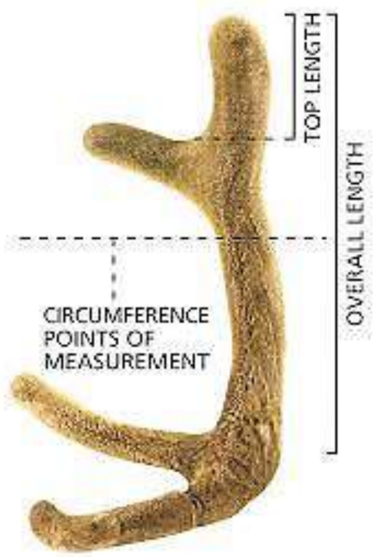

Figure 2: A diagram of velvet grading guidelines as outlined by Deer Industry New Zealand (2015).

The elements that make up the composition of velvet are well defined, but the treatment and methodology of velvet use are not yet proven beyond scientific repute (Fraser, 2009). The lack of peer-reviewed scientific literature on velvet use in medicine and as a health supplement provides limitations to the level of market development of new-generation health supplements.

The components that make up velvet are amino acids, minerals, lipids and water (Fraser, 2009). The relative proportion of the different elements changes during the velvet growth and development process. As a general trend, the ash and mineral levels increase and the moisture content decreases as the velvet or antler matures. A velvet stick is not of uniform composition (Figure 4). Figure 4 shows the differing compositions of the sections of a stick harvested at 55-65 days of growth (Fraser, 2009).

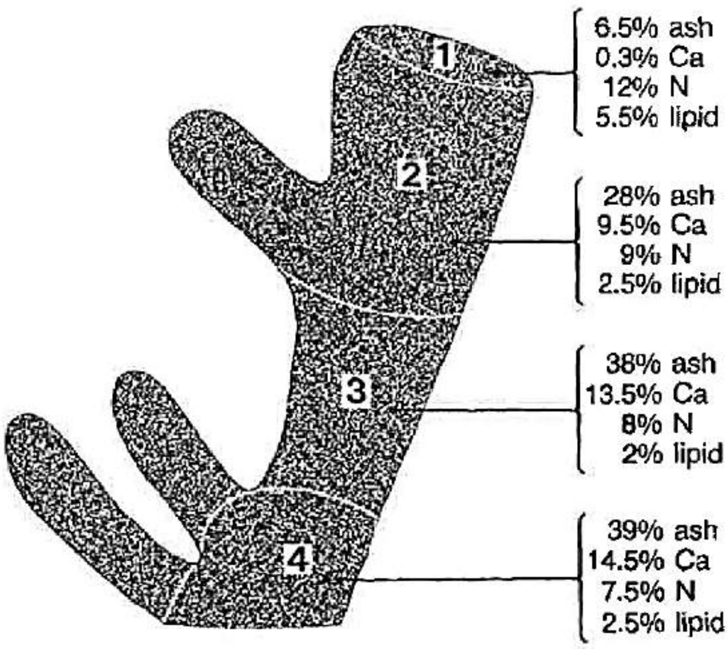

Figure 3: Approximate composition of the 4 sections of a typical NZ red velvet antler (Fraser, 2009).

There are a number of active ingredients within velvet. These “include collagen, glucosamine sulphate, chondroitin sulphate and growth factors that aid in cartilage development” (Fraser, 2009, p. 5). “It is a combination of these that contribute to the activity of velvet products” (Fraser, 2009. p. 5). However as we know there are compositional differences throughout the velvet stick. It can be assumed that there is likely to be differences in the levels of active ingredients throughout the stick as well.

Figure 4: Two velvet sticks harvested from a NZ champion velvet stag in Southland.

7.2 The Velvet Value Chain Opportunity

"Currently the NZ velvet industry relies on supplying a commodity to a small number of markets" (Fraser, 2009, p. 32). Velvet can be supplied in volume as a commodity into four countries worldwide and in these nations "velvet remains in the pharmaceutical channel where it moves from a licensed factory to the medicine doctors to be sold in the traditional sliced form" (Fraser, 2009, p. 32).

The South Korean market is the main market for consumers of NZ velvet products (Fraser, 2009). In Korea, velvet and ginseng are the two main potently active ingredients used in traditional health tonics (Fraser, 2009). In Korea, velvet is distributed in private medicine shops by highly trained Oriental Medicine Doctors who "prescribe velvet in combination with a number of herbs, according to the treatment required" (Fraser, 2009, p. 6).

In South Korea, it is believed that many traders and importers are "taking huge margins on the product but adding very little value to the supply chain" (Fraser, 2009, p 32). Therefore, creating shorter, more integrated value chains should generate more value within the supply chain for velvet producers in NZ (Fraser, 2009).

The balance of NZ's velvet is mostly sold into the Chinese and Taiwanese markets. The Chinese Taipei (Taiwan) market is limited by "a 5 tonne quota restriction on fresh velvet into Taiwan and an import duty of 22.5% (within quota) for fresh and dried velvet" (Deer Industry New Zealand, 2015, p. 1). Trade with China is proving to be problematic even though the China-New Zealand Free Trade Agreement was signed in 2008 (Deer Industry New Zealand, 2015). To enable better transparency and promotion of NZ velvet in the Chinese marketplace, more work is needed by DINZ.

In 2015, a Korea-New Zealand Free Trade Agreement was established. This agreement will mean that the 20% tariffs on processed NZ velvet imports will be eliminated over the next 15 years *(*Deer Industry New Zealand, 2015). The elimination in Korean tariffs will create more opportunities for velvet value chains, but more market gains for producers in the Korean market will be seen in a few years' time when the rate of tariff reduction becomes more significant (Deer Industry New Zealand, 2015).

Before the Korean free-trade agreement, Korean velvet product developers were not investing into creating NZ velvet value chains because they could not be price competitive with NZ velvet products entering Korea through other avenues (Fraser, 2009). Now the opportunities to create new value chains exist because of changes in the Korean velvet consumer profile.

Young Koreans are time poor, but still believe in the attributes of velvet and are requiring new capsule and extract based velvet products for faster consumption (Fraser, 2009). This demand for new-generation oriental medicines is not limited to just Korea, as globally the population is becoming time poor and they are willing to take a holistic approach to health care. This is creating growth in the healthy functional foods industry worldwide and the "potential for velvet consumption in new markets" (Fraser, 2009, p. 7).

High quality ingredients are required to meet the healthy functional food customer requirements of maintaining their brands integrity and reputation for quality within the marketplace. This has previously been achieved by DINZ by utilising new scientific research to establish new markets in western communities (Fraser, 2009).

The findings of the research have shown that these new generation velvet product supplements can have the following effects:

- *Stimulate the body's immune system to assist protection against infection and disease.*
- *Anti-inflammatory agents present may assist in reducing the pain and inflammation of a variety of degenerative diseases.*
- *Provide growth stimulating properties.*
- *The prevention or repair of muscle damage following exercise.*
- *An ability to increase muscular strength and endurance.*

(Fraser, 2009)

Recently, DINZ has successfully been raising the level of awareness of NZ velvet within the Korean Oriental Medicine Doctors market, with NZ velvet being recognised as a premium product, superior to Russian and Chinese velvet (Deer Industry New Zealand, 2015). To maintain this position, DINZ is currently developing a NZ velvet brand story and a product integrity system that will enable consumers to trace its velvet products back to NZ.

The customer demand for high quality velvet ingredients and the current status of NZ free-trade agreements, combined with NZ's capability for high quality velvet processing gives DINZ confidence that NZ based processing will have a competitive advantage within velvet value chains (Deer Industry New Zealand, 2015).

The encouragement of transparent pathways to market by DINZ and the creation of differentiated value chains to consumers, appears to be the best strategic fit for NZ velvet. “Once the optimum channel to market has been established, the continued promotion to position NZ velvet as the best in its class, will encourage maximum value to stakeholders” (Deer Industry New Zealand, 2015, p. 1).

The NZ velvet promotional story is based around the following attributes which give it its competitive advantage. The story outlines that velvet in NZ is produced:

- In a clean, green and free range farming environment.
- Under strict animal welfare controls for removal.
- Under robust quality control systems throughout the supply chain.
- With the absence of disease present in other parts of the world.
- As a safe ingredient for their customers to consume.
- At a consistent quality.

(Deer Industry New Zealand, 2015)

The changing dynamic of NZ’s velvet markets and increased access to Korea has created a number of new opportunities for the NZ velvet industry. DINZ is changing its focus to “marketing NZ velvet to larger healthy food and oriental medicine businesses with strong consumer brands” (Deer Industry New Zealand, 2015, p. 1).

The development of long term value chain relationships with these organisations is a huge opportunity for the NZ velvet industry. These businesses already account for around 20% of NZ velvet production (Deer Industry New Zealand, 2015). The Korean Ginseng Corporation (KGC) is already the largest single customer of NZ velvet and has a successful NZ velvet based children’s health tonic.

Figure 5: A hill country deer farm in Waikato, NZ.

7.3 Profitability of Velvet-Focused Farm Systems

Demand for NZ velvet is increasing worldwide "as a growing number of affluent consumers were looking for health foods containing traditional ingredients like velvet" (Law, 2014, p. 1). In recent years, velvet has been a stable agricultural commodity, with a price rise of 5-10% per year until 2014 since 2008 (Law, 2014). In the 2014/15 velvet season, there was a farm gate price increase of 25% to around $125/kg averaged across all grades (Deer Industry New Zealand, 2015). This is an increase from a farm gate price of just $60/kg six years ago (Law, 2014).

The historic fluctuations of NZ velvet prices make it difficult for accurate predictions to be made on what future price trends might be (Figure 6) (Deer Industry New Zealand, 2014). It is best to be conservative in unstable economic times and looking at global commodity trends it is reasonable to expect that there could be a reduction in the velvet price for this upcoming velvet season.

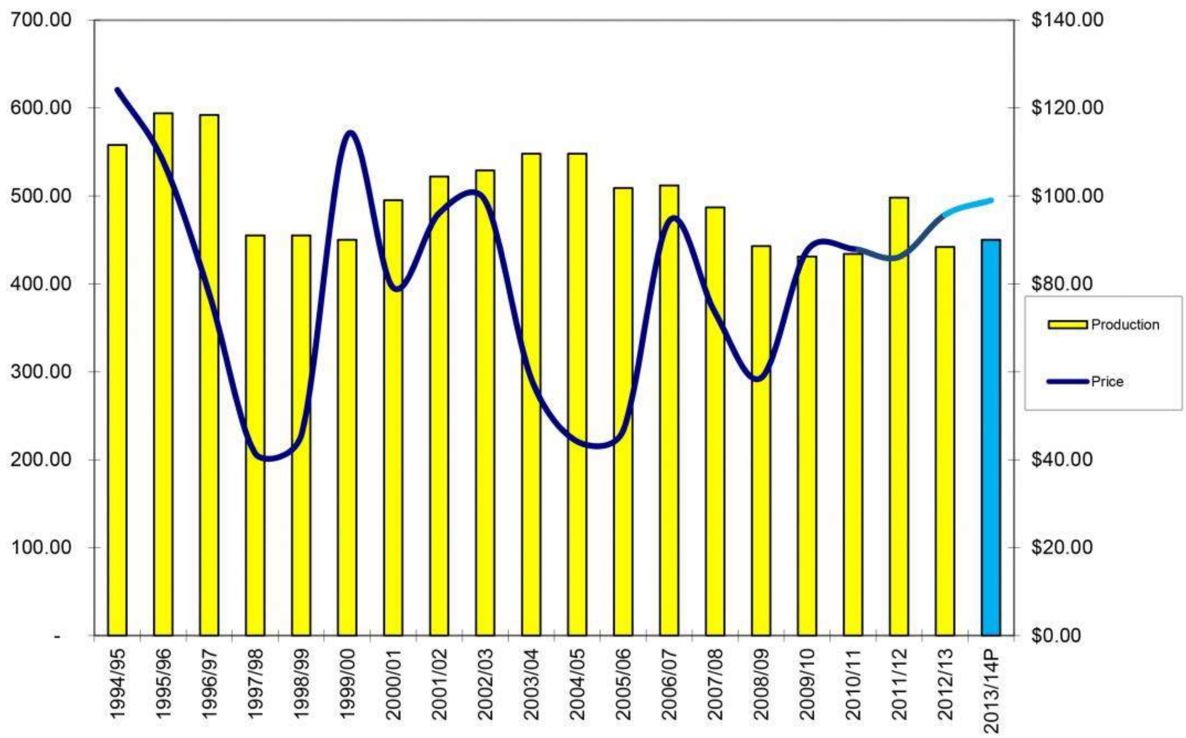

Figure 6: Price and volume trends of NZ velvet from 1994/95 to 2013/14 (Deer Industry New Zealand, 2015).

Feedback from the traditional velvet markets indicates that there is a price ceiling for NZ velvet in the market place. Customers have communicated with DINZ that some product substitution of deer velvet for alternative health products would occur if NZ velvet products are priced above the customer ceiling.

Currently, an average of around 4.0 kg of velvet is removed from each stag in NZ per year, with about 550 tonnes of velvet produced nationally per year (Law, 2014). Velvet is produced by both velvet focused and venison focused farm systems, with the majority coming from the velvet focused farm systems. The stable profitability of velvet is a big confidence boost for velvet producers in NZ, which should lead to reinvestment within the industry and its markets (Deer Industry New Zealand, 2015).

Figure 7: Velvet stags grazing on a hilltop airstrip within the Waikato.

Figure 8: New generation NZ velvet product from Fowler (2015).

7.4 Radio Frequency Identification

“Radio frequency identification (RFID) is a generic term that is used to describe a system that transmits the identity (in the form of a unique serial number) of an object or person wirelessly, using radio waves” (Kaur, Sandhu, Mohan, & Sandhu, 2011, p. 151). RFID can be divided into two groups: active and passive. The main difference between them is their requirement for a power source. Active RFID needs to be either connected to power infrastructure or powered by an integrated battery system, which limits its operational lifetime (Kaur, et al., 2011). This limits the opportunities for active RFID in the livestock industries of NZ. Passive RFID technologies are of significant interest to this study, because they do not require an integrated power source. Passive RFID has an indefinite infinite operational life and can be small enough to fit into an adhesive label.

How does a passive RFID tag operate? “A passive tag consists of three parts: an antenna, a semi-conductor chip attached to the antenna and some form of encapsulation” (Kaur, et al., 2011, p. 152). The tag is read through the use of a reader, which is responsible for powering and communicating with the tag (Kaur, et al., 2011). The tag’s antenna captures the reader’s energy and transfers the tag’s ID. This is a process that the tag’s chip coordinates and the “encapsulation maintains the tag’s integrity by protecting the antenna and chip from environmental conditions” (Kaur, et al., 2011, p. 152).

There three kinds of data transmissions for RFID which are low, high and ultra-high frequencies. They differ in physical capability “based on the behaviour of electromagnetic fields at the frequency used” (Kaur, et al., 2011, p. 153). Low frequency (LF) operates at 125–134 kHz and high frequency (HF) is around 13.56 MHz, but both work through the use of inductive coupling. UHF operates “in frequency bands ranging from 433 MHz, 865–956 MHz and 2.45 GHz) and operates through wave backscattering as the main means of transmission” (Kaur, et al., 2011, p. 153).

The different frequencies change the capabilities of the technology, but an operational failure at a given frequency does not mean that another frequency is not capable of completing the desired task. The “properties of some materials may be an obstacle to RFID application at a given frequency, as they may corrupt data transmission either by absorption or by ambient reflection of the signals” (Kaur, et al., 2011, p. 153). Water and metal are the two main materials that affect the performance of RFID, where “electromagnetic disturbance can be created by external sources, which is a common frequency dependent problem in industrial environments” (Kaur, et al., 2011, p. 153).

The range of RFID operational frequencies creates significant challenges in the creation of international standards for frequency allocation (Kaur, et al., 2011). There is increasing pressure for global frequency standards, but there is still "differences between three regions, forcing companies to employ different tags in several regions or restrict themselves" (Kaur, et al., 2011, p. 153).

Table 1: The applications of RFID which have been outlined by Kaur, et al. (2011).

Use of RFID	Explanation	Examples
Instance or class identification	With the help of a data base, RFID can enable the instantaneous identification of the purpose or class of an item.	NAIT
Location identification	If a given reader is assigned to a known location, it is possible to track the current location of a uniquely identifiable item.	Track and trace within postal services.
Transfer of further data	Auxiliary data can be read or written. Data read from the tag usually contains information which would be impractical or impossible to obtain from a pre-recorded database.	Food products may provide instructions for proper handling.
Asset tracking and finding	Is the most common use of RFID. Companies can put RFID tags on assets that are lost or stolen often, that are underutilised or are just hard to locate at the time they are needed.	Containers within the shipping industry.
Manufacturing	For more than a decade RFID has been used to track parts, work in process, increase throughput and manage the production of different versions of the same product.	Tracking and tracing of inventory.
Supply chain management	Has the ability to be used to automate closed loop supply chains or parts of the supply chain within a company's control.	NZ RFID Pathfinder Group.
Retailing	Making sure product is on the shelf when customers want to buy it. Through the use of integrated supply chains.	Tesco and Wal-Mart
Payment systems	Based on the principle of automated and quick service, in which RFID is linked to a convenient payment system.	Paying for road tolls without stopping.
Security and access control	Used as an electronic key to control who has access to office buildings or areas within office buildings.	RFID cat doors.

Both RFID and bar-code technologies are capable of automating operation processes, reducing labour requirements, eliminating human errors and creating electronic data (Kaur, et al., 2011). These combined abilities of RFID have created a number of applications for the technology.

Compared to bar-code technology RFID has a number of advantages. These advantages are:

- *Identify from a distance.*
- *Simultaneously read multiple tags.*
- *Operate without a direct line of sight (can read through wood and plastic, but not metal).*
- *Operate in more adverse conditions (dust, chemicals, physical damage and temperatures).*
- *Be used to store significant amounts of additional data (additionally to the unique coding identifier).*
- *Be programmed and reprogrammed on the move.*
- *Have additional data attached, stored and read on the move.*
- *Be combined with sensors (capable of measuring environmental factors such as temperature).*
- *Create easy to implement unique individual identifiers.*

(Kaur, Sandhu, Mohan, & Sandhu, 2011).

Table 2: The limitations of RFID which have been outlined by Kaur, et al. (2011).

Weakness	Explanation
Standardisation	Partners need standards for communication protocols, signal modulation types, data transmission rates, data encoding and collision handling algorithms.
Cost	The cost of tags depends on their type, but traditionally RFID has been used for scanning high-value goods over long ranges. However, with time and scale the costs are decreasing.
Collision	Attempting to read several tags at a time may result in signal collision and data loss. This can be prevented by patented anti-collision algorithms, but this is an extra cost.
Frequency	Different frequencies have different capabilities and effects; reading range, spatial selectivity and behaviour under environmental influencers. This requires standardisation.
Faulty detection	Tags can be damaged or influenced by a number of factors that prevent the tag being read by the antenna. Additionally, readers can malfunction and give incorrect results.
Quick technology obsolescence	These technologies are continually evolving. This leads to the creation of new protocol standards and faster and more fault-tolerant readers which outdate their predecessors.
Security and privacy	If it is necessary to prevent unauthorized persons from reading or writing data stored on or transmitted from tags. An encryption must be used and ensured at all interfaces.
Virus Attacks	RFID is used in conjunction to a backend database which is vulnerable to cyber-attacks.

"Extensive engineering efforts are underway to overcome current technical limitations and to build accurate and reliable tag reading systems" (Kaur, et al., 2011, p. 153). It's only a matter of time before the component costs fall low enough to make RFID a more attractive economic proposition.

7.5 Radio Frequency Identification in Livestock

RFID tagging (electronic identification, EID), works through the utilisation of automated electronic scanning technology. NAIT gives the ability to identify individual livestock animals through the scanning of a guaranteed uniquely numbered ear tag chip (Anselmi, Taylor, Good, Hansen, & McHugh, 2012). NAIT legislation requires all deer to be tagged with low frequency (LF) RFID tags. RFID animal tagging "is a means of automatically identifying individual livestock via a unique numbered tag which has the ability to be scanned and recorded onto an external database" (Anselmi, et al., 2012. p. 7).

NAIT tags are passive inductive couplers that remain dormant, but receptive for a longer duration than any animal can possibly live (Anselmi, et al., 2012). NAIT tags contain a transponder which is energised at nine times per second by the electro-magnetic field generated by the reader (Anselmi, et al., 2012). When fully energised NAIT tags transmit their unique number back to the reader, but upon its exit from the energising field, the RFID tag becomes dormant again (Anselmi, et al., 2012).

There are two main types of NAIT compliant tags and they differ in both performance and price (Anselmi, et al., 2012). The two types are HDX and FDX. HDX's superior performance creates some opportunities for the recording and collecting of an animal's productivity information in deer, but FDX is the lower cost option and provides NAIT legislation compliance (Anselmi, et al., 2012).

The LF (134.2 kHz) system is able to operate without a direct line of sight and is able to transmit through living flesh and wood (Anselmi, et al., 2012). This allows the tag to be placed deep into either ear of the animal, for permanent scanners to be capable of reading a tag from either side of the animal and for the tag to remain functional when covered in mud (Anselmi, et al., 2012).

The uniqueness of NAIT tags is achieved this through the utilisation of a unique pre-programmed 16 digit number that cannot be altered and begins with the manufacturer's 3 digit code (Anselmi, et al., 2012). Therefore, these RFID tags "comply with ISO 11784 and ISO 23 11785 standards, ensuring worldwide compatibility between any tags and reader of compliance" (Anselmi, et al., 2012. p. 23).

A drawback of LF tags is that they are not able to hold any extra information. The data gathered on an animal must be held and transferred through an electronic database via a linked reader, rather than through the tag itself. This requires further investment into supporting software technologies that integrate with LF RFID technologies (Anselmi, et al., 2012).

The types of supporting software technologies that are currently available have differing levels of data collection, utilisation and storage. An investment into the appropriate RFID scanning and productivity measurement system create an opportunity to efficiently access large amounts of captured, recorded and analysed individual animal data (Anselmi, et al., 2012).

It has been found that the intensive level of LF RFID technology adoption has the greatest financial benefit as it allowed the RFID technology to be used to its highest potential (Anselmi, et al., 2012). Individual producers should interpret their own advanced technology levels relative to their farm systems, business and skill-base, as an investment into RFID technology which is underutilised will give no return on investment (Anselmi, et al., 2012).

There are a number of benefits, limitations and traps identified beyond the benefits of RFID created by its traceability capability under NAIT. The benefits of the use of RFID technology for deer farmers have been identified by Deer Industry New Zealand & AgResearch, (2011) as:

- Improved efficiency and accuracy of recording productivity measurements.
    - Real-time data-input updates.
    - No paperwork.
    - Easy data transfer from RFID technology to smartphones and computers.

- Improved efficacy and accuracy of animal database updates.
    - No manual recording of groups.
    - Ability to keep accurate records of changes made to animal groupings.
    - Ability to upload individual animal health treatments.

- Easy identification of specific animals.
    - Identification of desired sub-groups within a larger mobs (age, mating, sire groups).
    - Identification of unwanted animals within a large group.
    - Identification of missing animals within a large group.

- Ability to make fast and accurate decisions on individual animals.
    - Automated drafting.
    - Ability to weight and simultaneously drench based on weight-gains.
    - Animal health treatment status.

Some additional skills required by farm managers for the utilisation of RFID technology are outlined by Deer Industry New Zealand & Agresearch (2011) as being:

- How to manage electronic data sets.
  - Naming data sets.
  - Keeping track of mobs.
  - Using integrated software and technologies.
  - Backing up data sets.
  - Software Management.

Some of RFID's limitations have been identified by Deer Industry New Zealand & AgResearch (2011) as being:

- It can add unnecessary complexity to the farm systems business.
- It can move focus away from techniques and concepts that have worked well in the past.
- Its reliance on the technology (it's only as good as how it's set-up).
- The ability of a farm manager to accurately interpret the complexity and variations within the data being collected. Some examples of complexities and variations within the data are:
  - State of the animals being weighed (emptied out vs full-gut animals).
  - Environmental factors.
  - Animal health challenges.
  - Genetic potential.
  - Stocking rate.

There were numerous future benefits that couldn't be quantified during a study by Anselmi, et al., (2012) and Deer Industry New Zealand & AgResearch (2011) because of their methodology. These benefits would increase an adopter's return on investment and would continually evolve within the deer industry (Anselmi, et al., 2012). The inclusion of whole deer product supply chains to on-farm RFID technologies, would create benefits beyond the farm gate and would create additional returns for deer farmers from RFID adoption.

8.0 Methodology

8.1 Method of Data Collection

A case study approach was used as defined by Perry (1998). Interviewees were selected based on their ability to provide the best possible data available (Perry, 1998). Two forms of data were utilised. The main form was semi-structured interviews, where the interviewees were documented through a verbal electronic recordings device and played back for analysis. Participants were contacted by phone or email, and the interviews were conducted in person or by phone at the interviewee's choice of location and time. The other form of data was written documentation and research, which was provided by interviewees to support their views and add additional depth to their opinions.

The interviewees were made up of industry professionals who have specific knowledge and viewpoints on the establishment of RFID technologies, velvet supply chains, the NZ deer industry and velvet-focused deer farming. During the interviews, the interviewees were asked if they were aware of any supporting research or supporting documents on their viewpoints. A number of the interviewees provided guidance to a variety of supporting documents. These documents were read and included within the common theme analysis if they were deemed relevant to this study.

8.2 Selection of Interviewees

The NZ velvet industry is a small industry therefore there were a limited number of cases that are available for interview. The cases selected were identified through cooperation with the DINZ who has dealings with the entities throughout the NZ velvet industry.

DINZ were able to give guidance on and facilitate introductions with a variety of stakeholders within the NZ velvet industry. This allowed for the best available cases to be selected for this study, which would give the best information available.

A total of three velvet production, three velvet marketing, three RFID technical and three DINZ representatives were interviewed, giving a total of 12 interviewees. Interviewees were selected based on their willingness to be open and honest, which is deemed essential by Perry (1998).

8.3 Interview Approach

The interviewees were approached by the interviewer through phone calls, emails and in person, in order to build a level of trust and understanding before the interview. The interviewing technique that was used was a semi-structured interview technique as described by Perry (1998). This technique involves the creation of a list of open ended interview questions, which are based around the projects research questions. A copy of the list has been included in the appendices.

The use of the semi-structured interviewing technique by Perry (1998) allows for the use of follow up questions and the collection of supporting data or documentation. Follow up questions are used to clarify and explore points which were introduced during the interview which are relevant to the study and are used as a guiding technique to direct the conversation towards the identification and discussion of the key questions of this study.

8.4 Analysis of the Data

A thematic analysis technique was used to analyse the data as described by Fereday, (2006). Thematic analysis is “the search for themes that emerge as being important to the description of the phenomenon” (Fereday, 2006, p. 82). It is a form of pattern recognition within the data, where emerging themes become the categories for analysis, which are identified through the careful listening and re-listening of the data. A theme is “a pattern in the information that at minimum describes and organises the possible observations and at maximum interprets aspects of the phenomenon” (Fereday, 2006, p.83).

The data was analysed through the use of a common theme approach, where the data is searched for reoccurring messages within the verbal record (Fereday, 2006). The data was then interpreted and consolidated into key themes (codes). A good code is “one that captures the quantitative richness of the phenomenon” (Fereday, 2006, p. 83).

Due to a lack of time and the nature of this study no transcripts were made of the interviews, but electronic recordings of the data were created under confidentiality. This allows the interviewees to be open and honest during their interviews, while simultaneously validating the study’s findings.

9.0 Findings and Limitations

The eight themes identified in this study will be described, explained and discussed in significant detail within the following sections. These themes are:

1. Ultra-high frequency
2. Traceability
3. Supply chain management
4. Data handling
5. Individualised management
6. Live data analysis
7. Industry data hub
8. Limitations to adoption

Early interviewees provided previous research from unpublished studies on RFID within the NZ deer industry. The vast majority of these studies had been done on with a venison industry focus, but they were revealing and easily adapted to the findings of this study. This provided a strong basis for discussion, but equally demonstrated the potential RFID has to be adapted to other NZ livestock industries.

A RFID extension programme appears to be a significant opportunity for the DINZ, RFID technology industry and NZ velvet industry, as there is a disconnect between RFID technology developers and commercial participants of the NZ velvet industry. There is a limited knowledge of RFID within the velvet industries commercial entities, but when the technological capability of RFID was explained, the opportunities created became instantaneously recognisable.

The vast majority of RFID technologies have not been developed specifically for velvet. This led to limitations in the data due to a lack of choice and selectivity of case studies, as there is a limited amount of RFID technology currently available which is currently deemed to be worthwhile investments by velvet producers.

Another limitation is that the velvet producers interviewed are not representative of the larger population. The velvet producers sample was made up of early adopters and producers at the top end of the bell curve. They were identified as being RFID technology leaders within the population. It was estimated that they would be able to contribute the best data for the study, but is should be recognised that this studies findings are ahead of the curve and are futuristic in nature.

10.0 Discussion

10.1 Ultra-High Frequency Tags

"As soon as we switch from read-only to write-to RFID tags it brings a world of possibilities in terms of traceability and information transfer" –NZ) Velvet Producer. "Ultra-High Frequency (UHF) technology presents our livestock industries with an outstanding opportunity to add significant value addition to the mandatory use of RFID for animal and product traceability" (Deer Industry New Zealand, 2013, p. 1).

UHF flag ear tags perform "single animal operations as effectively as low frequency (LF) RFID tags" (Ministry of Agriculture and Forestry, 2011, p. 4). UHF for agricultural use requires a UHF chip, antennae, tag converters and plastic encapsulation. However, UHF was not accepted as a viable technology for the implementation of NAIT (Pugh, 2013). UHF suffered from a wide-range of tag performance issues and lacked commercial availability in NZ.

LF was chosen for the start-up of NAIT, because it was being used overseas and UHF was an emerging, but unproven technology (Ministry of Agriculture and Forestry, 2011). The key difference between LF and UHF tags is their operating frequencies, which effects their application. LF can read through bodies of water which enables operators to read LF RFID tags through flesh (venison is around 75% water), which allows LF tags to be read when obscured by part of animals body (such as it neck, head or ear). UHF is able to read tags that are moving as a group, at higher speeds and across longer read ranges than LF (Pugh, 2013). UHF is internationally preferred in global supply chain applications and has the ability to revolutionise information sharing within these supply chains through its ability to link with GS-1 systems (Pugh, 2013). UHF is seen as a highly plausible solution to the traceability requirements of velvet value chains (Deer Industry New Zealand, 2013).

In addition to tag-orientation, there are a number of factors that can affect the percentage of successful tags reads of both LF and UHF. The percentage of successful UHF tags reads is impacted by:

- The deer handling facilities used.
- The antenna set-up (stationary readers).
- The orientation of the tag to the reader (especially for hand-held).
- The speed at which the deer is travelling.

Commercial tag manufacturers have responded to their exclusion from NAIT by creating new UHF animal tag designs which were self-described as 'ready for use' in NZ (Pugh, 2013). A study by Pugh (2013) investigated whether UHF ear tags meet NAIT standards for readability in deer and sheep.

Table 3: The performance of UHF tags on moving deer.

UHF Tag Performance on Moving Deer						
Test Session	1	2	2	3	3	4
Tag	A2	A2	C3	D2	C4	C4
Type	Button	Button	Button	Button	Flag	Flag
% of tags that read every time (100%)	39%	100%	N/R	100%	40%	79%
Average Readability	69%	100%	85%	100%	79%	84%

Source: Pugh (2013). *NB. N/R in the table above means not recorded.*

Table 4: The performance of UHF tags on stationary deer.

UHF Tag Performance on Stationary Deer						
Test Session	1	2	2	3	3	4
Tag	A2	A2	C3	D2	C4	C4
Type	Button	Button	Button	Button	Flag	Flag
Readability	100%	100%	92%	100%	55%	100%

Source: Pugh (2013).

Tables 3 and 4 demonstrate that in the right scenarios UHF tags can show a reliability rate of 100% (especially when animals are stationary). However, tag performances vary across different tag designs and form factors as shown by the results in Tables 3 and 4 (Pugh, 2013).

Both hand-held and stationary readers were tested and deemed successful (Pugh, 2013). Handheld readers had reading rates between 75% within large pens ($25m^2$) and 100% in smaller pens ($5\ m^2$) (Pugh, 2013). With a reading distance of 0.5–1.5 m regardless of pen size, an operator can achieve 20–40 reads per second provided that tags are in range and physically visible (Pugh, 2013).

UHF tags were priced in 2013 at 5-7 cents per chip (based on a 1 million chip order) and $0.80-1.00 to encapsulate generic tags, with unique identification code (a NAIT compliance requirement) UHF tags being $3.80-4.50 per tag (retail) (Deer Industry New Zealand, 2013). This is competitive with the NAIT tags currently on offer, which are priced at $5 per tag (NAIT LTD, 2015).

UHF tag performance will further improve through industry adoption and feedback to manufacturers from users, but UHF tags was deemed already adequate for NAIT by Pugh (2013), provided that quality standards were created and enforced. However, a lack of deer industry knowledge on UHF hardware setups and animal handling systems is the biggest limiting factors for UHF adoption by the velvet industry (assuming NAIT acceptance of UHF tag technology).

It was recommended in the study by Pugh (2013) that further research and development was needed for UHF technology as it continues to develop. Areas of particular importance are: quiet tags (does not work due to interference or damage), unintended tags (not the operator's target) and antenna configurations, as both flat and button style UHF tag designs have improved over time (Pugh, 2013).

Pugh (2013) deemed that some of the commercially available UHF tag designs currently on offer should be acceptable for NAIT use. However, "NAIT has no mandate for research or development for innovation development but it can support and approve technology that meets specifications and can be implemented without adding significant costs" (Deer Industry New Zealand, 2013, p. 1). Therefore, the emphasis is placed on the NZ velvet industry and DINZ to research and develop a strong case to lobby NAIT for the acceptance of UHF as a viable option for compliance.

Figure 9: UHF RFID tag technology from Swedberg (2015).

10.2 Opportunities with UHF

"Research in NZ has demonstrated the potential for UHF tags to be useful for identifying animals" (Ministry of Agriculture and Forestry, 2011, p. 3), but more research is needed "to fill in gaps before the systems can be reliably implemented across the livestock production chain" (Ministry of Agriculture and Forestry, 2011, p. 3).

"Modifying existing animal recording software designed for use with low frequency (LF) devices to work with UHF systems is straightforward" (Ministry of Agriculture and Forestry, 2011, p 6). The adoption of UHF by NAIT depends on the costs and benefits of using UHF systems, but this must be assessed on a case by case basis, as it depends on:

- The type of animal being traced (e.g. speed of movement, behaviour and size).
- The purpose and practicalities of tracing (on-farm only versus throughout the production chain including sale-yards and processing facilities).

(Ministry of Agriculture and Forestry, 2011)

For cattle, LF's capability to read through water is essential, as cattle often place their head down between other animals during movement, whilst deer behave very differently. Velvet stags naturally walk with their heads upwards to identify danger and protect their velvet from painful damage. This limits the need for LF's capability to read through flesh (water) and creates an opportunity for the use of UHF ear tags in deer farming.

Deer farming is not easy and it's no secret that deer have particular and sometimes challenging animal husbandry requirements, particularly in terms of handling deer, the speed of their movement and mob behaviour (Deer Industry New Zealand, 2013). One of the fundamental animal handling principles of deer husbandry is that deer strongly dislike being separated individually from a group. Separation is a very stressful environment for deer and should be minimised wherever possible within deer farming.

This creates difficulty when introducing automated LF systems into deer husbandry. Deer do not conform to being stationary in race-ways and do not line-up in single file for imminent handling. This animal management technique is the basis of most automated LF livestock handling systems, but due to their nature has very limited applications in deer farming systems.

UHF offers a solution to a number of the challenges and limitations that exist with the use of LF RFID technologies within deer. It allows the creation of new animal management systems, which utilise UHF ability to create more efficient (faster) stock movement systems and to complete tasks that are currently unpractical or impossible.

With UHF "animals do not need to be separated at the time of capture" (Deer Industry New Zealand, 2013, p. 2). Deer can continually move past the scanner multiple animals deep, which eliminates the need for a single file line-up and the physical separation of animals. This would substantially reduce tag reading time by handheld RFID scanning technology, as the majority of deer strongly dislike having objects in the area surrounding their head (necessary with LF) and move to evade the object.

UHF enables the reading of fast moving deer (UHF tags) at up to 7m (advanced technology) and 1.8m (standard technology), which is not possible with LF technology. Examples of ways that deer farmers could utilise UHF include, identifying anxious deer that cause environmental damage by running fence lines and automating the counting of deer through gate-ways which would allow farmers to provide proof of clean musters for tuberculosis testing compliance requirements, whilst also increasing animal movement efficiency.

Operator safety during deer handling will be increased through the longer reading range and the permanent reader capabilities of UHF by reducing the stress deer are under. Deer are prone to stress if they are over handled or mismanaged and they still retain a number of their wild behaviours including an anxious nature and a group-based flight response. By increasing the proximity of the person to the animal and reducing the time that the animal is in the stressful environment it creates a safer situation for both the animal and the operator.

Reducing the stress placed on deer reduces the likelihood of a flight or fight response. Reducing the risk of a stressed animal inflicting damage or harm on itself, other deer, the equipment and operators is beneficial, which is a particularly crucial in velvet-focused farm systems where operators work with mature male deer, which are prone to being both aggressive and dangerous.

UHF is capable of 'write to tags' which means the tag is capable of uploading, downloading and storing data. This is a capability which NAIT currently prohibits, but is a capability which is "an ideal conveyance for formal passport data" (Deer Industry New Zealand, 2013, p. 3). The identity, TB status, date of birth and pedigree of an animal could be uploaded onto an animal's tag. This information could then be transferred and downloaded automatically, which would reduce the risk of human error, incompetence and internet connectivity issues from the transfer of data between entities during animal movements between farming entities.

This capability also allows entities to share information vertically along the supply chain, through UHF's ability to collect and share information at multiple points by multiple users. UHF animal and velvet tags could allow producers to download and upload data from the stag to a stick of velvet during velveting. This could allow automated electronic information created on farm to be shared with velvet marketers, customers and consumers. However, automated electronic information could also be supplied back down the supply chain, allowing feedback on the performance of specific velvet products passed along the supply chain based on the uploaded data provided by the producer.

This ability to seamlessly integrate on farm activities and collect electronic on farm performance data would offer new insights into on-farm productivity and profitability for operators. It would reduce the paperwork and human resource requirements for compliance and product auditing. Particularly for activities that are of interest to the supply chain, such as animal drug treatments.

A further-off opportunity of UHF is its GPS capability. GPS technology would give velvet producers the ability to identify individual animals who express both unwanted behaviours (such as nervousness, breaking through fences and excessive wallowing) and desirable behaviours (such as easy stock movement and good temperament).

The Global Positioning System (GPS) capability of UHF was seen by a number of velvet producers as a highly beneficial futuristic technological opportunity for improved management of deer. In particular, looking at the management of desired or undesired behaviours and finding lost animals. RFID GPS is not currently financially feasible according to DINZ (2013), but as UHF technology continues to develop and more benefits are found for GPS technology this may change.

Figure 10: A group of velvet sires in full antler at a deer stud in Southland.

10.3 Traceability

Traditionally "NZ deer velvet has been a highly valued, low volume product that is difficult to differentiate in the market" (GS1, 2015, p. 1). Ongoing efforts by DINZ to differentiate NZ velvet from its competitors as a premium food ingredient have succeeded and NZ has become the premium priced product in the market place. This creates motivation for product counterfeit and opportunistic behaviour in the market place and a requirement for an authenticity guarantee of 'country of origin' for NZ velvet (traceability).

Traceability is "the ability to trace the history, application or location of an item (e.g. deer velvet) that is under consideration in a supply chain" (GS1, 2015, p. 4). The NZ velvet industry has historically invested into quality assurance (QA) by continually improving both medical and food product supply chain protocols through QA programmes and relevant grading standards (GS1, 2015). Product integrity is a key focus of DINZ and is essential for supplying the healthy functional food market (GS1, 2015).

The current DINZ product integrity system requires the declaration of deer health and velvet food safety standards by NZ velvet producers. This is done using a Velvet Status Declaration (VSD) form, which was implemented in 2014. The VSD added to existing traceability requirements for producers under the National Animal Identification and Traceability Scheme (NAIT), Velvet Antler Identification Programme and Origin Verification Programme. Most of these traditional velvet QA systems are based on manual data systems. These are tedious, error prone and exposed to the risk of accidental misinformation or the criminal act of document forgery.

Velvet value chains are very different in regards to the level of traceability they require. Many of the interviewees involved in velvet marketing recognised RFID as the most promising potential technology for traceability currently and see an increasingly strong demand for its future use. RFID's traceability abilities give a guarantee of the integrity of NZ velvet products. This will be a necessity in order to meet the stringent focus of protecting their brand and products reputation in these velvet value chains.

Full supply chain traceability is needed to provide customers with adequate assurances. RFID mitigates "counterfeiting and falsification problems by enabling the unique identification of each container, pallet, case and item manufactured" (GS1, 2015, p. 2).

Through the use of RFID, traceability and authenticity can be created by the use of a unique identification code (which is allocated to individual items, which is more economic than isotopic signature tests. RFID provides the ability to automatically track an items movement through the entire supply chain and share this information with velvet customers in a shared data-base. This system allows marketers to guarantee their product as authentic NZ velvet, which significantly reduces the risk of substitution with other non-premium velvet and brand plagiarism.

An industry wide adoption of RFID velvet tags would create a national risk management strategy for faulty velvet products. QA is created by RFID's ability to find, identify and recall product from the supply chain in an efficient and cost effective manner. For example, TB is still seen as a threat to the reputation of some velvet value chain customers of the NZ velvet industry. RFID would make the temporary recall of velvet (from a false-positive or positive reaction to a TB test) a much simpler, efficient and accurate process.

Figure 11: A RFID sticker being peeled off a roll from Produmex (2015).

10.4 Supply Chain Management

Seamless RFID scanning systems can increase supply chain efficiency by reducing duplication, inefficiencies and additional costs created by governments and businesses (GS1, 2015). RFID can overcome the limitations of manual recordings that expose entities to increases in data errors, data inaccuracies, data inefficiencies and choke points during product transfer. The utilisation of RFID and global data standards, creates the opportunity for entities to "minimise or eliminate re-keying or re-submission of trade data at multiple points across the supply chain" (GS1, 2015, p. 2).

This can be achieved by using standards-based information generated by activity of RFID traced products within supply chains a "reduction in compliance and transaction costs, which results in increased efficiency within supply chains" (GS1, 2015, p. 2). The creation of global RFID data standards would enable NZ velvet marketers to submit their product to e-commerce data tracking, which would allow them to identify and track their products for official purposes.

"Steps are being taken both internationally and regionally to harmonise data requirements by cross-border regulatory agencies and to streamline Government-to-Government (G2G) and Government-to-Business (G2B) communications about trade in goods" (GS1, 2015, p. 2). It would result "in better risk management and targeting of goods for inspection at the border (for biosecurity, proliferation security, intellectual property enforcement and management of environmental risks)" (GS1, 2015, p. 2).

A recent trial was conducted by GS1 (2015) which "provided comprehensive visibility into the what, why, where and when of two stick of velvet as they moved through the supply chain" (GS1, 2015, p. 2). It tracked "the unique identification of an animal on farm, to delivery of cartons of deer velvet to the customer in Seoul South Korea" (GS1, 2015, p. 5). "The GS1 identification (GTIN and GLN) and network (EPCIS) standards were used to identify the what, why, where and when details of the items as they moved through the 15 node supply chain" (GS1, 2015, p. 5).

The purpose of the trial was to identify where documents and information could be shared to improve the movement of products in the supply chain. To test the RFID technology, the event information was recorded (manually) and compared to the electronic data collected (GS1, 2015). Its results are as follows:

Farm to processor within New Zealand

Each animal and 'stick' of velvet was assigned a Global Trade Item Number (GTIN) and each farm was assigned a Global Location Number (GLN) based on where the event occurred. This created *"a unique identification of each animal and stick, and established an association between the two as well as the farm it came from"* (GS1, 2015, p. 5).

Processing within New Zealand

In preparation for export to South Korea, the GTIN of each stick was recorded and *"each of the two cartons (logistics units) were assigned a unique identifier, which was encoded into a RFID tag" (*GS1, 2015, p. 5*). During the packing process, "an association made with the carton"* (GS1, 2015, p. 5). This then had a 'fictitious' shipping document uploaded into the system and all event information was uploaded to the Electronic Product Code Information Service (EPCIS) (GS1, 2015).

Export, transport and shipping from New Zealand to South Korea

When the cartons left for export *"each carton and the GLN of the event location were captured" (*GS1, 2015, p. 6). The GLN of the event location was recorded as was each carton upon arrival into the transporters facilities. This established an event between them and was replicated. This process was replicated as the cartons were transported through the logistics of the export carrier's (airline) cargo system in a different city (GS1, 2015).

Customs and FDA Clearance within South Korea

When the Korean Customs Service and the Korea Food and Drug Administration (KFDA) had concluded inspections and clearance procedures at Incheon International Airport (Seoul) the cartons became available for collection. At this point *"the cartons RFID tags were read using hand held RFID readers and the data recorded in the EPCIS" (*GS1, 2015, p. 6).

Delivery of cartons within South Korea

Following this the final stage within the supply chain was when the cartons were received *"into the customers warehouse where the RFID encoded identifier tags from each carton were captured using RFID hand held readers, its data was recorded in the EPCIS" (*GS1, 2015, p. 6).

The trial "identified the items, legal entities and physical locations using an integrated and interoperable combination of global data and network standards" *(*GS1, 2015, p. 6). It "provided comprehensive visibility into the what, why, where and when of an item as it moved through the supply chain" *(*GS1, 2015, p. 6).

RFID is an "efficient, accurate and robust solution for traceability, provenance and product authentication" *(*GS1, 2015, p. 6). The supply chain visibility and electronic information sharing "provides an efficient, accurate and robust solution for traceability, provenance and product authentication outcomes unlikely achieved using proprietary data standards and infrastructure" (GS1, 2015, p. 10). It is "an effective tool for traceability and product authentication within the food and food product sectors" (GS1, 2015, p. 10).

RFID provides "an efficient and often cost-effective solution to counterfeiting and falsification problems by enabling the unique identification of each container, pallet, case and item manufactured shipped and sold" (GS1, 2015, p. 10). However, it should be used "in conjunction with global data standards and specifically the GTIN, GLN and Electronic Product Code (EPC) network standards (specifically the EPCIS)" (GS1, 2015, p. 2).

"EPCIS is now widely recognised as the de-facto method to share track and trace information and is widely used internationally" (GS1, 2015, p. 2). The key component of EPCIS is its event reporting function where "all parties who exchange EPCIS event data have a common understanding of the meaning of that data" (GS1, 2015, p. 2) and the ability of its design to provide the virtual 'attachment' of documents. This allows "more convenience, faster access to documents, faster shipment alerts and pre-clearance options for regulatory agencies" (GS1, 2015, p. 2).

The costs of RFID adoption was not seen as significantly prohibitive for potential adopters. There seems little doubt that adopters should be able to realised real quantifiable benefits if a standards-based approach were adopted and implemented by velvet supply chain partners. The use of RFID and barcodes would create new insights into the entire supply chains transport and logistics. The data collected would give new beneficial insights into the supply chain which were previously known and created an opportunity to improve its efficiency.

From a traceability standpoint there appears to be real merit in the utilisation of RFID technology within supply chain management. RFID provides the level of clarity and data collection which meets with the traceability needs of the NZ velvet industry. However, there is little motivation for government agencies (particularly in Korea) to adopt the technology systems needed to utilise RFID technology for supply chain management effectively.

10.5 Data Handling

Data handling is the biggest on-farm benefit for velvet producers. Being able to quickly, efficiently and accurately, assign and record data on both the quality and quantity of an individual animal's velvet animal is valuable for producers. The main benefit of data handing is a reduction in human error. Human error is 'an error that is typical of humans rather than machines' (Collins Dictionary, 2015).

A human's ability "to catch or avoid errors within data sets is inherently flawed" (Barchard, Pace, & Burns, 2009, p. 1). However, to reduce human error to practically zero, a single combined database that requires no replication or transfer of data is needed. Removing the human element to data transfer, removes the risk of direct or indirect consequences from data errors. Data errors have both negative direct and indirect consequences. Direct consequences within velvet-focused deer farm systems can be seen in the impact of inaccuracy of velvet weight data being further analysed on-farm.

Human error rates in manual data entries average between 1% and 5%, depending on the required complexity of the task and the environment that the person is operating within (Smith, 2005). However, within the NZ venison industry by Anselmi, Taylor, Good, Hansen, & McHugh (2012) utilised a 4% error rate for deer farmers. Therefore, direct errors lead to 4% (estimated from Anselmi, et al., (2012)) of velvet data recording being a mistake.

Indirect consequences are then created by the further use of the imperfect data. Every time the data errors are used we create another data error. To understand the scale of indirect data errors, you must multiply the original error rate by the number of times that the data has been transferred and transformed without correction.

Farmers manually weighing and recording the 550 Mt per year of velvet sticks produced in NZ, (assuming 2.0 kg per velvet stick and a 4% error rate), leads to around 11,000 direct velvet weight data errors per year. The recording of the animal tag number, DINZ number and the grading with the sticks of velvet, makes a total of 44,000 direct errors per annum, or 440,000 direct errors per 10 years.

This does not include the indirect consequences that are created through the further use of the data errors. Indirect consequences include misinformed farm management decisions, such as incorrect animal culling and breeding decisions. Decisions that have lasting and significant consequences make the accurate recording of data within velvet-focused systems "*a really important job" – NZ Velvet Producer*.

RFID reduces the human resources needed for data recording. Where manual data recording and transfer on a large scale is occurring, manual data transfer leads to a tremendous amount of wasted time relative to the cost of the required replacement technology and information systems. “Time that could be spent with friends and family creating moments are priceless” NZ Velvet Producer.

From a commercial standpoint it can be attempted through the explanation of the main costs that are often overlooked in managing human-error. These costs are brand reputation, human resources and incorrect management decisions (Ungerboeck Software Limited, 2014). The following table attempts to explain the five main costs that are created by data entry mistakes.

Table 5: The main data error costs from Ungerboeck Software Limited (2014)

Cost	Explanation
Quality Control	The costs of quality control systems and human resources in detecting and correcting errors throughout the entire supply chain.
Downstream	The costs incurred beyond the initial data collection point. Where data is passed on for other uses, but mistakes are not found or corrected and affects the end data user.
Uncaught	The costs incurred in remediation steps once an end data user is affected by data errors.
Soft	These costs are hard to quantify and not immediately evident, but are incurred due to back-office errors. Soft costs may include: lost revenue due to low customer satisfaction.
Billing	These costs are incurred when smaller items or changes in orders are not reflected in the final billing. Creating lost revenue due to oversight from multiple complex data entries.

It is possible to measure data entry level at a business level. However, no reliable data is available at this stage on the time saving that will be created through the utilisation of RFID within velvet-focused farm systems or velvet supply chains. To look at time savings a business should account for the savings created by reducing the human resources used in entering and re-entering data into their systems.

Investments in technology such as a single database system would give staff, customers and suppliers, the ability to enter new information (either manually or electronically) just once and have it available to all parties in real time. This creates unique opportunities for integration horizontally between velvet producers (benchmarking) and vertically within velvet value chains (integration). This further increases the level of personal satisfaction for participants within the velvet value chain, as there would be a reduced amount of time where individuals would be required to undertake data transfer activities.

10.6 Individualised Management

Within smaller or intensive farming operations an animal or a stick of velvet can be treated as an individual through manual methods. On a small scale producers are able to spend time ensuring that each animal is given its correct treatment, but on a large scale this is not practical. On a larger scale individual animals are traditionally treated with the average required for the group and little distinction is made between the requirements of top and bottom performers within the larger group.

The use of RFID in deer and velvet value chains gives rise to a host of techniques and technologies, which revolve around the ability of RFID to enable the treatment of an object as an individual. This is achieved through the scanning of an RFID tag and the utilisation of preprogramed software databases, which can be linked to supporting hardware systems (automation). RFID is critical to this system as it creates an individualised electronic link between an object and supporting software system.

RFID technology can automate and complete tasks which are very beneficial to on-farm productivity and profitability, but are seen as too tedious and difficult to be worthwhile. An example of this is the capturing and recording of live weights of velvet stags through an automatic RFID based velveting crush weigh system. Where no extra work is added, but more beneficial individual animal data is captured.

Velvet producers identified that their biggest current benefit was time savings during drafting. RFID supporting software allows animals to be pre-loaded into drafting mobs, which can then be loaded onto supporting hardware. This enables the quick and efficient identification of an animal’s subgroup.

The most recognised on-farm opportunities were the ability to identify and analyse animals into pre-determined age, gender and genetic groups and to tailor an individual animal’s access to an area or supplement ration. Specific examples that were given were: the ability for a sire stag to receive a specified ration within a larger mob of deer and to judge the velvet performance of a sire stag’s sons.

Traceability, automation and marketing were identified as the opportunities created through the identifying and managing an individual velvet sticks within supply chains. The opportunities created by RFID velvet tags for traceability have been previously discussed, so the following will concentrate on the automation and marketing opportunities of RFID.

RFID would allow marketers to give detailed feedback and payment to producers on each specific stick of velvet, which would allow producers to associate the feedback and payment with a specific stag. RFID velvet tag adoption creates the opportunity to automate the assessment of velvet within the supply chain. Velvet weighing and grading could be automated through velvet RFID tags and the development or adoption of hardware and software. This would create electronic data, which can be automatically compiled, processed and sent to the appropriate velvet customers and producers.

Through the use of on-farm weighing methodology, it already feasible to semi-automate the weighing of individual velvet sticks. The physical act of velvet grading is difficult to automate, but the utilisation of UHF allows for the grade of a velvet stick to be automatically recorded. Velvet sticks (UHF tags) of a certain grade can be placed together in a container. A velvet sticks grade can be automatically recorded by entering the containers grade and moving the container past a UHF scanner.

Velvet science is currently limited, which makes the opportunities for RFID based quality-based marketing limited. The definition of velvet quality within a grade is a topic of contention. One velvet marketer asked ‘what is a good velvet stick’? The subjective nature of velvet stick quality limits the potential of RFID creating commercial gains. Outside of the country of origin (traceability), there are few true market signals in the wider velvet industry that indicate demand for individual stick quality assessment beyond bulk grading.

The healthy functional food market will develop and the quality vs. quantity scenario will evolve and change. Customers within velvet value chains “have a very scientific approach when it comes to velvet quality” – *NZ Velvet Marketer*. NZ velvet marketers have recognised that continual hardware technology development and the added industry knowledge (research) should lead to change.

If it becomes viable to judge the content of high value components (such as jelly tip) within an individual stick of an individual stick of velvet then more research on what is velvet quality (including how it can be measured) becomes available. The variety of velvet sticks within each grade will need to be recognised and RFID’s abilities will become a valuable tool for velvet marketers of sufficient scale.

10.7 Live Data Analysis

Innovation has led to the creation of sensor based RFID tags which are able to monitor movement, temperature, humidity and other environmental sensitivity measurements (Hartley, 2013). RFID has the capability to capture and provide an operator with real time data through integration with connectivity technologies. There are now opportunities to gain insights that were previously unpractical on a commercial scale in both the supply chain and on-farm environments.

RFID creates a link between an object that has been identified and its associated electronic data. Data that is stored is made available by support software and hardware. This enables the use of live data analysis, which reduces or eliminates the need for decision making time, which reduces the time deer have to be contained within potentially stressful environments.

With RFID software, operators have the opportunity to make decisions within minutes based on an animal's entire lifetime worth of data including; velvet quality, velvet quantity, pedigree, offspring, genetically related animals and liveweight. This enables commercial farmers to become more like stud farmers, where they are able to gain better insights into their velvet genetics.

UHF RFID velvet tags would enable the inventory of velvet sticks loaded out for sale. This would allow entities to automatically audit electronic sales receipts against their own data and identify any mistakes. Sellers could audit the sticks that arrive compared to the number of sticks loaded in near real time, enabling sellers to identify missing or stolen velvet before the sale concludes.

Live data analysis and adequate connectivity (mobile internet) enables traceability and supply chain management. Through the use of a shared data-base a velvet farmer or DINZ representative would be able to quickly and accurately identify the positioning of an animal's velvet stick within the supply chain and contact and notify the correct entities of the need for a product recall.

Representatives could send the RFID code of the specific product that was being recalled, allowing it to be readily found, identified and removed without assistance. The specific RFID code could be uploaded into a scanner that was capable of recognising the specific tag code of the product in need of identification. This form of RFID technology enables efficient identification of the product in question and is being commercially developed as a tool for simplistic tasks such as finding valuables (keys, wallet etc.) around the home.

This is significantly different to the current system used by many velvet marketers. One interviewee stated that "*a product recall (from further along the supply chain) would be a nightmare" – NZ Velvet Marketer*. The products removal could then be easily confirmed through the use of RFID technology, which reduces both the risk and cost of product recalls

Figure 12: A velvet farm in the Hawke's Bay during late winter.

Figure 13: Hinds with fawns at foot running back into drought effected hills of the Waikato.

10.8 Industry Good Data Hub

The ability to compile electronic data is fast becoming a reality with on farm electronic data capture and sharing through new cellular, broadband and satellite technologies. The opportunity exists for NZ velvet industry participants to connect and create big data, which are data sets that are so large or complex that traditional data processing applications are inadequate. Big data collection would be powerful for the industry as it would enable information storage, transfer and analysis of industry and individual opportunities or issues.

Big data could be utilised by benchmarking software to automatically analyse and benchmark the productivity of NZ velvet producers compared with their peers. Producers could quickly evaluate themselves relative to industry wide productivity measurements and relationships. This would provide rural lenders with financial benchmarks and enable more informed decisions to be made on lending to deer farmers, which has the potential for easier access to capital for aspiring velvet producers.

A data hub would enable producers to upload velvet stick RFID – stag RFID relationships. This enables:

- Stolen velvet to be identified through:
    - A lack of existing stags
    - A lack of RFID velvet tags
    - Stolen RFID velvet tags
- Details of a velvet stick to be assigned to a stag at a later time and by another entity.
    - Velvet weighing
    - Velvet grading
    - Velvet value
- The industry to automate the generation of velvet breeding values (BV's).
    - Requires the pedigrees of animals to be uploaded
    - Requires software capable of automating the process
    - Simplifies progeny testing
    - Simplifies environmental variation testing

However, these opportunities rely on accurate and precise information being collected and uploaded as raw data or information. This will require the use of technologies of adequate quality which can communicate effectively (quick and simple for farmers) with the data hub.

The data hub could be used to openly share data (information) between entities within velvet value chains. This would create closer (value based) relationships between entities and would enable:

- DINZ to automatically audit product movement.
    - Traceability
    - Market analysis
- Customers and consumers to give feedback to marketers and producers.
    - Quality
    - Performance
- Producers to pass on farm insights to customers, consumer and marketers.
    - Provenance
    - Legislative compliance
    - Marketing
- Marketers to update customers and producers on product movement in the supply chain.
    - Quality assurance
    - Supply chain efficiency
    - Timing of payments

However, this requires technology cohesion between entities in the velvet value chains. The manufacturers of equipment will be required to make systems that cooperate and communicate so that information can be freely uploaded and downloaded successfully to an industry good data hub.

Figure 14: A hill country venison breeding unit in Otago during winter.

10.9 Limitations to Adoption

The biggest limitation to the adoption of RFID technology by the NZ velvet industry currently is that UHF RFID has not been deemed an acceptable alternative to low frequency (LF) RFID for regulatory purposes by NAIT.

The biggest physical limitation to adoption of RFID is that the majority of its current hardware and software supporting technologies were not designed for the velvet industry. These have to be adapted to suit and are not readily customised for the industries specific purposes. The process of adaption takes time and investment, but due to the small scale of the NZ velvet industry resources are limited.

This has created a lag in adoption compared to other larger and better recognised NZ livestock industries. Current RFID support technologies need to meet the velvet industries demands of today. User friendliness or functionality was the key decision maker on whether to adopt a RFID based technology. *"If it was going to be hard, I would have gone back to the old way" - NZ Velvet Producer.* This was recognised before price and was the main trait of comparison when assessing the RFID technologies available.

Velvet producers are innovative by nature, but the average age demographic of 55.8 years old, means many velvet producers are not engaged with electronic technologies and are risk adverse towards investment in non-physical assets. This is compounded by a lack of extension. This was demonstrated when producers became engaged and excited when the opportunities of RFID were explained to them. This could be partly explained by a lack of younger influencers in the decision making process.

Extension appears to be essential to the successful uptake of RFID technologies by the NZ velvet industry. It is well recognised in the literature that farmers trust and engage in extension programmes where information provided by trusted peers and is based on unbiased trailing. This is true for velvet producers and multiples interviewees eluded to witnessing peers in action prior to adoption.

The theory of partial technology adoption or the adoption of new technology systems in stages as a strategy for risk management was evident. Many had chosen or were planning to initially adopt less costly forms of RFID technology prior to investing in more expensive and beneficial alternatives.

One interviewee outlined that producers do not adopt until they start conceptualising the risk vs reward for themselves, *"after-all you don't know what you don't know, and seeing is believing" – Velvet Producer*. Therefore, *"things that are at the cutting edge can often just be ahead of their time. Meaning that they are not a bad idea, but that the industry is not yet ready for them" – NZ Velvet Marketer.*

Another limitation to adoption is that the traditional NZ velvet market environment, particularly in Korean does not correspond with the utilisation of consumer interaction. Some interviewees were concerned about the consequences of allowing information to be automatically passed along the supply chain. They identified that consumers finding out the products are from NZ could have potentially negative consequences, as "*Korean people like Korean things: first, second and third" – NZ Velvet Marketer*.

The NZ velvet industry's history and culture of arm's length transactions and opportunism has created an environment where NZ velvet marketers are very risk adverse to investment into technologies which do not create immediate financial reward. A number of the marketers saw very limited opportunities for immediate financial reward from RFID adoption outside of product management and traceability within velvet value chains.

This proves the adoption framework previously outlined aligns with the NZ velvet industry and its RFID based adoption. It appears that adoption of RFID will be driven by information sharing (extension) and time for adopter familiarisation, as much as the feasibility and capability of the RFID technology itself. A lack of good information and adequate time appears to be limiting the adoption of RFID technologies.

Figure 15: A laneway entrance to a velvet focused deer farm in the Waikato.

11.0 Conclusions

It was concluded that there are opportunities for RFID technology within velvet-focused farm systems. Seven main opportunities were identified from the adoption of RFID technology by the NZ velvet industry. All seven of these opportunities were shown to be interlinked through the adoption of RFID technology, but were shown to provide different impacts depending on the adopter's position within the supply chain. These seven opportunities are:

1. Ultra-High Frequency (UHF)
2. Traceability
3. Supply chain management
4. Data handling
5. Individualised management
6. Live data analysis
7. Industry data hub

The biggest opportunity for the velvet industry is the industry-wide adoption of UHF RFID technology. UHF is the preferred RFID frequency for supply chains, but it also creates additional opportunities for NZ velvet producers. UHF appears to better adhere to the behaviour of deer, which enables more applications in the animal management systems of producers compared to low frequency. UHF's key benefits were its animal handling, information storage and increased operator safety capabilities.

The traceability capability of RFID was seen as the biggest opportunity across all RFID frequencies. The benefits of RFIDs traceability capability are created through RFIDs ability to improve supply chain management, data handling, individualised management and live data analysis through the use of an industry data hub. This requires the integration of on-farm and supply chain RFID technologies, which is needed to create relatively seamless electronic information transfer between entities. This integration would enable the opportunities that have been identified to be implemented and would be beneficial for all parties within the NZ velvet industry.

In the long term, the potential opportunities of RFID for the NZ velvet industry will outweigh the limitations to adoption as the adoption of RFID has the potential to benefit all parties within the NZ velvet industry. The main limitations of the uptake of RFID technology within the NZ velvet industry are a lack of useful information sharing and time for user familiarisation. These limitations will be ongoing as more innovative RFID opportunities are created for velvet-focused farm systems and velvet value chains. Some of these opportunities we have yet to imagine, let alone recognise.

12.0 Recommendations

Based on this study, it has been recommended:

1. That further research is conducted into understanding the full potential of RFID technologies within the NZ velvet industry.

2. That NAIT urgently revisits and reassess its decision to exclude the use of UHF technology from the NZ velvet industry for animal identification and tracing.

3. That Deer Industry New Zealand (DINZ) makes the further exploration of UHF-RFID velvet tag technology as a suitable alternative to paper-based velvet traceability systems a priority.

4. That DINZ enables innovative customers, marketers and producers to freely experiment with RFID and identify their own tangible opportunities, limitations and benefits.

5. That DINZ does not immediately make a new RFID technology compulsory and instead enables the extension, support and time needed for users to become familiar with RFID.

6. That entities involved within RFID technology development, NZ velvet production and velvet value chains come together to communicate and collaborate in order to create:

    a. An improved extension framework for RFID within the NZ velvet industry.
    b. A development plan for the utilisation of data created through RFID.
    c. A strategy of enablement, which allows commercial entities both on-farm and in the velvet value chain to benefit from the opportunities that RFID can create.

7. That NZ livestock industries come together on RFID research and development to create and exploit mutually beneficial opportunities.

8. That visionary leadership is utilised for decisions regarding RFID within the NZ velvet industry. To ensure that RFIDs long term potential to create new opportunities is not wasted.

9. That a strategy for the creation of a national industry good livestock data hub is created. A hub that would enable the transfer of information between entities, the creation of powerful big data analysis and a framework for RFID data transfer and analysis technology developers.

13.0 Bibliography

Anselmi, M., Taylor, C., Good, S., Hansen, A., & McHugh, K. (2012). *Cost Benefit Analysis of Electronic Identification Tagging in the New Zealand Deer Industry.* Wellington: Deer Industry of New Zealand.

Barchard , K. A., Pace, L. A., & Burns , S. S. (2009). *Double Entry: : Accurate Results from Accurate Data*. Retrieved from Double Entry: https://faculty.unlv.edu/barchard/doubleentry/Double%20Entry%20APS%202009%20handout.pdf

Deer Industry New Zealand. (2013). *UHF Add Value Workshop.* Wellington: Deer Industry New Zealand.

Deer Industry New Zealand. (2014). *At a glance industry statistics*. Retrieved from Deer Industry New Zealand: http://www.deernz.org/about-deer-industry/nz-deer-industry/deer-industry-statistics/glance-industry-statistics#.VaW5pKNUanY

Deer Industry New Zealand. (2015). *Great season for velvet producers*. Retrieved from Deer Industry New Zealand: http://deernz.org.nz/great-season-velvet-producers#.Var4HqNG2nY

Deer Industry New Zealand. (2015). *Korea tariff reductions benefit value-added velvet*. Retrieved from Deer Industry New Zealand: http://deernz.org.nz/korea-tariff-reductions-benefit-value-added-velvet#.VasClqNG2nY

Deer Industry New Zealand, A. (2011). *EID on the Farm*. Retrieved from Deer Farming NZ: http://deerfarming.co.nz/wp-content/uploads/2011/11/EID-some-lessons.pdf

Drew, K. (2012, July 13). *Deer and deer farming - The beginnings of deer farming*. Retrieved from Te Ara - the Encyclopedia of New Zealand: http://www.teara.govt.nz/en/deer-and-deer-farming/page-3

Fereday, J. (2006). Demonstrating rigor using thermatic analysis: A hybrid approach of inductive and deductive coding and theme development. *International Journal of Qualitative Methods Vol 5*, 80 -92.

Fowler, P. (2015, May). *Venison prices down, deer velvet up*. Retrieved from Radio New Zealand: http://www.radionz.co.nz/news/national/274926/venison-prices-down,-deer-velvet-up

Fraser, H. S. (2009). *Stakeholder perceptions on the New Zealand velvet supply chain.* Lincoln: Lincoln University.

Ghadim, A. A., & Pannell, D. J. (1999). A conceptual framework of adoption of an agricultural innovation. *Agricultural Economics, Vol 21*, 145-154.

GS1, D. I. (2015). *The Use of Global Data and Network Standards in the Deer Velvet Supply Chain to Demonstrate Product Traceability, Authenticity and Supply Chain Efficiency.* Wellington: Deer Industry New Zealand.

Hartley, G. (2013). *The Use of EPC RFID Standards for Livestock and Meat Traceability.* Wellington: New Zealand Pathfinder Group.

Kaur, M., Sandhu, M., Mohan, N., & Sandhu, P. S. (2011). RFID Technology Principles, Advantages, Limitations & Its Applications. *International Journal of Computer and Electrical Engineering, Vol 3.*, 1793-8163.

Law, T. (2014, March 29). *Velvet even dearer as NZ matches Russian prices*. Retrieved from NZ Farmer: http://www.stuff.co.nz/business/farming/agribusiness/9878523/Velvet-even-dearer-as-NZ-matches-Russian-prices

Marra, M., Pannell, D. J., & Ghadim, A. A. (2003). The economics of risk, uncertiainty and learning in the adoption of new agricultral technologies: where are we on the learning curve? *Agricultral Systems, Vol 75*, 215-234.

Ministry of Agriculture and Forestry. (2011). *Departmental Report: Primary Production Select Committee*. Retrieved from NATIONAL ANIMAL IDENTIFICATION AND TRACING (NAIT) BILL: http://www.parliament.nz/resource/mi-nz/49SCPP_ADV_00DBHOH_BILL10501_1_A185937/d74e69937f70cd18484d00c5b3383abfa8d4ae67

NAIT LTD. (2015). *Requirements for farmers and lifestylers with cattle or deer*. Retrieved from NAIT: http://www.nait.co.nz/nait-basics/farmers-and-lifestylers/

Perry, C. (1998). Process of a case study methodology for postgraduate research in marketing. *European Journal of Marketing Vol 32*, 785-802.

Produmex. (2015). *PDMX Batch Attributes enable compliance with the Produce Traceability Initiative*. Retrieved from Produmex: http://www.produmex.com/pdmx-batch-attributes-enable-compliance-produce-traceability-initiative/

Proudfoot, I. (2015). *KPMG Agribusniess Agenda.* Auckland: KPMG.

Provelvo. (2015). *Frequently Asked Questions*. Retrieved from Provelvo: http://www.provelco.com/faq/

Pugh, G. (2013). *RFID Technical Study.* Wellington: The New Zealand RFID Pathfinder Group.

Sensoretech. (2015). *Survey Says: "UHF RFID works*. Retrieved from Sensortech: https://sensortech.wordpress.com/2012/02/15/survey-says-uhf-rfid-works/

Spiers, I. B. (1987). The development of the deer industry. *Proceedings of the Deer Branch of the New Zealand Veterinary Association, Vol 4*, 1-8.

Swedberg, C. (2015). *USDA Embarks on 18-Month UHF RFID Pilot for Tracking Cattle*. Retrieved from RFID Journal: http://www.rfidjournal.com/articles/view?12579

Ungerboeck Software Limited. (2014, May 19). *When Good Info Goes Bad: The Real Cost of Human Data Errors*. Retrieved from Ungerboeck Software Limited: http://ungerboeck.com/blog/when-good-info-goes-bad-the-real-cost-of-human-data-errors-part-1-of-2

Yerex, D. (1979). *Deer farming In New Zealand.* Wellington: David F. Jones ltd.

Young, R. (2011). *Nait: barriers and opportunities for New Zealand sheep farmers.* Lincoln: Kellogg Rural Leaders Programm.

14.0 Appendix

14.1 Interview Questions

Could you please tell me?

1. How did you become a part of the velvet / RFID industry?
2. How does your organisations information or data system operate?
3. How does the velvet industry utilise RFID technology?
4. How could the velvet industry utilise RFID technology?

5. What RFID-based technologies are opportunities for NZ velvet producers?
6. Why are these RFID-based technologies opportunities for NZ velvet producers?
7. How are these new RFID-based technologies opportunities for NZ velvet producers?

8. What RFID-based technologies are opportunities for velvet value chains?
9. Why are these RFID-based technologies opportunities for velvet value chains?
10. How are these RFID-based technologies opportunities for velvet value chains?

11. What is limiting the adoption of RFID technologies within the velvet industry?
12. Why is the adoption of RFID technologies being limited in the velvet industry
13. How is the adoption of RFID technologies being limited in the velvet industry?