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Using injectable transponders for sheep identification

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Abstract
Feasibility study of sheep identification using transponders injected to groin, abdomen, neck and armpit. Losses were lowest and recovery was best with injection into the abdomen.

Keywords: electronic identification, lambs, inject, transponder

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Samenvatting
Haalbaarheid identificatie van schapen met transponders geïnjecteerd in lies, buik, nek of oksel is bestudeerd. Lage verliezen en gemakkelijke terugwinning werd gevonden voor buikholte.

Trefwoorden: elektronische identificatie, lammeren, injecteren, transponder

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Using injectable transponders for sheep identification

Het gebruik van injecteerbare transponders voor de identificatie van schapen

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November 2007

Introductory remarks

A considerable number of Dutch small scale sheep and/or goat keepers (breeders and smallholders) have raised objections to the use of ear tags. Some of the larger professional keepers have also raised objections to ear tags. The reason for their resistance is the increased risk of ear inflammation after application of the ear tags. Also, depending on the farming circumstances, there is a high risk of ear tags tearing the ear e.g. where ear tags hook onto fencing. From an animal welfare and traceability viewpoint this is an undesirable situation. An alternative to the ear tag is the bolus transponder. Some of the keepers consider the bolus to be an animal unfriendly alternative. A drawback to the bolus transponder is that the size of the bolus transponder does not allow application at birth, while breeders need to identify lambs directly after birth.

The small scale hobby keepers, represented by the NBvH (Dutch Association of Smallholders), would like to have Dutch approval for using injectable transponders as a legal identification device. Currently some NBvH members illegally identify their sheep and goats with an injectable transponder while others leave their animals unidentified.

The NBvH has, in consultation with the Dutch Ministry of Agriculture, Nature and Food Quality, asked the Animal Sciences Group to assist in the development of injectable transponders application and to evaluate the use of injectable transponders.

Animal well-being was the most important motive of the NBvH when initiating this project. However the main bottleneck for the use of injectable transponders is the food safety aspect. It has to be guaranteed that the injectable transponders do not enter the food chain after the animals have been slaughtered.

Samenvatting

In een experiment zijn 559 lammeren op een gemiddelde leeftijd van 1 maand geïnjecteerd met een transponder (32x3,9mm) voor elektronische identificatie. De transponders werden aangebracht in nek, oksel, lies of buik door de veehouder of een dierenarts. Het injecteren in de lies werd als het gemakkelijkst beoordeeld, de buik en nek als het moeilijkst. De reactie van de dieren bij het injecteren was het sterkst bij de nek en het minst bij de lies. Op een gewicht van ongeveer 30 kg zijn de lammeren geslacht. Eén keer tijdens de mestperiode en bij aankomst in het slachthuis werden de geïnjecteerde transponders uitgelezen. Niet gelezen transponders werden als verlies beoordeeld. De controle tijdens de mestperiode leverde verliezen op van 9,0, 0,0, 6,6 en 15,7% voor respectievelijk lies, buik, nek en oksel. Bij slachthuiscontrole waren deze verliezen opgelopen tot respectievelijk 10,0, 3,8, 8,3 en 17,4%.
Bij het terugwinnen van de transponders in het slachthuis kon men 50% van de in de lies geïnjecteerde transponders bij het onthuiden uit het karkas verwijderen. Voor de nek, oksel en buik waren deze percentages respectievelijk 40,4, 13,0 en 5,0%. De overige transponders werden verder in de slachtlijn teruggewonnen. De tijd die nodig was voor het terugwinnen was het kortst voor buik en lies en het langst voor oksel en nek. Dit werd mede veroorzaakt doordat men bij nek en vooral oksel meer in het karkas moest snijden voor het terugvinden en -winnen van de transponders. Van alle lammeren die bij binnenkomst in het slachthuis een werkende transponder hadden, is 92% ook fysiek teruggewonnen in het slachthuis.
Verliezen zijn veroorzaakt doordat transponders met de kop (bij nek), huid (bij lies en oksel) en buikinhoud (bij buik) de slachtlijn verlieten en daardoor niet konden worden teruggewonnen. Bij de eindcontrole kan nagenoeg met 100% zekerheid worden vastgesteld dat er geen transponders in de karkassen aanwezig waren.
Opmerkelijk was dat bij vrijwel alle beoordelingen (inbrenggemak, dierreactie bij inbrengen, verliezen en terugwinnen van transponders) een duidelijk effect van de persoon die de transponders had aangebracht, optrad.
Conclusie: vooral gezien het lage verliespercentage en het eenvoudig terugwinnen in het slachtproces biedt het toepassen van injectaten in de buikholte de beste perspectieven. Daarbij is het wenselijk dat de procedure en instructie voor aanbrengen op deze positie verder wordt verfijnd en getoetst.

Summary

In an experiment 559 lambs at an age of about one month were injected with a transponder (32x3,9mm) for electronic identification. Transponders were injected in neck, armpit, groin or abdomen. The application was carried out by the farmer or a veterinarian. Application in the groin was assessed as easiest, while abdomen and neck were assessed as most difficult. The animal reaction during injection was strongest for neck and lowest for groin. All the lambs were slaughtered at approximately 30 kg bodyweight. The ID number of each transponder was checked once during the fattening period and again upon arrival in the slaughterhouse. Transponders not read were referred to as losses. The check during the fattening period showed losses of 9.0, 0.0, 6.6 and 15.7% for groin, abdomen, neck and armpit respectively. At the slaughterhouse losses had increased to 10.0, 3.8, 8.3 and 17.4% respectively.

At slaughter 50% of the transponders in the groin were removed from the carcass during skin removal. For the neck, armpit and abdomen recovery levels were 40.4, 13.0 and 5.0% , respectively. The other transponders were recovered further along the slaughter line. Time needed for recovery was shortest for abdomen and groin and longest for armpit and neck. This was also influenced by extra time required for cutting the carcass necessary for further recovery of the transponders. In total 92.1% of the transponders were actually recovered. Losses in the slaughterhouse occurred because some transponders left the slaughter line with the head (transponders in the neck), skin (transponders in groin and armpit) and abdominal content (transponders in abdomen). At the final control at the end of the slaughter line it was possible to ascertain with almost 100% certainty that all transponders were removed from the carcasses.

Remarkable was the clear effect of operators on almost all assessments (easiness of application, animal reaction during application, losses and recovery of the transponders).

It was concluded that because of the low losses and ease of recovery of the transponders application in the abdomen offers the best perspective. Fine-tuning and further testing of application procedures and instructions for transponders in the abdomen are required.

Contents

1 Introduction

Conform EUROPEAN COUNCIL REGULATION (EC) 21/2004 REGARDING THE IDENTIFICATION OF SHEEP AND GOATS all animals older than six months, born after 9 July 2005 have to be identified with two means of identification. The animals have to be identified with an ear tag, that has been approved by the competent authority of that country, in each ear. As option it is allowed that one ear tag is replaced by an electronic identification device. This can be an ear tag transponder or a bolus transponder.

The present position of the European Union is that insufficient scientific information is available to allow a balanced judgment concerning the approval of injectable identification devices.

The use of injectable identification devices has been evaluated in a practical experiment. Four different application sites were evaluated. The experiment focused on the animal reaction during application, loss rates of the transponders, injectable transponder recovery during slaughter and the impact of the injection operator.

2 Material and methods

2.1 Literature study

Technology for electronic identification (ID) of animals is currently widely available. At issue is the most appropriate position to inject a transponder into the body of a sheep or goat.
The optimal injectable transponder's location must allow ease of application and reading, provide protection from breakage or loss, have no negative effects on welfare and health and it must ensure that the transponder remains secured in the injection area. The permanence of the transponder in the injection area will facilitate easy and quick location and recovery in the slaughter line.

Several studies have been performed into injectable transponders in cattle, pigs, rabbits and sheep. An overview of the observed effects is given in annex 1.

Injection position: ear region
The experiments with pigs showed large variation in recovery. Losses were higher with larger transponders (Stärk et al., 1998, Klindtworth et al., 2004, Caja et al., 2005). Klindtworth et al. (2004) reported that injection of large transponders was impossible with very young piglets. Injection of small transponders gave better wound healing, however migration of small transponders was greater (Stärk et al., 1998). On- farm losses and slaughterhouse recovery were affected by the devices used (transponders and application tools) and injector (Lambooij et al., 1995). In more than 58% of the carcasses more than 10s elapsed before the transponders were recoverd (Caja et al., 2005).
In cattle on-farm transponder losses injected in the ear region varied between 5 and 30% (Hasker & Bassingthwaigte, 1995, Lambooij et al., 1999, Conill et al., 2000). Lambooij et al., 1999 also reported effects of injection age and operator on losses; injection at younger age reduced losses. Recovery losses varied between 5 and 15% caused by transponders being removed with ears or hide.
Caja et al., 1998 and Conill et al., 2002 looked at the ear base as injection position for sheep and lambs. They concluded that losses were still to large; although they were relatively low (about 4%) compared with pigs and cattle. Adult sheep showed a strong reaction to the injection (Caja et al., 1998). Conill et al. (2002) observed some problems with the injection in very young animals. Recovery losses were recorded at 18%; recovery time was more than 2 minutes in 0.3% of carcasses.

Injection position: upper lip
Lambooij et al. (1999) and Conill et al. (2000) reported losses of 10-15% with injections in the upper lip of veal calves. Recovery rates differed between 26.3 and 99.2% in these studies.

Injection position: armpit
Studies using the arm pit as injection site involved veal calves (Lambooij et al., 1999 and Conill et al., 2000), adult sheep (Caja et al, 1998) and lambs (Conill et al., 2002). Transponder losses injected in the arm pit varied between 0 (adult sheep) and 5.5% (lambs). In veal calves Lambooij et al. (1999) reported a recovery rate of only 65%. Conill et al. (2000) recovered 97% however with a mean recovery time of more than 1 minute. Injection in the armpit of sheep and lambs was assessed as easy and safe (Caja et al., 1998 and Conill et al., 2002). About 10% of the transponders were not recovered and for more than 4% of the carcasses recovery time was in excess of 2 minutes (Conill et al., 2002).

Injection sites: neck, chest, groin and tail (Caja et al., 1998)
Transponders injected in the neck of adult sheep showed no losses; however the animals reacted strongly during injection and about one third of the transponders migrated to shoulder or chest.
Chest and groin injection in adult sheep was easy and no losses were observed. Losses of transponders injected in the tail were much too large. Animal reactions during injection were medium for chest and tail and low for groin.

Injection position: abdomen cavity (intraperitonial)
Experiences with transponders injected in the abdomenal cavity were available for pigs (Klindtworth et al., 2004, Babot et al., 2006 and Santamarina et al., 2007) and rabbits (Pinna et al., 2004). Striking were the very low loss rates (maximum 2%). In piglets it was possible to place large sized transponders (34 x 3,8 mm) from a young age. No negative effects on the animal performance were measured. Recovery was generally easy; recovery

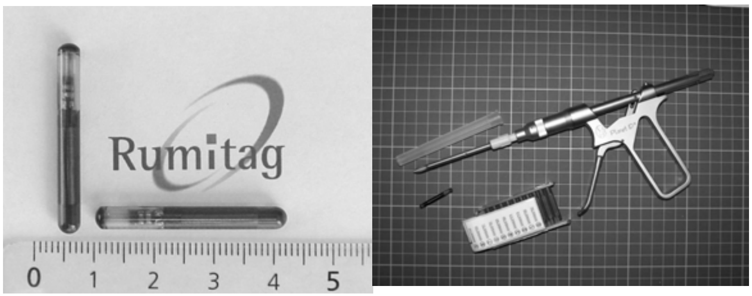
losses in pigs (approximately 10%) mainly occurred because transponders fell out at the moment of evisceration of the gut mass. In rabbits recovery was 100%.

Choice of injection sites to be included in the current research
Based on the afore mentioned results the head (ear region, upper lip) was not chosen as injection site for the current study. The main reason was the finding that large transponders were not suitable for injection in the head of young lambs. Large transponders are needed because of the required identification distance.
The armpit showed acceptable loss levels and recovery results in sheep and lambs. Acceptance for the current research was also influenced by the finding that injection was easy and safe.
From the neck, chest, groin and tail only the tail was rejected for the present study because losses were too high. Despite some less favourable results in adult sheep concerning animal reaction and migration, the neck and groin sites were accepted for the current study. In additional, no results were available in current literature concerning injection of transponders in these positions of young lambs.
Results with transponders injected into the abdomenal cavity of pigs and rabbits were considered promising and lead to their acceptance for the current study.

2.2 Selection of the material and injection site

The reading performance of the injectable transponder technology was an important issue for selection of the type of injectable transponder to be used. Conform the EUROPEAN COUNCIL REGULATION (EC) 21/2004 REGARDING THE IDENTIFICATION OF SHEEP AND GOATS a bolus transponder must have a reception reading distance of 20 cm with a portable receiver and 50 cm with a stationary receiver. Minimum requirement was that an injectable transponder must give the same reading performance as a bolus transponder. The injectable transponders are available in three different sizes: 12 mm x 2.1 mm; 23 mm x 3.9 mm and 32 mm x 3.9 mm. Because the 32 mm transponder has a good reading performance and meets the requirements of the EU the 32 mm injectable HDX transponder of the manufacturer Rumitag was selected (ICAR product code 964002). For injectable transponder application the Planet ID applicator was selected because the device was considered as being very user-friendly (figure 1).

Figure 1 Injectable transponder and applicator used for transponder injection



Transponders can be injected into different parts of the animals' body. Important aspects of injection site selection are: effect on animal well-being, ease of application, ease with which the transponder can be read, ease and reliability transponder recovery during slaughter. Based upon the results of the literature study the following 4 application sites were selected for evaluation: groin (figure 2), abdomen (figure 3), neck (figure 4) and armpit (figure 5).

Figure 2 Application of the injectable transponder in the groin

Figure 3 Application of the injectable transponder in the abdomen

Figure 4 Application of the injectable transponder in the neck

Figure 5 Application of the injectable transponder in the armpit

2.3 Selection of farm, animals and slaughterhouse

It was essential to the investigation all animals used were slaughtered (or died a natural death) before the end of the experiment. This requirement implied that only fattening lambs that were slaughtered within one year of age were used. Another requirement was that all animals were slaughtered under controlled conditions and in a limited number of slaughterhouses. This meant that all animals used in the project were not allowed to be sold on the open market.
A farmer with a flock of 1500 ewes was prepared to cooperate in the project, 559 lambs (housed in 9 different groups) were used. The lambs were kept in stables together with their mothers from birth to slaughter. The lambs were slaughtered upon reaching a weight of 30 kg (expected slaughter weight 15 kg). All lambs were slaughtered in the same slaughterhouse. The injectable transponders were planned to be applied within 4 weeks after birth. During the application of the transponders 4 persons were present for:

- collection of the lambs
- application of injectable transponder (the operator)
- observation
- registration of information

Application of the injectable transponders was performed by two persons (farmer or vet). The application site was randomly distributed. The procedure for handling the lambs during application of the transponder at the different positions were as follows:
Neck: lamb standing while firmly held between the legs of the operator. The transponder was injected in a dorso-ventral direction at the middle of the left side of the neck (figure 4).
Arm pit: lamb was sat on its rump with its back towards the operator and immobilised between the legs of the operator. The skin of the right armpit was stretched and the transponder injected cranio-caudally in a virtual space between the thoracic wall and the muscles of the M. triceps brachii (figure 5)
Groin: Lamb was restrained as mentioned above. The transponder was injected subcutaneously in the M. gracilis of the right leg in a cranio-caudal direction (figure 2).
Abdomen: Lamb was restrained as mentioned above. The operator injected the transponder 4 cm caudal to the navel and 4 cm to the right of the linea alba intraperitonially. At first the needle was inserted subcutaneously in a medial direction approx 1 cm and then directed towards the abdomen to enter the cavity via the muscles and peritoneum (figure 3).

A new applicator needle was used after every ten applications. The reaction of the animals during application was scored by the observer on a scale from 1 to 4 (1: no reaction, 2: light reaction, 3: medium reaction and 4: strong reaction). The person responsible for the application (operator) scored the easiness of application on a scale from 1 to 3 (1: easy, 2: moderate and 3: difficult).

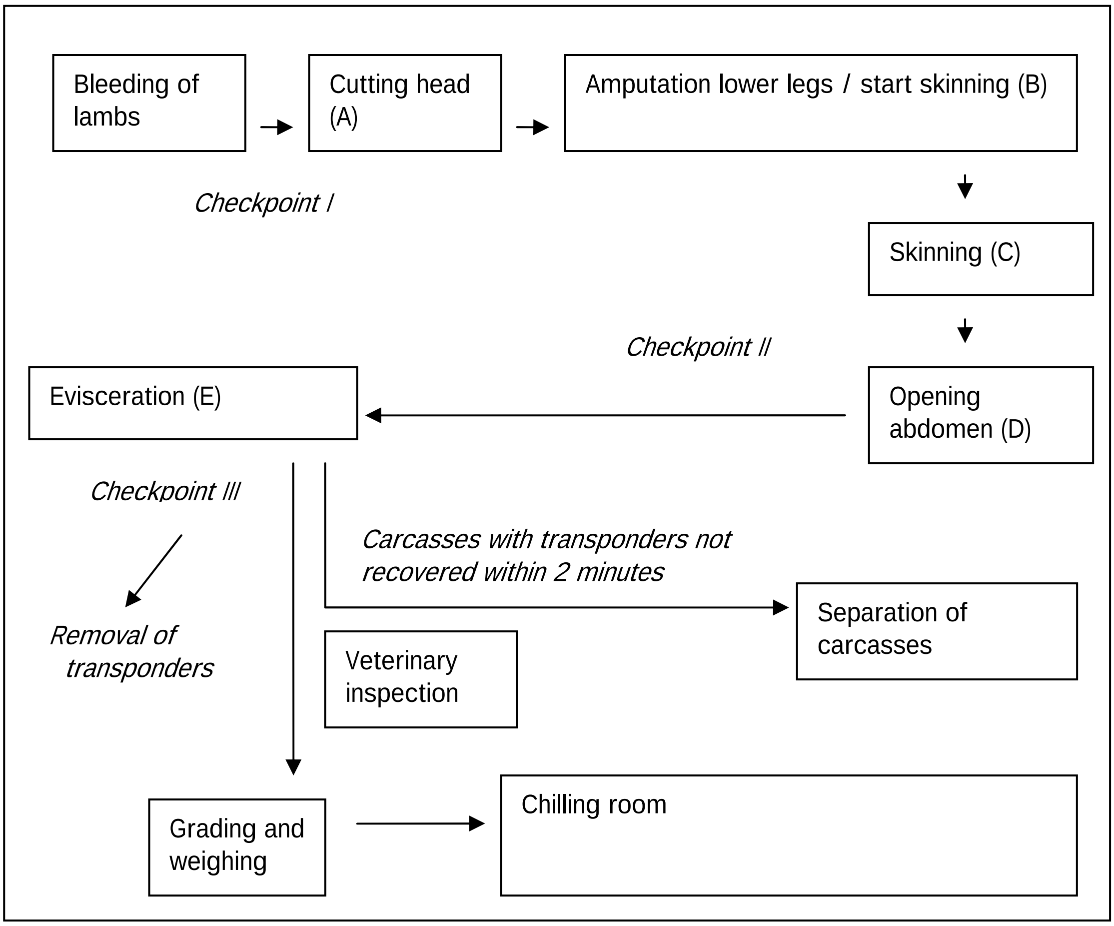
Lambs used for the experiment received a special blue ear tag in each ear with a special id-code series. The injectable transponders were coded with the manufacturing code (the official electronic identification scheme uses the 652 country code). This was to simplify distinction between normal lambs and those used in the experiment.

Transponders were injected during a three day period between 21February and 1March 2007.

Readability (yes/no) of the transponders and an inspection of the injection sites (inflammation yes/no) were performed three weeks after the last injection, on 22 March 2007.

The lambs were slaughtered on 8 dates in the period between 30 March and 1June 2007. During the slaughter process recordings were made of removal and recovery of transponders from the carcasses. Figure 6 gives a schematic drawing of the slaughter line.

Figure 6 Schematic overview of the slaughter line with action sides and checkpoints for presence of transponders



During slaughter after bleeding each carcass was placed horizontally on a conveyor belt. Head and lower parts of the legs were then amputated and some preparations for skinning were made (A and B). Thereafter, the carcass was hung by the hind legs, the skin removed (C) and the abdomen was opened (D). At the following point (E) evisceration took place. Subsequently the carcass was inspected by a meat inspector. Finally the carcass was graded, weighed and stored in a chilling room.

At checkpoint I the ear tag number, injection position and presence of the transponder by reading the electronic number were determined and recorded. At checkpoint II again the presence of the transponder was determined and recorded by reading the electronic number. At checkpoint III a final check was made of the identification of the transponder in a carcass. Carcasses in which the transponder was difficult to detect (searching for more than 2 minutes) were hung aside. After the whole batch had been slaughtered a more intensive search was performed on the carcasses hung aside.

2.4 Statistical analyses

Qualitative characteristics with 2 possible outcomes, as used for slaughtered lambs, lost transponders during fattening period, transponders recovered from carcass after skin removal and transponders lost in slaughterhouse, were analyzed with a GLM (Generalized Linear Model) with binomial distribution.
Ordinal characteristics with more than 2 possible outcomes, as used for easiness of injection, animal reaction during injection, recovery duration and carcass damage, are analyzed with a threshold model also belonging to the GLM's. In this case the distribution is multinomial.
Analyzed effects in both models were the factors Injection site, Injection operator and their interaction.
The analyses were performed using the statistical package GenStat for Windows 9th Edition.

3 Results

3.1 Transponder application

All the 559 transponders were injected during a three-day period (table 1). The injections were carried out by two persons, vet and farmer. The transponders were injected in the groin, abdomen, neck or armpit.

Table 1 Number of injected transponders according to injection site and operator

Operator /	Injection site				
No. injected transponders	Groin	Abdomen	Neck	Armpit	Overall
Vet	62	61	60	62	245
Farmer	71	77	81	85	314
Overall	133	138	141	147	559

The age of the lambs during application of the transponders varied between 8 and 45 days (mean: 30 days).

During application ease of the injection was scored by the operator. The results of the scores per class are given as percentage of the total number of scores per injection site and operator (table 2). In total 4 scores out of 559 were missing.

Table 2 Ease of injection (as percentage of number of observations) according to injection site and operator

Operator / Ease of injection, %	Groin	Abdomen	Neck	Armpit	Overall
Vet					
- Easy	87.1	63.3	45.0	79.0	68.9
- Moderate	9.7	26.7	31.7	19.4	21.7
- Difficult	3.2	10.0	23.3	1.6	9.4
Farmer					
- Easy	95.8	8.0	16.1	61.9	44.7
- Moderate	4.2	40.0	64.2	34.5	36.7
- Difficult	0.0	52.0	19.8	3.6	18.7
Both					
- Easy	91.7	32.6	28.4	69.2	55.3
- Moderate	6.8	34.1	50.4	28.1	30.1
- Difficult	1.5	33.3	21.3	2.7	14.6

Injection site: $p < 0.001$ Operator: $p < 0.006$ Injection site x operator: $p < 0.036$

Injection site significantly affects ease of injection. Groin was found easiest; neck and abdomen were more difficult sites. There was also a significant difference in the scores between vet and farmer. Injection at the groin has the easiest site for both vet and farmer. Except for the groin the farmer gave lower scores for abdomen, neck and armpit. Injections in the abdominal cavity were frequently scored ‘difficult’ by the farmer.

An assessment of the reaction of a lamb during the application was given by two experienced observers. Table 3 presents the results of the scores per class as percentage of the total number of scores per injection position and operator. Out of 559 scores two were missing.

Table 3 Animal reaction during injection (as percentage of number of observations) according to injection site and operator

Operator / Animal reaction, %	Groin	Abdomen	Neck	Armpit	Overall
Vet					
- No	59.7	53.3	15.0	59.7	47.1
- Light	33.9	28.3	48.3	29.0	34.8
- Medium	6.5	11.7	15.0	9.7	10.7
- Strong	0.0	6.7	21.7	1.6	7.4
Farmer					
- No	84.5	54.6	37.0	61.9	58.8
- Light	15.5	37.7	29.6	33.3	29.4
- Medium	0.0	1.3	23.5	1.2	6.7
- Strong	0.0	6.5	9.9	3.6	5.1
Both					
- No	72.9	54.0	27.7	61.0	53.7
- Light	24.1	33.6	37.6	31.5	31.8
- Medium	3.0	5.8	19.9	4.8	8.4
- Strong	0.0	6.6	14.9	2.7	6.1

Injection site: $p < 0.001$ Operator: $p = 0.064$ Injection site x operator: $p = 0.523$

There was a significant effect of injection site on the animal reaction. More than 30% of the animals showed 'medium' or 'strong' reactions during injection in the neck. 'No' or 'light' reactions were highest for groin followed by armpit and abdomen. There was a tendency (p<0.10) that animals injected by the farmer reacted less intensive.

During the fattening period 20 lambs (3.6%) died. Injection site and operator had no significant effect on the percentage of lambs that died prematurely.

After the fattening period 537 lambs were slaughtered. The age at the end of the fattening period varied between 58 and 135 days (mean: 91 days). The final destination of two lambs was not recorded. Table 4 shows the percentage of lambs that died prematurely per site and operator category.

Table 4 Number of lambs that died prematurely (as percentage of applied injectables) during the fattening period

Operator / Died prematurely, %	Groin	Abdomen	Neck	Armpit	Overall
Vet	3.2	3.3	8.5	3.2	4.5
Farmer	1.4	5.3	3.7	1.2	2.9
Both	2.3	4.4	5.7	2.0	3.6

Injection site: $p = 0.287$ Operator: $p = 0.293$ Injection site x operator: $p = 0.596$

3.2 Transponder losses

Detection of transponders in the lambs was checked by reading the electronic number on two occasions. When there was no response to the number code in the vicinity of the injection site the transponder was recorded as lost. Three to four weeks after application the first check was carried out in 553 lambs. In the meantime, six lambs had died. During this first check an inspection of the injection site was performed. The second check was carried out at the moment the 537 remaining lambs entered the slaughterhouse. Twenty lambs had died prematurely and the destination of two lambs remains unknown.

Table 5 presents the results for lost transponders per category (injection site x operator) as percentage of available lambs at that moment (dead or missing lambs excluded).

Table 5 Lost transponders (as percentage of applied injectables) during the fattening period

Operator	Groin	Abdomen	Neck	Armpit	Overall
1st check for lost transponders					
Vet	3.2	0.0	12.3	12.9	7.1
Farmer	14.1	0.0	2.5	17.7	8.7
Both	9.0	0.0	6.6	15.7	8.0
2nd check for lost transponders					
Vet	3.3	0.0	14.8	13.3	7.7
Farmer	15.7	6.9	3.9	20.2	11.8
Both	10.0	3.8	8.3	17.4	10.1

1st Injection site: $p < 0.001$ Operator: $p = 0.506$ Injection site x operator: $p = 0.014$
2nd Injection site: $p = 0.002$ Operator: $p = 0.124$ Injection site x operator: $p = 0.001$

At the 1st check 8.0% of the injected transponders were lost; at the second check this had increased to 10.1%. The injection position had a significant effect (at 1st check $p < 0.001$ and at 2nd check $p = 0.002$) on the losses. There was no overall effect on losses accountable to the operator (at 1st check $p = 0.506$ and at 2nd check $p = 0.124$). However for farmer the losses were significantly higher for the groin and for the vet significantly higher for the neck.

At the 1st check injections as well as inflammation of the injection site were evaluated. Inflammation of the injection site was recorded in 8 lambs (1.5%). Injection site or operator had no significant effect on the percentage of inflammations.

3.3 Recovery of transponders in slaughterhouse

In total 537 lambs entered the slaughterhouse. As shown (table 6), 10.1% of these lambs had lost the transponder. Transponder recovery was evaluated for those lambs (483 head) from which the presence of a transponder was recorded at checkpoint I in the slaughterhouse (figure 6) .

At checkpoint II, presence of the transponder was determined by reading the electronic number and recorded (table 6).

Table 6 Transponders out of the carcass at checkpoint II (in % of carcasses with transponder at checkpoint I)

Operator / Transponders out of carcass after skinning, %	Groin	Abdomen	Neck	Armpit	Overall
Vet	51.7	5.3	51.3	5.9	27.3
Farmer	48.3	4.8	33.9	20.3	26.4
Both	50.0	5.0	40.4	13.9	26.8

Injection site: $p < 0.001$ Operator: $p = 0.758$ Injection site x operator: $p = 0.037$

Table 6 shows that halfway through the slaughter process at checkpoint II (figure 6) 26.8 % of the transponders had been recovered from the carcasses. However, there is a large difference between the injection sites. In particular the largest difference was found between groin and neck (resp. 50.0 and 40.4%) than between abdomen and armpit (resp. 5.0 and 13.9%). For vet operator the percentage transponders recovered after skinning was significantly higher for neck and lower for armpit. Groin and abdomen showed no differences between farmer and vet.

Table 7 Physically recovered transponders in the slaughterhouse (in % of carcasses with transponder at checkpoint I)

Operator / Transponders recovered in slaughterhouse, %	Groin	Abdomen	Neck	Armpit	Overall
Vet	96.2	93.2	93.2	98.1	95.2
Farmer	98.2	80.6	87.8	93.8	89.7
Both	97.2	86.5	90.0	95.7	92.1

Injection site: $p = 0.005$ Operator: $p = 0.028$ Injection site x operator: $p = 0.488$

On average 92.1% of the transponders were physically recovered in the slaughterhouse. Groin and armpit showed the highest percentage recoveries (table 7). Operator had a significant effect on the recovery rate.

At the end of the slaughter line all carcasses in which a transponder had been detected were examined until the transponder was actually found. As a result no carcasses with a detectable transponder were allowed to enter the chilling room.
Transponder recovery duration was recorded in four classes. The results are given in table 8.

Table 8 Effect of operator on transponder recovery duration at slaughter (in % of total number of assessments)

Operator \ Recovery duration, %	Groin	Abdomen	Neck	Armpit	Overall
Vet					
- <10s	82.1	98.2	56.8	10.2	64.1
- 10-30s	7.1	1.8	18.9	16.3	10.1
- 30-120s	7.1	0.0	8.1	18.4	8.1
- >120s	3.6	0.0	16.2	55.1	17.7
Farmer					
- <10s	74.1	96.6	48.3	33.9	62.9
- 10-30s	6.9	1.7	17.2	35.5	15.6
- 30-120s	8.6	1.7	15.5	14.5	10.1
- >120s	10.3	0.0	19.0	16.1	11.4
Both					
- <10s	78.1	97.4	51.6	23.4	63.5
- 10-30s	7.0	1.7	17.9	27.0	13.1
- 30-120s	7.9	0.9	12.6	16.2	9.2
- >120s	7.0	0.0	17.9	33.3	14.3

Injection site: $p < 0.001$ Operator: $p = 0.130$ Injection site x operator: $p = 0.008$

Injection site had a significant effect on the recovery duration (table 9). The duration was shortest for abdomen followed by groin, neck and was longest for armpit. Armpit and neck had a relatively higher number of carcasses that had to be separated (hung aside) because recovery lasted more than 2 minutes. The vet had a large number of carcasses in the class '> 120s' for armpit; for the farmer the class '>120s ' was somewhat larger for groin. Differences between vet and farmer were small for the abdomen and neck. For abdomen not a single carcass had to be separated and only a few in which the recovery lasted more than 10s.

During the recovery of the transponders recordings were made concerning carcass damage on 5 of the 8 slaughter dates. The results are given in table 9.

Table 9 Effect of operator on carcass damage for transponder recovery at slaughter (in % of total number of assessments)

Operator \ Carcass damage, %	Groin	Abdomen	Neck	Armpit	Overall
Vet					
- No	91.2	97.7	76.2	30.3	75.8
- Light	8.8	0.0	19.1	27.3	12.1
- Medium	0.0	2.3	4.8	12.1	4.6
- Strong	0.0	0.0	0.0	30.3	7.6
Farmer					
- No	75.8	100.0	65.9	56.3	75.2
- Light	9.1	0.0	24.4	34.4	16.6
- Medium	9.1	0.0	4.9	6.3	4.8
- Strong	6.1	0.0	4.9	3.1	3.5
Both					
- No	83.6	98.8	69.4	43.1	75.5
- Light	9.0	0.0	22.6	30.8	14.4
- Medium	4.5	1.2	4.8	9.2	4.7
- Strong	3.0	0.0	3.2	16.9	5.4

Injection site: $p < 0.001$ Operator: $p = 0.437$ Injection site x operator: $p = 0.019$

No damage was observed in 98.8% of the carcasses during recovery of the transponders from the abdomen. This percentage fell to 83.6% for the groin. For neck and armpit the values were much lower at 69.4 and 43.1% respectively. For the groin damaged carcasses were lower for the vet than for the farmer; neck and armpit values for damaged carcasses were higher for vet than for the farmer. Remarkable is the high percentage of strongly damaged armpit transponders injected by the vet.

Due to the fact that observations in the slaughterhouse had to be performed without disturbing the slaughtering process approximately 5% of registrations for the presence of transponders and 10% of transponder recovery data duration are missing.

4 Discussion

4.1 Transponder application

Ease of application of injectable transponders is dependant on site of application. Explanations for the differences can be:

- easiness of restraining the lamb;
- presence of wool at application site;
- thickness of the skin;
- proximity of the application site;
- emotional problems with application methods.

Both the vet and farmer found application in the groin easy because the lamb could easily be restrained, there is almost no wool in the groin and the skin is thin and the application spot can easily be reached. Both vet and farmer found application in the neck difficult because of problems with thickness of the skin, the presence of wool and the often quite strong reaction of the lamb. Application in the abdomen the was an emotional problem for the farmer. Both vet and farmer mentioned that application in abdomen is quite difficult because the needle penetrates the abdomen through the skin and peritoneum.

Both farmer and vet mentioned that the length of the application needle was too long. This made application difficult in the neck and especially in the abdomen. In some cases the needle went in too deeply. In a number of cases during application in the neck the needle was pushed through the fold of the skin, resulting in a failed application of the transponder.

In general, the farmer and vet had the opinion that application of an injectable transponder is less difficult than application of ear tags or boluses.

Animal reaction to application of injectable transponders is dependant upon injection site. The highest percentage 'no' or 'light' reactions were recorded at the groin and the neck recorded the highest percentage 'moderate' or 'strong' reactions. The operator has a significant impact on the reaction of the lambs. When injected by the farmer (who is more experienced in working with lambs) a significantly higher percentage of lambs showed 'no' or ' light' reactions during application.

The persons responsible for application and scoring the animal reaction had the opinion that in general the animals displayed less reaction to injections of the transponder than to application of ear tags or boluses.

The percentage of lambs that died prematurely during the fattening period averaged 3.6%. No effects of injection site and operator were found. Conill et al. (2002) found in a comparable experiment with fattening lambs slightly higher mortality rates. According to the farmer the 3.6% of lambs that died prematurely in the experiment was comparable to other groups of lambs fattened on the farm in the same period (Personal communication, 2007). From this it was concluded that the use of injectable transponders had no effect on mortality rate.

4.2 Transponder losses

Injection site has a significant effect on transponder losses. The abdomen has the lowest loss while armpit shows the highest loss. The farmer had significantly higher losses for the groin while for the vet losses at the neck significantly higher. Effects of operator on losses were also found in veal calves by Lambooij et al. (1999). So application method can have an impact on loss rate.

The loss rates recorded over a period of two months for armpit, groin and neck were high (>8%). Schuiling et al. (2004) reported a loss rate for electronic ear tags of 5.5% during a period of 1 year. It was expected that loss rates for injectable transponders should be < 4% in order to affect EU approval. Also the loss rate at the abdomen was at this stage quite high (3.8%), but it was expected that by improving the application method lower losses could be achieved. In piglets (Klindtworth et al., 2004, Caja et al., 2005 and Babot et al., 2006) and rabbits (Pinna et al., 2004) only losses lower than 2% were reported for transponders injected in the abdomen.

During observations in the slaughterhouse it was found that some of the transponders injected into the abdomen had ended up in the viscera while most of the transponders were found between the intestines (for farmer injected transponders 16% was recovered in the intestines, and 3% injected by the vet). Some of the transponders that (mistakenly) were injected into the viscera might have been removed from the body through the digestion system. This could explain the abdomen losses that were recorded during the last observation. The higher percentages of farmer injected transponders recovered in the intestines endorses this because all abdomen injected transponders recorded as lost were injected by the farmer.

4.3 Recovery of transponders in slaughterhouse

It is important to the slaughter process that the reading and recovery of the transponder can be performed efficiently. This can only be achieved if the injectable transponders are recovered at a single position in the slaughter process where recovery is reliable and quick.

The lambs entered the slaughter process ad random and the slaughterers were not informed about the application site of the lamb. Only the person responsible for transponder recovery (Figure 6 checkpoint III) knew the application site. So the personnel could not focus on a certain application method.

Halfway along the slaughter line a quarter of the transponders had already been recovered from the carcasses, most having been removed by slaughter personnel to prevent undetected losses. Percentages for groin and neck were much larger than for abdomen and armpit. The operator had a significant impact on the percentage transponders removed after skin removal for neck and armpit. Groin and abdomen showed no differences between operators. In general the observation is that there is an increased risk of transponder removal (accidentally or intentionally) during skinning with transponders injected under the skin .

On average 92.1% of the transponders were actually recovered in the slaughterhouse. Groin and armpit showed the highest and the abdomen the lowest percentage recoveries.

Many transponders injected in the groin were recovered during preparations for skinning and actual skinning (figure 6 B and C). Some of the injectable transponders might have been removed inadvertently with the skin.

During opening of the abdomen (Figure 6 D) some transponders were recovered from the carcass. It is conceivable that during the opening of the abdomen transponders fell from the carcass without being noticed. In quite a number of cases during evisceration (Figure 6 E) the intestines were disposed and consequently the transponders were not recovered.

Many transponders injected in the neck were recovered during removal of the head (Figure 6 A), preparation for skin removal and skinning (figure 6 B and C). Some of the injectable transponders might have been removed together with the head or skin without being noticed.

A relatively low percentage of transponders at the armpit had left the carcass before the actual removing at the transponder site (Figure 6), resulting in a high percentage of recovered armpit injectables.

Injection site had a significant effect on recovery duration. For the abdomen 97.4% of the injectable transponders were recovered within 10 seconds and no carcass with an abdomen transponder had to be separated from slaughtering line (hung aside). Also Caja et al. (2005) and Santamarina et al. (2007) reported easy recovery (in majority less than 10s per carcass) of intraperitonial injected transponders in pigs. Armpit and neck had relatively large numbers of carcasses that had to be separated because recovery took longer than 2 minutes. This corresponds with experiences of others for retrieval of armpit injected transponders of veal calves Lambooij et al. (1999) and Conill et al. (2000). For lambs Conill et al. (2002) reported that in 4% of carcasses recovery time of transponders in the armpit was longer than 2 min. For armpit and groin there was a significant impact of the operator on recovery time, while for abdomen and neck the differences were small. The effect of operator on recovery of injected transponders in piglets was also mentioned by Lambooij et al. (1995).

Recovery of the injectable transponders from the abdomen gave almost no carcasses damage. For the groin, neck and armpit more then 15% of the transponders could only be recovered with light to strong carcass damage. An operator effect on carcass damage was observed for groin, neck and armpit.

5 Conclusion

In table 10 an interpretation of the results is given for ease of injection, animal reaction, loss rates, physical recovery, recovery time and carcass damage for the different application sites.

Table 10 Overview of the results application, loss rates and slaughterhouse recovery for injection site

	Groin	Abdomen	Neck	Armpit
Easiness of injection	+ +	±	±	+
Animal reaction	+ +	+	±	+
Loss rates	-	±	-	- -
Physical recovery	+	-	-	+
Recovery time	-	+ +	- -	- -
Carcass damage	-	+ +	-	- -

Application is not difficult at any of the injection sites. The operator interacts with transponder losses and recovery during slaughter.
Conclusion: instruction and specific application tools are a requirement.

The animals show no strong reactions to methods of application.
Conclusion: all methods are acceptable from an animal well-being point of view.

Loss rates for groin, neck and armpit positions are high, loss rate at the abdomen position is of an acceptable level.
Conclusion: abdomen has an acceptable loss rate level.

Physical recovery is a requirement from a food safety point of view for groin, neck and armpit positions. For the neck position the physical recovery is a problem.
Conclusion: food safety can not be guaranteed if transponders are injected into the neck.

The recovery of transponders at groin, neck and armpit sites takes quite some time in contrast with the abdomen.
Conclusion: abdomen transponders could be recovered within an acceptable time frame.

Many carcasses were damaged during the recovery of transponders at the groin, neck and armpit. Conclusion: abdomen transponders do not damage the carcass.

The above mentioned conclusions are summarized in table 11 considering affects on animal well-being, slaughter and food safety..

Table 11 Overview of conclusions regarding the use of injectable transponders

	Groin	Abdomen	Neck	Armpit
Animal well-being	+ +	+	±	+
Slaughtering process	-	+ +	-	- -
Food safety	±	+ +	-	- -

General conclusion: low losses and simple recovery of transponders injected into the abdomen are encouraging. Fine-tuning and further testing of abdomen application procedures and transponder instructions are required.

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Annex 1 Overview of results from studies into the use of injectable transponders

Authors	Animals	N	Transponder size	Injection site	Transponder losses** (%)	On farm remarks	Recovery (%)	Remarks recovery
Lambooij et al., 1995	piglets	3436	30 x 3,5 mm	ear base	1,6 - 6,9			- 62 and 82% retrieved from ear base: too low for accurate retrieval - effect of farm/operator and devices: adequate instruction important
		5947	30 x 3,5 mm	ear base	4,9 - 7,3	- differences in losses between devices/suppliers		
Stärk et al, 1998	piglets	100	23 mm long	ear base	20,8	- 4% had sings of infection		
		80	11,5 mm long 23 mm long	ear base	0 15,8	- small transponders: healing faster, migration larger		
Klindtworth et al., 2004	piglets	405	12 x 2,1 mm 23 x 3,0 mm 23 x 3,8 mm	ear base	1,9 4,1 5,8	- injection of large transponders (3,0/3,8) in area of ear at very young age not possible		- direct 42,%, indirect 49,6%, afterwards 0,9%, no doc. 7,4%
			12 x 2,1 mm 23 x 3,0 mm	outer ear	50,0 50,0	-transponder size 23 x 3,8 mm not used; too large		- indirect 88,9%, migrated 11,1%
			12 x 2,1 mm 23 x 3,0 mm 23 x 3,8 mm	abdominal cavity	0 0 2,0	- all sizes (also large) possible from young age		- 88% fixed between intestines - 8,3% fell from the carcass - no doc. 1,5%
Caja et al., 2005	piglets	557	12 x 2,12 mm 23 x 3,8 mm 32 x 3,8 mm 34 X 3,8 mm	auricle base	19,5 29,8 48,7 75	- all on farm losses during 1st month after application - no negative effects on animal performance - injection time auricle base 102s and intraperitonial 84s	96,8	- mean recovery time: 28,6s - 42,3% recovered in less than 10s
			12 x 2,12 mm 23 x 3,8 mm 32 x 3,8 mm 34 X 3,8 mm	intraperitonial (*)	1,0 0,0 0,0 0,0		81,4	- mean recovery time 18,9s - 61,4% recovered in less than 10s - 18,6% fell out at moment of evisceration - no transponders in carcasses
Babot et al., 2006	piglets	1455	32/34 x 3.8 mm	intraperitonial (*)	1,8	- no negative effects on animal performance		
Santamarina et al, 2007	piglets	1264	32/34 x 3.8 mm	intraperitonial (*)			89,0	- 87% adhered to omentus; 12 % in gut mass; 0,8% in bladder. - losses: 11% fell on floor - most transponders recovered in less than 10s

(continuation annex 1 see next page)

Annex 1 continued

Authors	Animals	N	Transponder size	Injection site	Transponder losses** (%)	On farm remarks	Recovery (%)	Remarks recovery
Hasker & Bassingthwaighte, 1995	feedlot steers (>20 mo)	4630	29 x 3,6 mm	scutiform cartilage	23-28		94,1	- not recovered transponders (5,9%) fell to the floor when the ear was removed or were removed with the hide
Lambooij et al, 1999	veal calves	89	19 x 2,8 mm	upper lip	10,1		26,3	- recovered during skinning of the nose
			28 x 3,6 mm	scutiform cartilage	25,8		83,3	- recovery losses with skin or on floor
			28 x 3,6 mm	armpit	3,4		65,1	- 30% found in the slaughter line; 35% recovered later from the carcass
	veal calves	421	28,6 x 3,6 mm	scutiform cartilage	16,4			
			19 x 2,8 mm	scutiform cartilage	31,3	- effect of injection age on losses		
	veal calves	199	medium size (~28x3,6 mm)	scutiform cartilage	5,0	- effect of operator on losses	20,6	
Conill et al., 2000	veal calves	686	23/32 x 3.8 mm	armpit	2		96,7	- mean recovery time: 75s
			23/32 x 3.8 mm	ear scutulum	5,2		96,7	- mean recovery time: 52s - 23,4% of transponders in hide
			23/32 x 3.8 mm	upper lip	15,3	- on farm losses much larger for 32 mm than for 23 mm tarnsponder	99,2	- mean recovery time: 27s
Pinna et al., 2004	rabbits	79	32,5 x 3,8 mm	abdomen cavity	0,0	- no negative effects on animal performance	100	- easy recovery

(continuation annex 1 see next page)

Annex 1 continued

Authors	Animals	N	Transponder size	Injection site	Transponder losses** (%)	On farm remarks	Recovery (%)	Remarks recovery
Caja et al., 1998	adult sheep	26	32,5 x 3,8 mm	ear base	3,8	- easiness of injection: medium - anim. reaction at injection: strong - problem: losses/breakages		
			32,5 x 3,8 mm	neck	0,0	- easiness of injection: medium - anim. reaction at injection: strong - more than 1/3 migrated to shoulder or chest		
			32,5 x 3,8 mm	armpit	0,0	- easiness of injection: easy - anim. reaction at injection: low - early fixation of transponder		
			32,5 x 3,8 mm	chest	0,0	- easiness of injection: easy - anim. reaction at injection: medium		
			32,5 x 3,8 mm	groin	0,0	- easiness of injection: easy - anim. reaction at injection: low - after 90 days transponders fixed - location problematic for dairy/suckling sheep		
			32,5 x 3,8 mm	tail	23,1	- easiness of injection: easy - anim.reaction at injection: medium - losses/breakages too high		
Conill et al., 2002	lambs	1159	32 x 3.8 mm	armpit	5,5	- easiness of injection: easy and safe - no negative effects on animal performance	90,2	- mean recovery time: 22s - in 4.0% recovery time > 2 min
			32 x 3.8 mm	retro-auricular region	4,3	- no negative effects on animal performance - some problems in very young animals	82,1	- mean recovery time: 14s - in 0,3% recovery time > 2 min

(*) = in the abdominal cavity between the intestines
(**) = including breakages