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Individual identification in pigs using microchips

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Individuell märkning av slaktsvin med mikrochips

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Nyckelord: gris, individuell, märkning, mikrochip, elektroniskt id

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Abstract

Individual identification of pigs could be used in commercial herds for production monitoring, disease monitoring and breeding evaluation. This study investigates the possibility of using microchips designed for dogs and cats to identify individual pigs from birth, through rearing to carcass at the slaughter plant. Two different sizes of microchips, and two different ages of the pigs at injection were tested. Castrates and gilts from ten litters were evenly distributed between chip sizes and injection ages. All pigs were identity marked with both electronic ear tags and injected with microchips. The readability and the presence of wounds for the different methods of identification were recorded through rearing and post slaughter. The results showed that the microchip is not a significantly better method than electronic ear tag for individual identification of pigs regarding readability (due to lost microchips). Moreover, the difference in presence of wounds between electronic ear tags and microchips were not significant. The results showed that a significantly higher proportion of the large microchips are lost during rearing than the small microchips and that a significantly higher proportion of microchips among the early injected (1-2 weeks of age) were lost than among the late injected (9-10 weeks of age). The conclusion of this study is that the use of microchip as well as electronic ear tags as reliable methods (according to the recommendation of >98 % readability by ICAR) for individual identification is not possible without further research at this moment.

Sammanfattning

Individuell identifiering av grisar skulle kunna användas i kommersiell produktion för produktionsuppföljning, sjukdomsregistrering och avelsvärdering. Den här studien undersöker möjligheten att använda mikrochip anpassade för hundar och katter för att identifiera grisar individuellt från födsel till slaktkropp på slakteriet. Två olika storlekar på mikrochip testades vid två olika åldrar vid injektion. Från tio kullar märktes lika många kastrater som gyltor med mikrochip samt elektroniskt öronmärke. Avläsningsbarheten och förekomst av sår för de olika identifieringsmetoderna registrerades under uppväxten och efter slakt. Resultaten visar att mikrochip inte är en signifikant bättre metod än elektroniskt öronmärke för individuell märkning av grisar med avseende på läsbarhet (på grund av förlorade mikrochip). Skillnaden i förekomst av sår runt chip/öronmärke var inte signifikant. Resultaten visar att litet mikrochip har signifikant högre läsbart än stort mikrochip samt att sen märkning (9-10 veckors ålder) har signifikant högre läsbarhet än tidig märkning (1-2 veckors ålder). Slutsatsen i den här studien är att varken mikrochip eller elektroniskt öronmärke är säkra identifieringsmetoder (enligt ICARs rekommendation för >98 % läsbarhet) och att vidare studier behövs.

Introduction

The aim of this study was to evaluate a novel method for identification in pigs using microchips. Identification of pigs that are moved between herds or to a slaughter is compulsory for pigs in the European Union (EU). But the requirement is not specific for individual identification as it is in other species intended for human consumption such as cattle and horses. Today, pigs are commonly produced in batches where the only identification at slaughter is a common production site number on an ear tag or as a tattoo.

Identification methods used today such as an ear tag can easily be destroyed in the slaughter process and then the purpose of individual identification is lost. The purpose for a new individual identification is to improve monitoring of production and disease by being able to connect production data to slaughter performance. With a reliable method of connecting individual rearing data to slaughter performance, this could also be used in breeding evaluation. Expensive boar testing at test stations could be replaced or combined with data collected directly from offspring in commercial production at the slaughter plant regarding, e. g. growth rate, carcass leanness and slaughter remarks.

A new method for individual identification in pigs could be subcutaneously injected microchips into the auricle base. There are microchips available for dogs and cats with barbs or bioactive coating which prevents the microchip from migrating to other body parts.

Literature review

Pigs and pig production

The pig (*Sus scrofa*) is believed to have been domesticated approximately 8000 years ago in Asia and Europe by settled tribes. The domesticated pigs were generally kept loose in the country side or in the town until the 19th century when the trade of live pigs and the production was intensified and pigs consequently were kept in pens more commonly (Christiansen, 2010).

Pigs are gregarious omnivores with great curiosity. They are very social with a strong social hierarchy. The have good eye sight, hearing and a very well developed sense of smell. Pigs have a wide range of natural behavior in the wild yet in production they are remarkably adaptable. However, signs of stress in pigs can be tail biting, restlessness, flank sucking and fighting behavior (Christiansen, 2010).

In Sweden pigs are mainly kept for meat production. The number of pigs produced per sow was 23.8 (19.8-26.3) in 2011 (Eriksson, 2012). The piglets weigh about 1400 grams at birth and reach slaughter maturation at 90-120 kg live weight in approximately 5-6 months. At this time the pigs reach sexual maturity and grow less quickly (Christiansen, 2010). The growth rate in finishing pigs is approximately 0.9 kg per day (Svenska Pig, 2013a). There are two breeding organizations who provides the producers with breeding material by working with breeding goals, breeding programs and live animals in Swedish pig production. These are called Nordic Genetics and Avelspoolen. Recruitment of females in Swedish herds is done either by buying gilts or recruitment in the own herd (Svenska Pig, 2013b).

In commercial production, pigs are often separated per age group to prevent the risk of spreading disease. The identification system used often depends on production system, and even though individual identification is common for sows, it is scare among growing-finishing pigs. Farrow-to-finish batch wise production rarely uses individual identification methods for growing-finishing pigs since the pigs never leave the farm until slaughter. A common farm identity is then satisfactory for traceability but this also means that there are no individual readings of the pigs' properties. Individual identification is essential when assessing genetic merits of individual animals' performance (Madec *et al.*, 2001).

Identification of animals

Marking and identification of animals has been performed since the early days of domestication and animal husbandry. Identification started as a way to prove ownership (Madec *et al.*, 2001) but the markings were less likely on individual basis. However, individual identification with markings on the body has been practiced in some cases, and there are records of individual identification as long as 3800 years back (Blancou, 2001). Today, the worldwide organization International Committee for Animal Recording (ICAR) has established guidelines and standards regarding identification of farm animals that applies to its member organizations and member countries. ICAR is a nongovernmental and nonprofit organization that works for improvement in this field by standardization, evaluation and invention of identification systems as well as recording systems and genetic evaluations (ICAR, 2012).

Laws and requirements

Identification and registration of animals is compulsory in many countries. These laws and requirements apply to many different species of food-producing animals as well as for pets in the European Union (EU) and in Sweden.

The requirements for identification in pigs in the EU are stated in EU directive 2008/71. Each country has to keep a registry of pig producers within the own territory and the markings that are used by the producers to trace the origin of animals. The registry is kept on farm level with accurate information about the flow of animals in numbers, destination and dates. All pigs in the EU have to be identity marked with an ear tag or a tattoo before they leave their birth place and the markings are not allowed to be removed or replaced without permission from the authorities, which in Sweden is the Department of Agriculture. The marking should take place as early as possible and at the latest before the pigs are moved from their birth place.

Individual identification is not compulsory for pigs in the EU unlike other species such as cattle and horses. Identification in cattle in Sweden is done with two yellow ear tags with country code, production site number and individual animal number. Lost ear tags have to be replaced. Calves have to be marked with two ear tags before leaving the production site or at the latest at 20 days of age. One ear tag can contain an electric transponder (Jordbruksverket, 2013a). Sheep and goats in Sweden are required to be identity marked before they leave their production site or at the latest at six months of age with one ear tag including country code and production site number. Individual identification is not required for goats and sheep that live less than one year. If the sheep or goat is meant to live longer than one year, they are marked with two ear tags including an individual number of five digits. In addition to the regular plastic ear tag and electronic transponders, ear tags of clamp model in plastic or metal are allowed in sheep and goats (Jordbruksverket, 2013b). All dogs older than four months in Sweden are required to be identity marked with a tattoo or microchip and registered in the Department of Agriculture's central dog registry. The reason is that it is easier to keep control over aggressive or dangerous dogs in the society. It also works as a tracking registry in case people lose their pets (Jordbruksverket, 2013c). Horses, regardless of age and breed, are in the EU required to have a horse passport issued within six months of age. The horses are generally identity marked with a microchip but trotters can be freeze branded. In addition to the microchip, all horses have a unique Universal Equine Lifetime Number (UELN). The horse passport is meant to ensure that pharmaceuticals do not enter the human food chain if the horse is slaughtered. It also ensures the right identity when trading and competing and for breeding purposes. Moreover, traceability can limit the spreading of contagious diseases (Jordbruksverket, 2013d). As with the pig registry, there are registries for cattle (bovine registry, CDB), horses and dogs where information regarding owners and animal flow have to be reported.

Pigs that are moved between countries in the EU are allowed to be remarked but pigs that are imported into Sweden have to keep their original identification. Animals imported from a third country have to be marked within thirty days from a compulsory veterinary control if they are not meant to be slaughtered within this period. Markings that are lost or have become unreadable are required to be replaced. The replacement marking has to contain the same information as the original marking, even if the pigs have moved to another production site. Any remarking of animals has to be cross-referenced in the registry so that it is always possible to trace the origin. Pigs that are kept to be slaughtered for private purpose at the birth site are excused from the directives in 2008/71/EG regarding marking.

In accordance to these directives Sweden require the registration of a production site with a production site number within the Department of Agriculture (SJVFS 2012:35) tied to each animal producing farm. Every producer has to keep journal of their animal flow; number of animals leaving and entering the production site, where the animals are going and where they came from and dates. Records have to be made within 48 hours from changes in the animal flow and they have to be kept for three years.

Identity marking of pigs in Sweden is done by an ear tag or a tattoo. The ear tag or tattoo has to be approved by the Department of Agriculture and has to contain country code (SE for Sweden) and the production site number. The male part of the ear tags has to be yellow in pigs and the female part must not be red. The ear tags can also be complemented with individual identification but it is not required for slaughter pigs in Sweden. All pigs have to be identity marked before leaving their production site. Pigs that are transported to slaughter directly from their birth place may be tattooed only with a supplier number providing that the supplier numbers are reported to the Department of Agriculture and thereby tied to the production site (Jordbruksverket, 2013e).

Sweden is a member of the organization ICAR which means that certain guidelines and rules have to be followed in accordance to the agreement with ICAR. These guidelines largely correlate to the national and EU laws about identification (ICAR, 2012).

Traceability

The laws about identification of animals exist because there are infectious diseases that spread when animals are transported and animals from different herds are mixed. To be able to trace disease back to its origin it is important to be able to identify the animals and the animal flow between herds. This is important both for animal health and human health as it reduces the risk for spreading of disease (Jordbruksverket, 2013f). Traceability is also important for the food industry and there is a demand among consumers to be provided with more knowledge about the products and traceability increases the trust between consumers and producers. The use of a secure electronic individual identification can be a good method to control the potential transmission of diseases between herds (Saatkamp *et al.*, 1997).

Although the pigs can be identified during rearing, the link between live animals and carcasses is broken in the slaughterhouse. To keep a sufficient traceability in pig meat production, the identification has to be readable at different point of the slaughter line. Few experiments have been done on this matter since the problem has not been in focus for scientists (Santamarina *et al.*, 2007).

Identification systems in pigs

There are different kinds of identification used in the Swedish pig industry; the most common are tattoos, ear tags, ear notching and electronic identification (ID).

An efficient identification system should be easy to apply, permanently fitted and low in cost. Other important aspects are animal welfare and consumer safety as well as functionality. It is also important that the devices are tamper proof. Depending on the purpose of identification, the marking also have to be individualized (Stärk *et al.*, 1998; Madec *et al.*, 2001; Caja *et al.*, 2005). ICAR recommends a minimum readability of >98 % for identification systems (ICAR, 2012). Reasons for inefficiency in an identification system can be losses, code erasing, short reading distances, transcription errors as well as negative effects on animal welfare or fraud (Caja *et al.,* 2005).

Tattoos

Tattoos are a common identification method in growing-finishing pigs in Sweden. The tattoo should be located on the shoulder or neck (Jordbruksverket, 2013e). Tattoos are a permanent marking method that can be individualized but they often fade away as the pig grows and can be difficult to read (Madec *et al.,* 2001).

Ear tags

Ear tagging is an easy and common method for identification in pigs. The external identification often provides quick and reliable reading if the print is clear. However, external identification methods are not tamper proof and the losses can be extensive, 5-60 % loss of ear tags during rearing is reported (e.g. Madec *et al.,* 2001; Caja *et al.,* 2005; Babot *et al.,* 2006; Marchi *et al.,* 2007; Santamarina *et al.,* 2007). Because pigs are curious by nature, the ear tags are often the targets of biting from littermates. Pigs may also loose their ear tags when getting them caught in the interior, both in the pen and at slaughter (Stärk *et al.,* 1998). Ear tagging is quite painful for the pig since it is done without analgesic and lesions with subsequent infections occurs relatively often (Leslie *et al.,* 2010).

Ear notching

Ear notching is not allowed to be used as the only identification in pigs in the EU. This identification system is permanent and inexpensive. The notching is usually performed at 1-3 days of age but can be done at any time. The notches are placed around the ears on both sides and/or in the middle of the ears. The notches correlate to a certain number that depends on where on the ear and which one of the ears that the notches are placed (Engström & Anliot, 1997).

Electronic transponders

The electronic transponder (ID) can either be embedded in an ear tag, injected subcutaneously or intraperitoneal. Studies comparing the different electronic ID's throughout rearing of pigs as well as for animals of other species show that the most successful method for traceability and identification is the intraperitoneal injection. However, the recovery of the intraperitoneal transponders in the slaughterhouse is not efficient (Caja *et al.,* 2005). Studies have also indicated that the intraperitoneal injection of a transponder is less painful for the pig than ear tagging or ear notching (Leslie *et al.,* 2010). The most successful site for subcutaneously injection in pigs is the auricle base (Merks & Lambooij, 1990) and one study showed that injection at four weeks of age is more successful than injection at 10 days of age due to the size of the ear (Lammers *et al.,* 1995).

Practical advantages with the electronic ID are e. g. less time consuming since the administrative work is automatic. The reading device can be connected with a computer program to keep track of important parameters such as birth date, weight and pedigree which enables easy monitoring of economy and production. The electronic ID's are less likely to be tampered with which makes selling and buying of animals and traceability safer (Eradus & Jansen, 1999). This allows for a safer determination of origin of disease and infection control which in term creates a greater customer confidence (Jordbruksverket, 2011).

The electronic ID ear tags can be damaged in the slaughter process by boiling water and superficial burning (Stärk *et al.*, 1998; Madec *et al.*, 2001; Caja *et al.*, 2005). The purpose of identification for traceability is lost if the electronic ID fails to be read after the slaughter process. Because of the quick pace in the slaughter line, the removal of identification markings has to be made in less than 5 seconds to be considered efficient (Caja *et al.*, 2005).

Microchips

An identification system using microchips is based on the same principle as auricle base injected electronic transponders. Microchips are normally used in identification of horses, dogs and cats and the potential for use in pig production is currently investigated. Microchips offer a unique identification which is easy to read and cause little suffering for the pigs since the pathological damage is very small.

A pilot study was performed in 2013 with 69 pigs. The pigs were injected with a subcutaneous microchip (LifeChip manufactured by Destron Fearing) in the auricle base of the right ear at 10 weeks of age. The readability of the chip and the presence of lesions caused by the microchip were controlled every two weeks. The results from this study showed that the microchip did not wander under the skin, which could potentially be a problem in the food industry, and there were no health problems related to the injection of the microchips. There was a numerical but not statistical significant difference between pigs with unreadable microchips (18.2 %) and pigs with lost ear tags (9.1 %). However, the tissue damage of the ear were significantly lower in the pigs with microchip (11.4 %) than the pigs with ear tags (88.6%) ($p<0.001$). A possible reason for the unacceptable large loss of microchips could be the size of the microchip and the needle that is used for injection which could cause the microchip to fall out before the skin in healed (Bergqvist, 2013).

Materials & Methods

This study investigates readability of larger (2x13 mm) and smaller (1.4x8 mm) microchips injected in the ear at 1-2 weeks or 9-10 weeks of age. The study was approved by the Swedish Ethical Committee of Experimental Animals in Uppsala (Dnr: C381/12) and funded by the Royal Swedish Academy of Agriculture and Forestry. The study was carried out as a master thesis study during September 2013 to January 2014. The collection of data began in June 2013 and was finished at slaughter in November 2013. The study was preceded by a pilot study performed in 2012-2013 investigating the readability of 2x13 mm microchips and electronic ear tags in slaughter pigs were 69 pigs were studied.

Animals, housing and management

The pigs used in this study were reared at the Swedish Livestock Research Center situated at Lövsta outside of Uppsala, Sweden. The herd consists of 100 purebred Yorkshire or Yorkshire-Landrace crossbred sows with a yearly production of approximately 2000 slaughter pigs. The production at Lövsta is an integrated farrow to finish production with batch wise production in two week intervals and has a maximum capacity of 900 growing/finishing pigs.

The herd and production at Lövsta is Specific Pathogen Free (SPF). The standard tests for SPF herds are swine influenza, *Actinobacillus pleuropneumoniae* (APP), *Mycoplasma hyopneumoniae* (SEP), scabies *(Sarcoptes scabiei)*, swine dysentery *(Brachyspira hyodysenteriae)* and toxin producing *Pasteurella multocida*. SPF herds are also free from diseases that are tested free on a national level such as African swine influenza (ASFV), Aujeszky's disease (AD, pseudo rabies), Japanese encephalit virus (JEV), Hoof and mouth disease (MKV), porcine epidemic diarrhea virus (PEDV), porcine reproductive and respiratory syndrome virus (PRRSV), rabies virus, swine fever virus (CSFV), swine vesicular disease virus (SVDV), transmissible gastroenteritis virus (TGEV) and Brucellosis (Vallgårda & Wallgren, 1998).

Piglet production

Dry sows and gilts are kept in loose housing with deep litter bedding. One week before expected farrowing, the sows are moved to individual conventional combined farrowing-weaner pens where they stay until weaning approximately 4-5 weeks after farrowing. The combined farrowing-weaner pens measure 1.95 x 3.26 m (6.4 m^2) whereof 1.95 x 1.19 m (2.3 m^2) is slatted floor with 10 mm width. Three sides of the pen have bars to prevent piglets from being crushed and the piglets are provided with a secluded, heated corner, see figure 1. One week prior to farrowing the pens are provided with 10 kg straw. An additional 2 kg chopped straw is provided each day until one week after farrowing. After that the pens are provided with chopped straw once per day from an automatic straw distributor.

The piglets are tattooed with an individual three digit number in the right ear at a routine examination after birth. The piglets are weighed at birth and at four days of age. At four days of age the piglets are marked with an ear tag with a built in transponder (electronic ID) in the left ear. The female part of the ear tag is placed inside the ear and the male part (with the tag) is placed on the outside of the ear. A three digit individual number (same number as the tattoo) is written on the ear tag with an Alflex marker pen. An iron injection (1 ml of Gleptosil in the neck) and surgical castration is also performed at four days of age. Analgesic

(0.1 ml of Metacam) is injected in the neck 15-30 min prior to castration. A second iron injection (1 ml of Pigeron in the neck) is administered at two weeks of age.

Figure 1. *A combined farrowing-weaner pen with a secluded, heated piglet corner and bars along the sides to prevent piglets from crushing. (Photo: Anna Wallenbeck)*

Figure 2. *A growing/finishing pen. (Photo: Frida Forsberg)*

Piglets have access to the sow's feed from birth. At three weeks of age, a feed dispenser (yellow Groba) is installed in the piglets' corner. The piglets are fed Lantmännens Solo *ad libitum*. Iron pellets (1 dl) are additionally provided two days per week until the weaning is completed at five weeks of age. The heat lamp is removed at three weeks of age.

The sow is removed from the pen at weaning at five weeks of age. The movable gate is secured and the board is lowered to the bottom position. The piglets get 5 dl of peat once per day during the first week after weaning. The piglets are weighed at five weeks of age. Uneven litters can at the latest be equalized at this point. This is to reduce the risk of fighting that is more likely to increase if mixing occurs at higher age. The piglets are dewormed at seven weeks of age with Rintal in the feed dispenser according to dosage.

Growing/finishing pig production

The piglets are weighed at nine weeks of age and thereafter moved to the growing/finishing stable. The growing/finishing pens measure 3.25 x 2.00 m (6.5 m^2) with both slatted and concrete floor, see figure 2. There are two nipple drinkers with unlimited water access in each pen in the area with slatted floor. The pens are provided with chopped straw once per day with an automatic straw dispenser. Manure is manually removed from the unslatted laying area once per day. The feeding system is fully automatic (Skiolds) with wet feed provided four times per day in long troughs.

A maximum of twelve pigs can be fit into each pen but the litters are not mixed or equalized when moved to the growing/finishing stable to avoid fighting. The pigs are regularly weighed when they start to reach slaughter maturation at 105-115 kg live weight. Prior to slaughter, the pigs are marked with a herd production number using a tattooing hammer on both sides of the body. Pigs from the Lövsta herd are slaughtered at the Lövsta slaughter plant owed by SLU and run by the company Lövsta Kött.

Experimental design

A total of 80 pigs from 10 litters from the same batch were included in the study. The piglets came from nine litters of F1 crosses between Yorkshire (dam)-Hampshire (sire) and one litter of purebred Yorkshire. Each litter consisted of 8-18 piglets born 6^{th} – 17^{th} of June. Eight pigs from each litter were selected to be injected with a microchip in the right ear in addition to the standard tattoo (right ear) and ear tag with embedded electronic ID (left ear). Generally the ones with a higher birth weight were selected because they were assessed to be more likely to survive. The goal was a gender distribution of 50 % males and 50 % females. The remaining piglets in each litter were identity marked only with a tattoo and electronic ID. The piglets were identity marked with a tattoo in the right ear at birth and an electronic ear tag in the left ear at 4 days of age.

Table 1. Distribution of pigs between size of microchip, time of injection and gender

	Early injection (1-2 weeks)		***Late injection (9-10 weeks)***	
N of	*Castrates*	*Gilts*	*Castrates*	*Gilts*
Small microchip	9	11	10	10
Large microchip	10	10	9	11

The animals were divided into groups in order to study differences in age, gender and size of microchip, see table 1. The first group of piglets was injected with a subcutaneous microchip in the ear at 1-2 weeks (2-13 days) of age. Two different sizes of microchips (Large 2x13 mm, Small 1,4x8 mm) were used in this study. One male and one female in each litter received one large and one small microchip respectively. The same was applied for the second group that was injected at 9-10 weeks (64-75 days) of age. The pigs were moved to the growing/finishing stable at 9-10 weeks of age after the injection of the second group.

Microchips

Two sizes of microchips of different brands were used. The large microchip (LifeChip manufactured by Destron Fearing) is 2x13 mm, see figure 3, coated with a patented bio-compatible material called BioBond© which prevents subcutaneous migration within 24 hours after injection. LifeChip can be read by any ISO-scanner (134.2 kHz) and is programmed with a unique 15 digit number. The small microchip (MICRO ID Mini) is 1.4x8 mm and read by an ISO-scanner (134.2 kHz ISO FDXB).

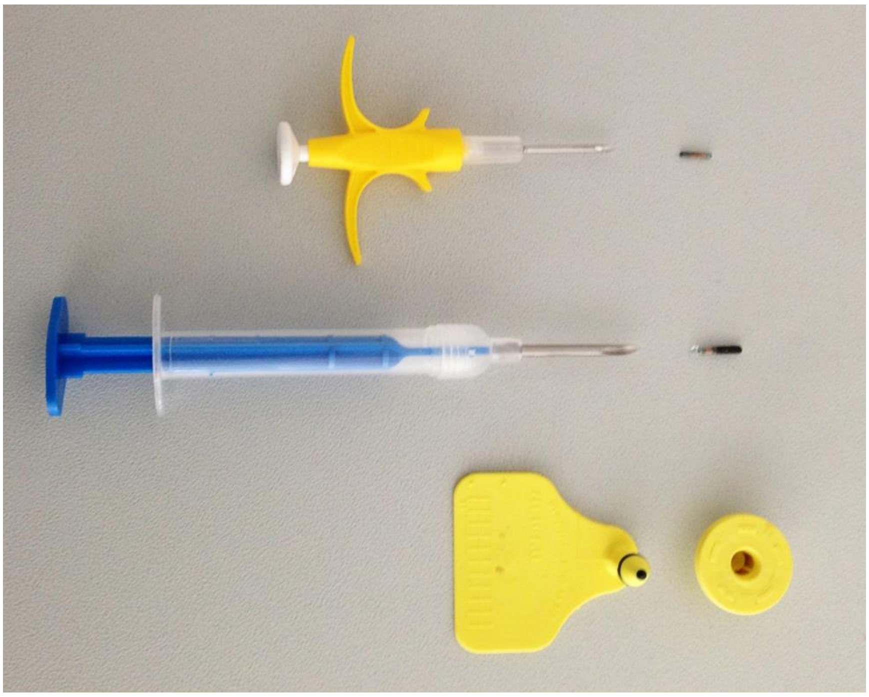

Figure 3. *The small microchip with disposable syringe, the large microchip with disposable syringe, the male part (left) and the female part (right) of the ear tag. (Photo: Anna Wallenbeck)*

Electronic ID

Ear tags (23 mm Combi E® from Stallmästaren) embedded with an electronic transponder using radio frequency identification (RFID) were used in this study, see figure 3. The electronic ear tags are valid for the international standards for identification of animals (ISO11784 and ISO11785) and approved by ICAR (Stallmästaren, 2013).

Injection of the microchips

The injection of the microchips was performed by the same veterinarian at both times of injection. The microchips were injected subcutaneous into the auricle base using the disposable syringes that were provided with each microchip, see figure 4. At the early injection at 1-2 week of age, the piglets were held by a staff member at Lövsta and another person (me) fixated the piglet's head during injection if necessary. The piglets were between 2 and 13 days old (6.89±3.66 days, Mean±Std) and their birth weights were between 1.21 kg and 2.77 kg (1.87±0.33 kg, Mean±Std). The individual microchip number were noted and listed with the piglets' individual electronic ear tag number and individual tattoo number.

At 9-10 weeks of age, the second group of pigs was injected with microchips. The pigs were fixated with a snout twitch; see figure 5, by a staff member at Lövsta as the veterinarian injected the microchips subcutaneously into the auricle base. The pigs were between 64 and 75 days old (68.9±3.61 days, Mean±Std) and their birth weights were between 0.96 kg and 2.48 kg (1.60±0.35 kg, Mean±Std). As at the first time of injection, the individual microchip numbers were noted and listed with the piglets' identity information.

Figure 4. *The early injection of microchips (1-2 weeks of age) with the small microchip (left) and the large microchip (right). (Photo: Frida Forsberg)*

Figure 5. *The late injection of microchips (9-10 weeks of age) using a snout twitch to fixate the animals. (Photo: Anna Wallenbeck)*

Recording of data

The readability of the microchip was controlled once a week for the first four weeks after both times of injection. The whole body of the pig was scanned if a microchip did not read to make sure that the microchip had not migrated to other body parts. Maintenance of the readability was conducted with approximately 14 day intervals for the remaining time. Readability of the microchip along with readability of the electronic ID system and lesions due to both marking systems were collected as data.

Scanner

The reading of both microchips and electronic ID were performed with HHR 3000 Pro with a 10 cm antenna from BioControl, see figure 6. This scanner reads ISO 11784/11785 and FDB-X transponders and uses Advanced Digital Decoding technology (ADD).

Figure 6. *Recording the readability of the electronic ID's and the microchips were performed with a scanner. (Photo: Frida Forsberg)*

Slaughter

The pigs in this study were slaughtered at Lövsta slaughter plant situated approximately 2.5 kilometers from the Swedish Livestock Research Center. The pigs were transported with an authorized animal transport. In this study, the pigs were slaughtered in three batches. The pigs were 135-144 days at 28th October (29 pigs), 140-151 days at 4th November (23 pigs) and 154-158 days of age at 18th November (25 pigs).

At the slaughter plant, the pigs are anaesthetized with carbon dioxide (CO_2) and then bled by opening the carotid arteries. The ear tag numbers were controlled at bleeding in the beginning of the slaughter line. Both of the ears were collected in the end of the slaughter line at weighting and classification of the carcass. The removal of the ears from the carcass was performed by an employee at the slaughter plant. An ocular control of the ear tag number and a control of the readability of the microchip and the electronic ID were done at this point. The ears were paired and put into individual plastic bags per pair and saved for further analysis.

Evaluation of skin lesions and tissue damage

A macroscopic evaluation of skin lesions and tissue damage was performed at SLU by a veterinarian in the days following slaughter. The readability of the ear tag number, tattoo, electronic ID and microchip were controlled again. The ears injected with microchips were first evaluated for skin lesions (0=no lesions, 1=mild swelling) due to the injection of microchips and then dissected to find the microchip, see figure 7. The surrounding tissue was macroscopically evaluated for tissue damage (0=no damage, 1=alteration in the connective tissue, 2=grey discoloration in surrounding tissue). The ear tag was removed and skin lesions surrounding the hole was evaluated (0=no lesions, 1=partially mild redness, 2=mild swelling, 3=swelling of the whole ear, 4=severe swelling), see figure 8. Tissue samples were saved for the purpose of a possible histologic analysis.

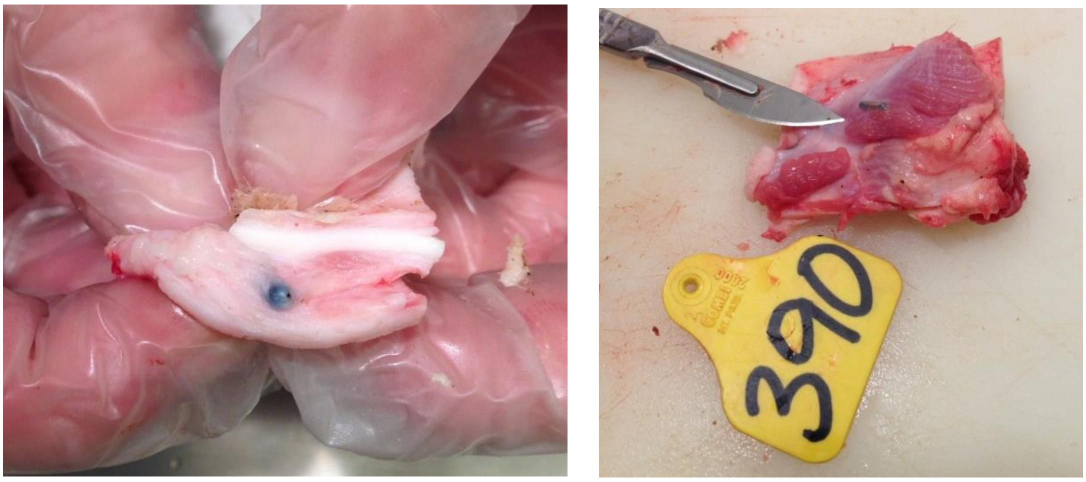

Figure 7. *Dissection of the ear to find the injected microchip. The surrounding tissue was then evaluated for damage. (Photo: Frida Forsberg)*

Figure 8. *Redness surrounding the hole where the ear tag was. (Photo: Frida Forsberg)*

Statistical analysis

The data in this study is divided into two sets; readability and wounds during rearing and readability and wounds post slaughter. The readability and wounds during rearing was recorded on 12 different occasions. The slaughter was performed in three batches but the readability and wounds post slaughter is considered as one data set. The statistical analysis was performed using the program Statistical Analysis Systems (SAS) version 9.2. The descriptive data was estimated using proc FREQ and proc MEANS.

Rearing data

The rearing data was binomially distributed with 0=unreadable/no wounds and 1=readable/wounds. The difference in frequency within the binomial parameters (readability and presence of wounds during rearing) was analyzed with logistic regression with the Generalized Linear Model for Mixed procedures (proc GLIMMIX) (logit link and binomial distribution). Least square means (LSM) and standard errors (SE) were estimated for size of microchip, time of injection and gender. Interactions between the parameters, and the effect of birth litter (pen) was investigated, and based on the results of these investigations, two models were developed, one for the readability of microchips and one for the presence of wounds.

Model 1 (readability): y = size of microchip + time of injection + gender + time of injection*gender + observation occasion (pig) + e (residual)

Size of microchip, time of injection and gender were included as fixed class effects and observation occasion (pig) is a random effect repeated within pig (subject).

Model 2 (presence of wounds): y = size of microchip + time of injection + gender + observation occasion (pig) + e (residual)

Size of microchip, time of injection and gender were included as fixed class effects and observation occasion (pig) is a random effect repeated within pig (subject).

Post slaughter data

The post slaughter data was binomial for the readability. The presence of wounds were assessed on an ordinal 0-4 scale for the ear tags, a 0-1 scale for skin lesions due to the microchip and a 0-2 scale for tissue damage due to the microchip. All post slaughter data used the proc FREQ and proc MEANS for descriptive data. The data concerning wounds were then converted to binomial data with 0=no wounds and 1=wounds for the proc GLIMMIX analyze. Least square means (LSM) and standard errors (SE) were estimated for size of microchip, time of injection and gender. Interactions between the parameters, and the effect of birth litter (pen) was investigated, and based on the results of these investigations, two models were developed, one for the readability of microchips and one for the presence of wounds.

Model 3 (readability): y = size of microchip + time of injection + gender + time of injection*gender + e (residual)

Where size of microchip, time of injection, gender and time of injection*gender are fixed effects.

Model 4 (presence of wounds): y = size of microchip + time of injection + gender + e (residual)

Comment on testing of models

Interactions between size of microchip, time of injection and gender were tested all together and separately for model 1 to 4. The data did not converge when all of the interactions were tested together. The only significant separate interaction was time of injection*gender ($p<0.001$) for model 1 and 3. The models were tested including age in days but this led to that the data did not converge which is why it could not be included in the model. The models were also tested for the pen effect which was not significant.

Results

The results presented below consist of two sets of data; 1) analysis of data from rearing and 2) analysis of data post slaughter. The data was collected on 12 occasions during rearing. The pigs in this study were slaughtered at 3 different occasions and the ears were collected at each separate time. After collecting the ears at the slaughter plant, they were macroscopically evaluated by a veterinarian. During the first time of injection, a total of 40 piglets were injected. Among them 19 were castrates and 21 were gilts. In the first week after injection, three piglets (one castrate and two gilts) died of other causes not related to this study and were thus excluded from the study. At the second time of injection a total of 40 pigs were marked. Among them 19 were castrates and 21 were gilts which made a total of 37 castrates (48 %) and 40 gilts (52 %) in the study.

Readability and wounds during rearing

The presence of wounds was limited to the first two weeks after injection for both times of injections, see table 2, and there were no external signs of severe infection, inflammation or swelling apart from normal healing progression that was visible during scanning. None of the microchips had migrated to other parts of the body.

At the end of rearing, just before slaughter; 14.3 % of the microchips were lost or broken (could not be read) and 3.9 % of the electronic ID's were lost, see table 2. All of the electronic ID's that were still in place were readable for both the ear tag number and the electronic transponder. The difference in readability between microchips and electronic ID's was not significant. The presence of wounds during rearing due to the different marking methods were significantly less ($p<0.001$, x^2) in ears injected with microchips than the ears with electronic ear tags.

Table 2. Proportion of unreadable microchips and electronic ID's and the presence of wounds due to microchips and electronic ear tags on each separate occasion

	Microchip				***Electronic ID***				
	Unreadable		*Wounds*		*Unreadable*		*Wounds*		***Total N***
Occasion	*N*	*%*	*N*	*%*	*N*	*%*	*N*	*%*	
2013-06-28	3	8.1	4	10.8	0	0.0	8	21.6	37
2013-07-05	5	13.5	0	0.0	0	0.0	1	2.7	37
2013-07-12	5	13.5	0	0.0	0	0.0	1	2.7	37
2013-07-19	6	16.2	0	0.0	0	0.0	0	0.0	37
2013-08-02	7	18.9	0	0.0	1	2.7	0	0.0	37
2013-08-17	7	18.9	0	0.0	1	2.7	0	0.0	37
2013-08-31	9	11.7	2	2.6	3	3.9	0	0.0	77
2013-09-06	10	13.0	1	1.3	3	3.9	0	0.0	77
2013-09-13	11	14.3	0	0.0	3	3.9	0	0.0	77
2013-09-20	11	14.3	0	0.0	3	3.9	0	0.0	77
2013-10-02	11	14.3	0	0.0	3	3.9	0	0.0	77
2013-10-18	11	14.3	0	0.0	3	3.9	0	0.0	77
Slaughter	11	14.3	2*	2.6*	9	11.7	18	23.4	77

*Skin lesions

Size of microchip

A total of 38 pigs were injected with small microchips and 39 pigs with large microchips. The birth weights for the pigs injected with the small microchip were between 1.16 kg and 2.77 kg (1.2±0.3 kg, LSM±SE) and the birth weights for pigs injected with the large microchip were between 0.96 kg and 2.48 kg (1.7±0.4 kg, LSM±SE).

At the end of rearing, 5.3 % of the small microchips and 23.1 % of the large microchips were lost or broken, see figure 9. The results from the logistic regression analysis showed that a significantly higher proportion ($p<0.001$) of the small microchips (95.2±1.02 %, LSM±SE) are readable throughout rearing in comparison with the large microchips (82.5±2.1 %, LSM±SE). There was no significant difference in the presence of wounds between the two sizes of microchips (1.49 % for small microchip and 0.57 % for large microchip).

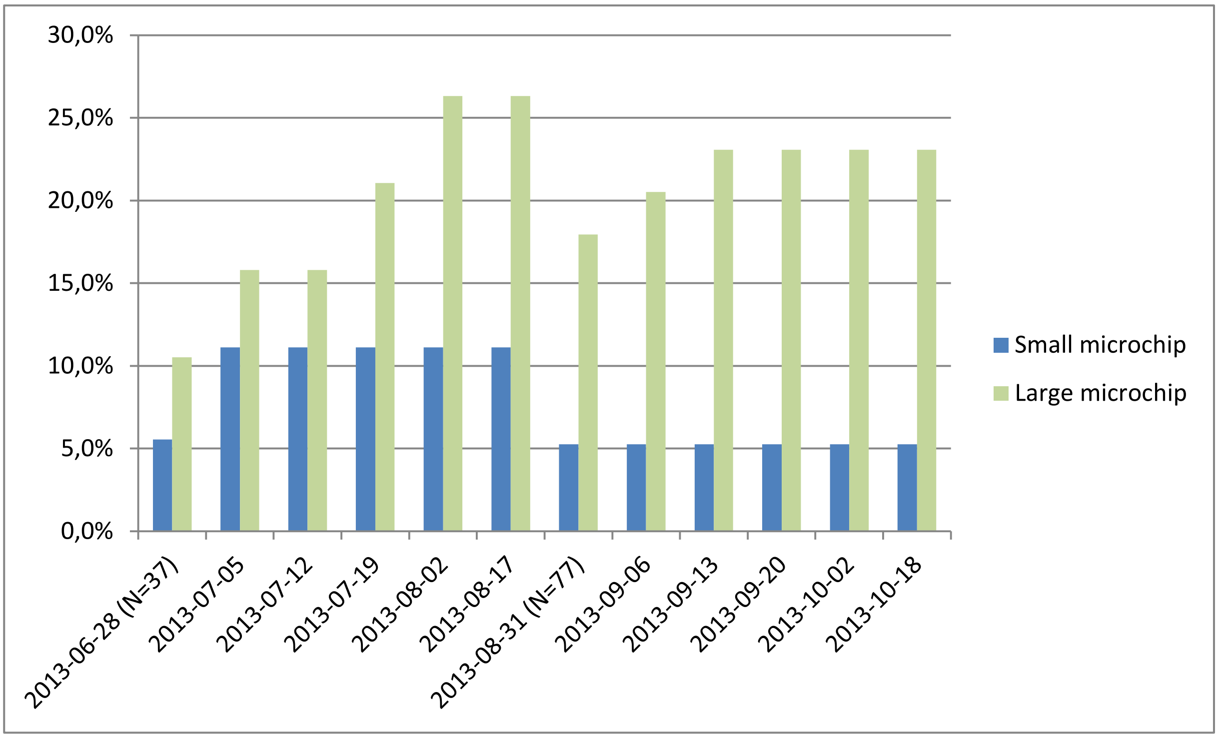

Figure 9. *Percentage of lost or broken microchips of the two different sizes for each recording during rearing.*

Influence of gender

A total of 37 castrates were injected with microchips, their birth weight was between 0.96 kg and 2.77 kg (1.7±0.4 kg, LSM±SE). A total of 40 gilts were injected with microchips, their birth weights were between 1.16 kg and 2.47 kg (1.8±0.3 kg, LSM±SE).

There were no significant differences between castrates and gilts regarding readability of the microchips. Among the 37 castrates and 40 gilts, 13.5 % and 15.0 % respectively had lost their microchip at the end of rearing, see figure 10. Also, there were no significant difference in the occurrence of wounds related to the microchips between castrates and gilts. Of the castrates and the gilts, 0.9 % respectively 1.1 % had wounds.

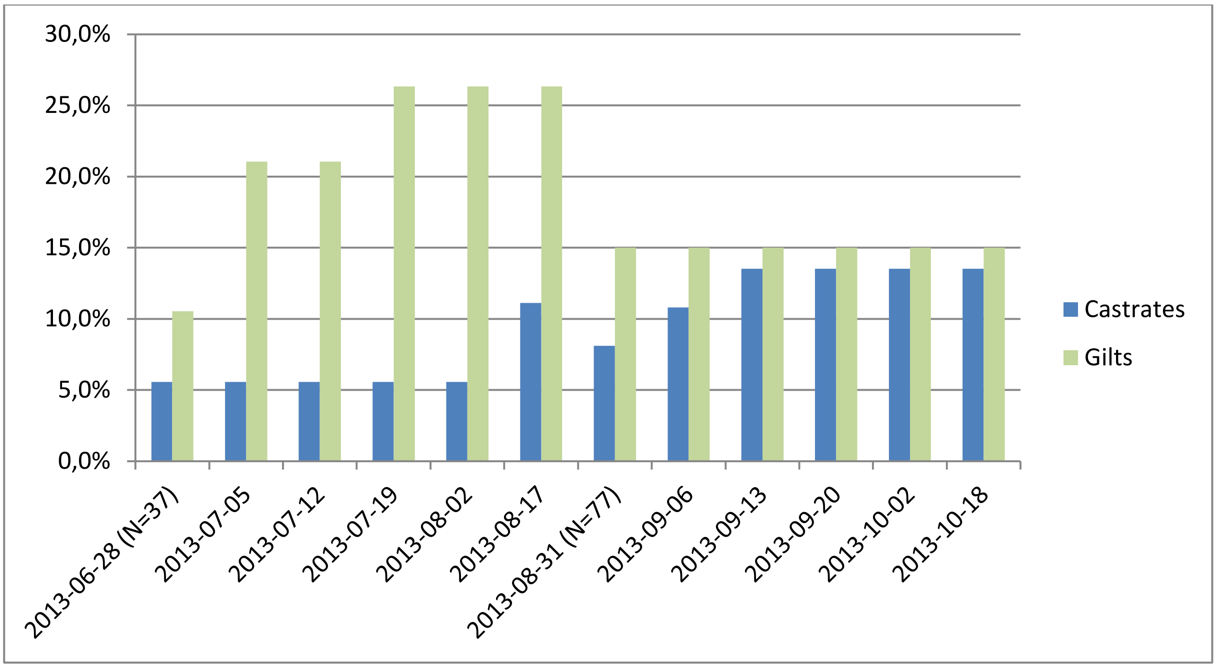

Figure 10. *Percentage of lost or broken microchips by gender for each recording during rearing.*

Time of injection

The microchips were lost during the first four weeks after injection for the piglets that were injected early, see figure 11. The pigs that were injected at the later occasion lost their microchips during the first two weeks after injection. Among the early injected piglets, 18.9 % had lost their microchip and among the later injected pigs, 10.0 % had lost their microchips. The variance analysis showed that a significantly higher proportion (p=0.058) of the later injected microchips (93.3±1.5 %, LSM±SE) are readable throughout rearing in comparison with the earlier injected microchips (87.0±1.6 %, LSM±SE). There was no significant difference between the presences of wounds between early injection (0.8±0.4 %, LSM±SE) and late injection (1.1±0.7 %, LSM±SE).

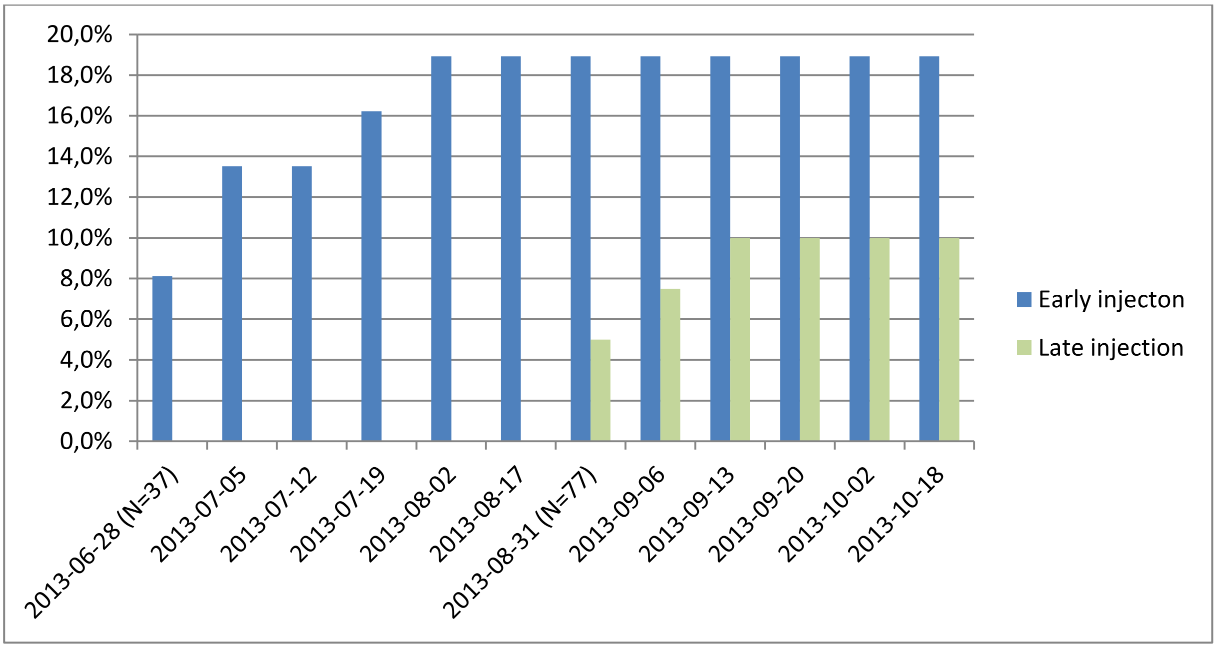

***Figure 11**. Percentage of lost or broken microchips in the two times of injection for each recording during rearing.*

The piglets who were injected early were 2-13 days old and the pigs who were injected late were 64-75 days. Within each time of injection, there was a significant difference between readability in concern to age at injection (p=0.001, x^2) in that it is more likely to lose the microchip the younger the pigs are, see figure 12.

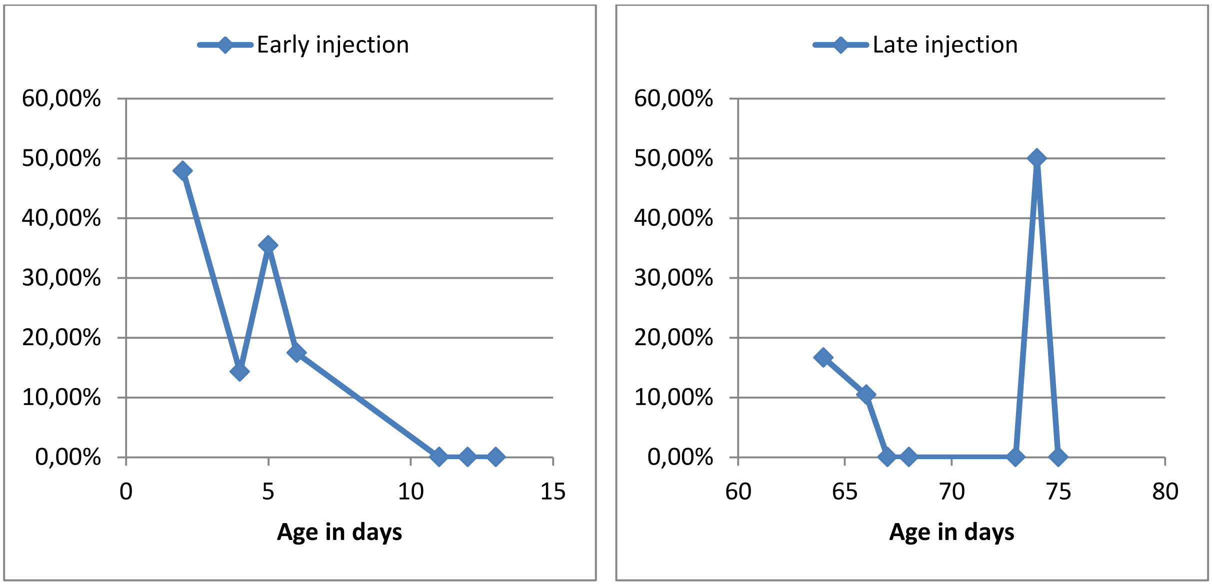

***Figure 12.** Percentage of lost microchips at end of rearing for the early and late injected groups scattered over age (in days) at injection.*

Time of injection and gender

An analysis between genders within early and late injection showed that a significant lower proportion of microchips in gilts from the early injected group (77.6±2.7 %, LSM±SE) were readable in comparison to gilts that were injected late (96.3±1.4 %, LSM±SE) and also in comparison with castrates for both times of injection, see table 3.

Table 3. Analysis between genders within each time of injection during rearing. Least square mean (LSM) for readability in microchips and standard error (SE)

		LSM %	SE
Castrate	Early injection	92.8	1.5
Castrate	Late injection	88.5	2.7
Gilt	Early injection	77.6	2.7
Gilt	Late injection	96.3	1.4

Readability and wounds post slaughter

The pigs in this study were slaughtered on three separate occasions but readability at slaughter are onwards treated as one set of data. Post slaughter, 14.3 % of the microchips were lost or broken (could not be read) and 11.7 % of the electronic ID's were lost, see table 2. All of the electronic ID's that were still in place were readable for both the ear tag number and the electronic transponder. Additionally, 33.8 % of the tattoos were unreadable at the analysis. The difference in readability between microchips and electronic ID's was not significant.

The presence of wounds visible on the skin post slaughter was in total 2.6 % and the tissue damage inside the ear was 6.2 %. Wounds due to the electronic ear tag was in total 23.4 %, see table 4.

Table 4. The presence of wounds due to electronic ID (0=no wounds, 1=partially mild redness, 2=mild swelling, 3=swelling of the whole ear, 4=severe swelling) and skin lesions (0=no lesions, 1=mild swelling) and tissue damage (0=no damage, 1=alteration in connective tissue, 2=grey discoloration in surrounding tissue) due to the microchips post slaughter. The binomial distribution for the statistical analyze with 0=no wounds and 1=wounds

	Electronic ID		***Microchip***			
	Skin lesions		*Skin lesions*		*Tissue damage*	
Scale	*n*	*%*	*n*	*%*	*n*	*%*
0	59	76.6	75	97.4	61	93.9
1	15	19.5	2	2.6	3	4.6
2	1	1.3			1	1.5
3	1	1.3				
4	1	1.3				
Binomial distribution in presence of wounds						
0	59	76.6	75	97.4	61	93.9
1	18	23.4	2	2.6	4	6.2

Size of microchip

The percentage of unreadable microchips was the same post slaughter as just before slaughter, and thus the proportion of small and large microchips also were the same. There was a significant difference in readability between the small microchips (96.0±3.0 %, LSM±SE) and the large microchips (78.7±7.1 %, LSM±SE) were a significant higher proportion of the small microchips were readable (p=0.031). There was no significant difference between the presence of skin lesions and tissue damage due to injection of microchips between the small and large microchip. The distribution of skin lesions and tissue damage between the two sizes of microchips are shown in figure 13.

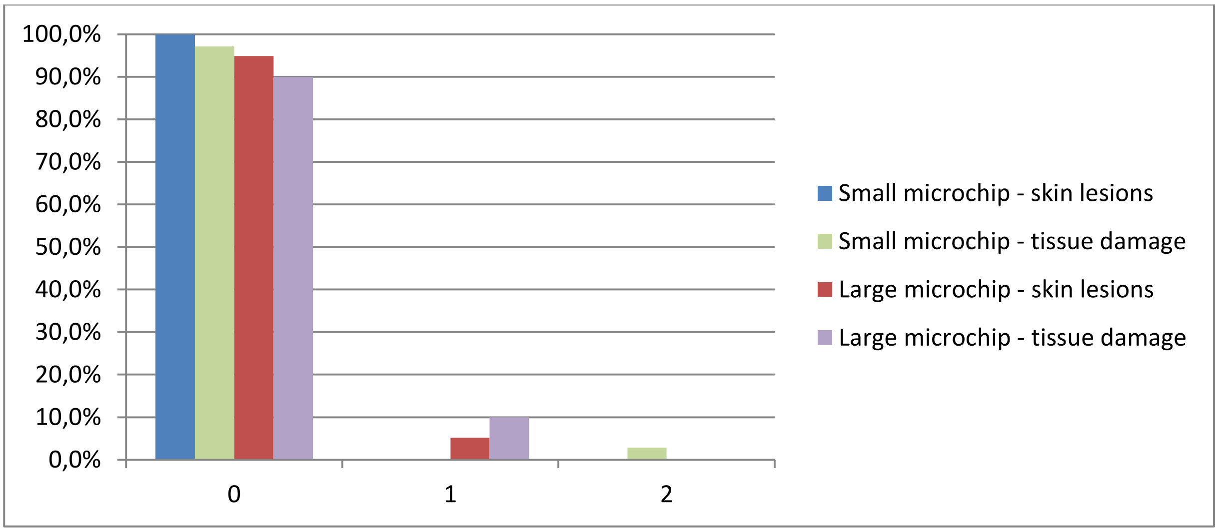

Figure 13. *Skin lesions and tissue damage due to microchip in size of microchip. Skin lesions (0=no lesions, 1=mild swelling) and tissue damage (0=no damage, 1=alteration in connective tissue, 2=grey discoloration in surrounding tissue).*

Influence of gender

The readability of the microchips was the same post slaughter as just before slaughter and thus there were no significant differences between castrates and gilts regarding readability of the microchips or the presence of wounds due to the injection between the two genders. The distribution of wounds due to the electric ear tag between genders is shown in figure 14 and the distribution of skin lesions and tissue damage between genders is shown in figure 15.

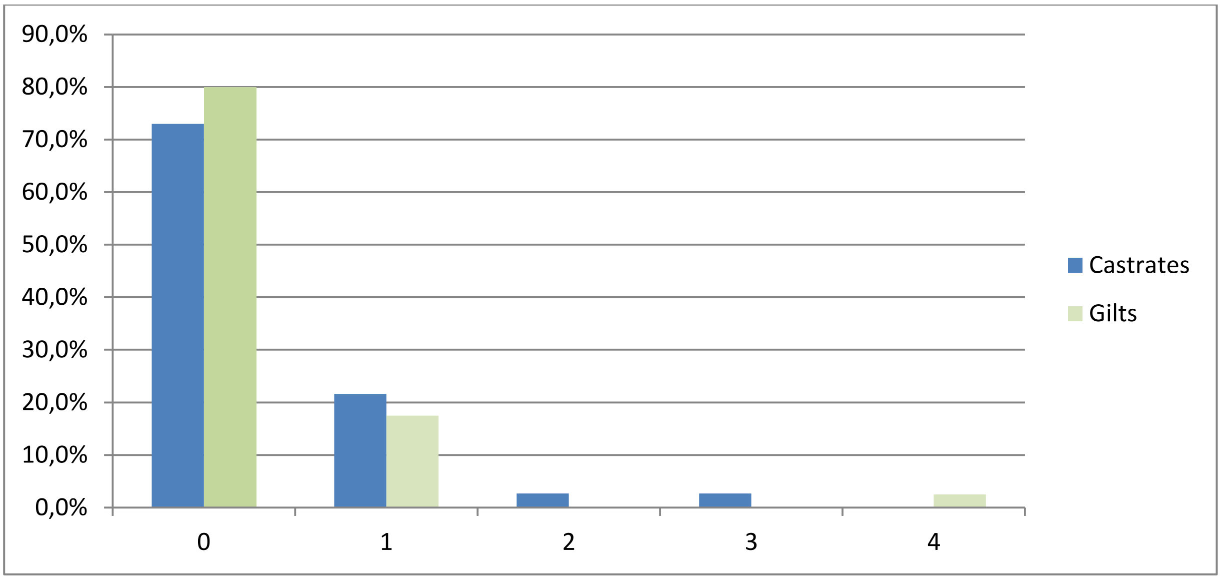

Figure 14. *The presence of wounds due to the electronic ID in gender (0=no wounds, 1=partially mild redness, 2=mild swelling, 3=swelling of the whole ear, 4=severe swelling).*

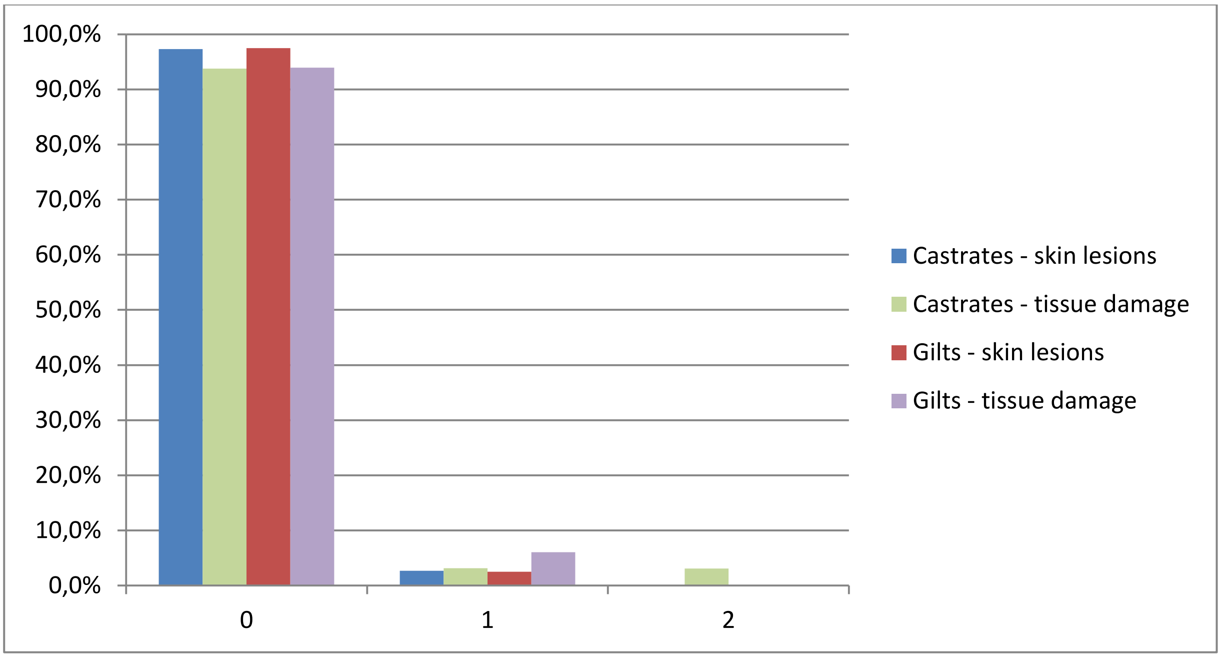

Figure 15. *The presence of skin lesions and tissue damage due to the microchips in gender. Skin lesions (0=no lesions, 1=mild swelling) and tissue damage (0=no damage, 1=alteration in connective tissue, 2=grey discoloration in surrounding tissue).*

Time of injection

There was no significant difference between times of injection for the readability of the microchips. There was no significant difference in wounds due to the injection of microchips between the early and late injected pigs. The distribution of wounds due to the injection of microchips for early and late injection is shown in figure 16.

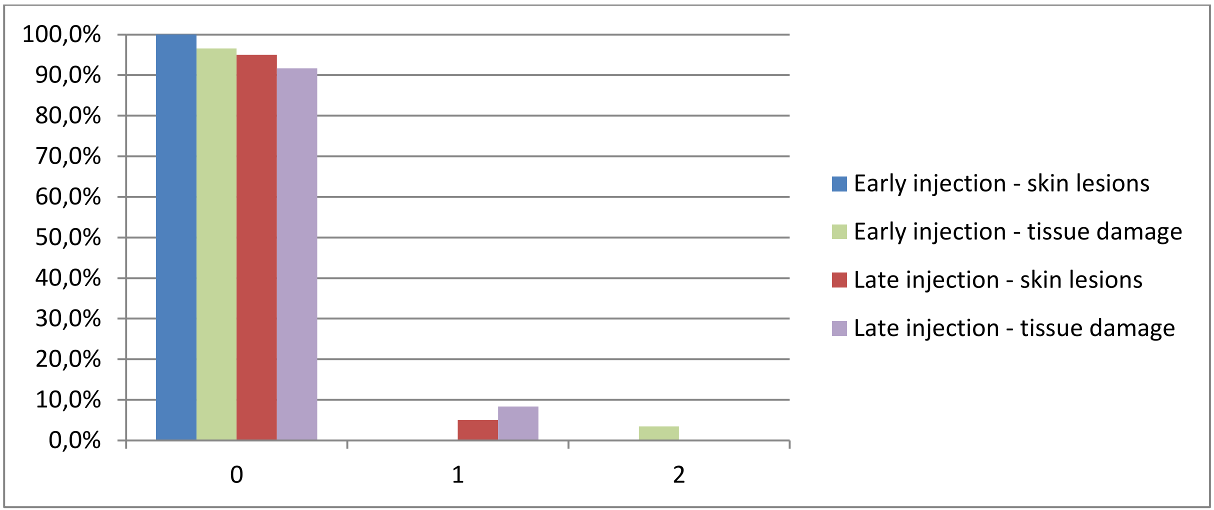

Figure 16. *The presence of skin lesions and tissue damage due to the microchips in time of injection. Skin lesions (0=no lesions, 1=mild swelling) and tissue damage (0=no damage, 1=alteration in connective tissue, 2=grey discoloration in surrounding tissue).*

Time of injection and gender

The analysis of interaction between genders within early and late injection for readability showed that there was a significant difference (p=0.081). There was a lower proportion of gilts from the early injected group (76.7±10.5 %, LSM±SE) were readable in comparison to gilts that were injected late (96.7±3.4 %, LSM±SE), see table 5.

Table 5. Analysis between genders within each time of injection post slaughter. Least square mean (LSM) for readability in microchips and standard error (SE)

		LSM %	SE
Castrate	Early injection	92.3	5.9
Castrate	Late injection	87.2	7.8
Gilt	Early injection	76.7	10.5
Gilt	Late injection	96.7	3.4

Discussion

The purpose of this study was to investigate the possibility of using microchips as an individual identification system in pigs regarding readability and presence of wounds due to the injection of microchips. The first part of this discussion considers the main results of readability and wounds. The following part discusses the methods used in this study. Last, the conclusions of this study and suggestions for further research are presented.

Readability and wounds during rearing

The total number of pigs injected with microchips was planned to be 80. Three piglets died during the first week after injection at the first time of injection due to causes other than this experiment, thus there were 77 pigs (37 castrates and 40 gilts). The gender distribution was planned to be even within litters but due to the lack of castrates there were two litters with more gilts than castrates injected with microchips. This possibly influenced the results. However a gender distribution of 48 vs. 52 % is within acceptable level with regard to normal fluctuations.

There was no significant difference in readability between microchips and electronic ID's at the end of rearing but there was a numerical difference (11 unreadable microchips (14.3 %) and 3 unreadable electronic ID's (3.9 %)). Electronic ID's can fail due to biting or friction from interior (Babot *et al.,* 2006) but in this experiment the reason for failure in readability during rearing was due to that the electronic ear tag was lost for all three cases.

In previous studies with subcutaneously injected electronic transponders the best site for injection has been concluded to be the auricle base. This is also an easy site for removal at the slaughter plant compared with the intraperitoneal injection. Several studies have reported a great variance in losses of electronic transponders injected into the auricle base with 1.6-6.9 % (30 mm transponder) (Lambooij *et al.,* 1995), 19.4 % (23 mm transponder) (Stärk *et al.,* 1998) and 17.1-72.5 % (12-34 mm transponder) (Caja *et al.,* 2005). There seems to be increased losses with the increase in size of transponder in pigs as well as in other species (Caja *et al.,* 2005). This was also seen in the readability between the small and the large microchip in this study where the smaller microchips (5.3 %) were significantly fewer unreadable/lost microchips than the larger microchip (23.1 %). As shown in figure 9; the losses of the large microchip were more extensive whilst the small microchips were more consistent, especially during the late injection period.

There was a significant difference between ages of the pig at injection. This has been seen in other studies where they found it more difficult to inject an electronic transponder in pigs younger than 4 weeks of age (Lambooij *et al.*, 1995; Lammers *et al.*, 1995; Stärk *et al.*, 1998). This is in accordance to the results in this study where the readability of the microchips was higher for the later injected pigs (90.0 %) than the early injected pigs (81.1 %). The loss of microchips happened during the first four weeks among the early injected and during the first two weeks for the late injected which also strengthens that theory. It is probably easier to inject the microchip correctly in a larger ear than a smaller ear. Within each time (age) of injection, there was a significant difference between readability in concern to age (number of days) at injection (p=0.001, x^2) in that it is more likely to lose the microchip the younger the pigs are. This was not included into the model but the difference in readability between ages in the early injection is evident in figure 12. This tendency can also be seen in the late injection although there is a deviation which is probably random. Stärk *et al.* (1998) also showed that it is more suitable with a smaller transponder when injecting younger pigs. This was not investigated in this study and further studies on this are needed.

The analysis between genders within each time of injection showed that there was a significant difference between the gilts for early and late injection. This is most likely a random event.

The presence of wounds due to the different identification systems was significantly lower for microchips than electronic ID's ($p<0.001$). However, this was determined by a chi square test which may not be a valid test due to low frequency of data and without adjusting for other effects. There were no significant differences between the sizes of microchips, genders or time of injections. This could be due to the low frequency of wounds recorded.

Readability and wounds post slaughter

There was no difference in the readability of the microchips between rearing and post slaughter. None of the microchips had migrated to other body parts from the site of injection. The losses of electronic ear tags increased from 3.9 to 11.7 % post slaughter but there was still no significant difference in the readability between electronic ID and microchips. Reasons for losing the ear tags could be due to fighting when different groups are mixed in the transportation and at the slaughter plant. The ear tags could also be damaged or lost during the slaughter procedure. In this study all of the unreadable electronic ear tags were lost from the ear during rearing or slaughter unlike other studies where the electronic ID were damaged in the slaughter procedure by scalding and superficial burning (Stärk *et al.,* 1998; Madec *et al.,* 2001; Caja *et al.,* 2005). By losing the individual identification the link between the live animal and the carcass is broken.

The presence of wounds due to the microchips was higher post slaughter than during rearing. This was due to the fact that the ears were not as thoroughly examined during rearing as they were during the post slaughter evaluation of the ears by the veterinary. At evaluation both the skin lesions and the inner tissue damage due to the microchips were assessed unlike at rearing where only the apparent skin lesions were recorded. Previous studies on electronic transponders have found prevalence of inflammation from 1-2 % (Stärk *et al.,* 1998) to 40 % (Janssens *et al.,* 1996). They found that the size of the transponder and size of the syringe had influence on the healing process but there were no significant differences in this study between the presences of wounds due to small or large microchip. Good hygiene is important when injecting the transponder or the microchip (Janssens *et al.,* 1996). This study used disposable syringes which keeps the injection from being contaminated. Lambooij *et al.* (1995) found that the transponders were lost shortly after injection due to rejection during inflammation caused by using the same syringe which led to abscesses. As for during rearing, there were no significant differences between the sizes of microchips, genders or time of injections in the post slaughter data. The presence of wounds due to electronic ID and microchips in this study was not excessive and most likely did not have a negative impact on the pigs' welfare.

Methods

Incorrect injection has been discussed as reason for losses of transponders in previous studies. In this study the microchips were injected by the same veterinarian at both times but the size of ears differed due to difference in age which could have led to inaccuracy in the injection method. However, the injection method was not the main focus in this study.

The recording of data could have been done in shorter intervals to be able to determine more exactly at what stage the microchips were lost. A more exact assessment of wounds during the healing process in the weeks following injection could have been useful to determine the reason for the loss of microchips. A method for the evaluation of wounds during rearing could have been elaborated.

The scanning of the microchip ears was sometimes difficult because the electronic ear tag seemed to have a wider readability distance. This led to that the scanner more easily could read the electronic ID than the microchip. The scanner had to be closer to the microchip than the electronic ear tag and preferably only within centimeters of the microchip. It was hard to tell if it was just that the electronic ID was more readable on a distance or if the microchip was hard to read at a distance. To use both electronic ID and microchips would not be desirable in a herd but the possible lack of range in the microchips could be a practical problem.

Conclusion

The results of this study concludes that microchips as of now is not a reliable method for individual identification in pigs due to the loss during rearing. The loss of electronic ID’s at slaughter concludes that they neither are a reliable method. However, microchips are a reliable identification method throughout the slaughter procedure and are quick and easy to recover at the slaughter plant. In this study, none of the identification methods meet the requirements of >98 % readability from ICAR and thus they need more research to be satisfying.

Further research in the use of microchips as identification in pigs can be done about method of injection and age of injection.

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