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in

Gabiña D. (ed.), Bodin L. (ed.).
Data collection and definition of objectives in sheep and goat breeding programmes: New prospects

Zaragoza : CIHEAM
Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 33

1997
pages 43-57

Article available on line / Article disponible en ligne à l'adresse :

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http://om.ciheam.org/article.php?IDPDF=97605988

To cite this article / Pour citer cet article

Caja G., Nehring R., Conill C., Ribo O., Peris S., Solanes D., Barillet F., Marie C., Ricard E., Aurel M.R., Jacquin M., Lagriffoul G. **[Situation actuelle de l'identification électronique chez les ovins et caprins à l'aide de transponders passifs].** In : Gabiña D. (ed.), Bodin L. (ed.). *Data collection and definition of objectives in sheep and goat breeding programmes: New prospects* . Zaragoza : CIHEAM, 1997. p. 43-57 (Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 33)

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State of the art on electronic identification of sheep and goat using passive transponders*

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SUMMARY - Electronic identification using radiofrequency transponders is a new tagging technology that can provide a reliable and useful method for the control and recording of sheep and goats. Injectable, electronic ear-tags and ruminal bolus transponders are the devices used in sheep and goat electronic identification in practice and are reviewed in this paper. Injectable transponders are embodied into a bio-compatible glass capsule and are injected subcutaneously into the animals' body. The main problems observed are losses, breakages and recovery after slaughter. Advantages and drawbacks of different injection body sites and transponder technology are discussed. In conclusion, only the armpit and ear-base are recommended as suitable body sites for sheep in field conditions. The armpit was also the recommended body site for subcutaneous injections in goats. Electronic ear-tags are at present applied in dairy sheep or dairy goat farms for automatic feeding of concentrates. The ear-tag weight must be limited when it is applied in young animals, reducing its reading distance and dynamic reading efficiency in consequence. The main advantages of ear-tags are related to its easy recovery and reutilization in the farm. The use of a ruminal bolus as a carrier of electronic devices is a new strategy for electronic identification of ruminants. With this aim, a ceramic bolus has been proposed to be used indistinctly in sheep, goat and cattle at different ages. Oral administration of bolus is easy and safe, but the application in animals heavier than 25 kg is only recommended in practice. No negative reaction or behaviour alteration were observed in any animal after bolus administration. No losses, breakages or failures were observed one year after application in grazing or semi-stabled sheep and goat and reading efficiency in restrained and in moving animals walking through a race-way was 100%. Two comparative trials using electronic ear-tags, injectable and ruminal bolus transponders carried out in two experimental dairy sheep farms, are also discussed. In conclusion, the electronic identification proved to be a reliable and useful tool for management and milk recording in dairy sheep.

Key words: Electronic identification, sheep, goats.

RESUME - *"Situation actuelle de l'identification électronique chez les ovins et caprins à l'aide de transponders passifs". L'identification électronique à l'aide de transponders de radiofréquence est une nouvelle technique d'identification qui peut offrir une méthode fiable et utile pour le contrôle et l'enregistrement des ovins et des caprins. Les transponders injectables, électroniques agrafés à l'oreille ou incorporés au bol ruminal sont des gadgets utilisés dans la pratique pour l'identification électronique des ovins et des caprins et ils sont révisés dans cet article. Les transponders injectables sont incorporés dans une capsule de cristal biocompatible et ils sont injectés de façon sous-cutanée dans le corps de l'animal. Les problèmes principaux observés sont des pertes, ruptures ainsi que la nécessité de récupération après l'abattage. L'article discute les avantages et les inconvénients des différents sites d'injection dans le corps ainsi que la technologie des transponders. Pour conclure, seulement l'aisselle et la base de*

*Results summarized in this paper are part of the activities developed by the authors in the frame of the AIR3-CT 2304 project, under the support of the DG VI (Agriculture) from European Commission, and in the France-Spain's Cooperation Project 271-B "Program Picasso 1995".

l'oreille sont recommandées comme sites adéquats pour les ovins dans des conditions de terrain. L'aisselle est aussi le site recommandé pour l'injection sous-cutanée chez les caprins. Aujourd'hui les "ear-tags" électroniques sont utilisés dans les exploitations d'ovins et de caprins pour l'alimentation automatisée en aliment concentré. Le poids des "ear-tags" doit être limité quand ils sont appliqués sur de jeunes animaux et par conséquent la distance de lecture et l'efficience de la lecture dynamique se voient réduites. Les avantages principaux des "ear-tags" sont la récupération et réutilisation faciles dans l'exploitation. L'utilisation du bol ruminal comme support du gadget électronique est une nouvelle stratégie pour l'identification électronique chez les ruminants. Dans ce but, on a proposé l'utilisation d'un bol ruminal de céramique par les ovins, caprins ou bovins indifféremment et à différents âges. L'administration orale du bol ruminal est facile et sûre, mais l'application chez les animaux ayant un poids supérieur à 25 kg est seulement recommandée dans la pratique. On n'a pas observé de réactions négatives ou d'altérations de comportement chez les animaux après l'administration du bol ruminal. On n'a pas observé non plus de pertes, ruptures ou défauts de fonctionnement un an après l'application chez les ovins et caprins en pâturage ou en semi-stabulation ; et l'efficience de la lecture chez les animaux entravés ou en mouvement dans une piste est de 100%. Deux essais comparatifs à l'aide de "ear-tags", transponders injectables ou incorporés au bol ruminal réalisés dans deux exploitations expérimentales d'ovins laitiers sont aussi discutés. Pour conclure, l'identification électronique s'est avérée être un instrument fiable et utile pour la gestion et le contrôle laitier chez les brebis laitières.

Mots-clés : *Identification électronique, ovins, caprins.*

Introduction

Despite the fact that the use of radiofrequency in electronic identification of livestock comes from the 70's (Spahr, 1992; Ribó, 1996), sheep and goat have been only recently electronically identified. The main reason invoked to consider the electronic identification not recommendable for sheep and goat is the relatively high price of the electronic identification device in relation to the animal value.

This focusing seems to be inadequate when animal control and recording are included in the evaluation of costs. In this situation, the cost of conventional ear-tag identification can be in practice from 10 to 15% higher than electronic identification (Caja *et al.*, 1997b). Reduction of costs is explained by both lower identification losses and labor costs in medium and big size flocks. Moreover, electronic identification of sheep and goat have been studied as an efficient way to control big flocks of sheep and goat under FEOGA subsidies in the European Union (Caja *et al.*, 1994b,c).

Therefore, electronic identification of sheep and goat can be inefficient or operate in unauthorized radiofrequency bands when some technologies, not ISO conforming (ISO standards 11784 and 11785), are used. This aspect is summarized in Table 1. Only the FDX-B (full duplex) and HDX (half duplex) methods of information exchange are today in full agreement with the approved ISO standards as discussed by Caja *et al.* (1997b). Recently some brands classified as FDX-A in Table 1 (Nedap, Datamars and Avid) move to the FDX-B duplicity method and have presented in the market the new ISO agreeing transponders.

The electronic identification device is called transponder (from the words transmitter and responder) and passive technology (without batteries) is preferably used in practice. The passive transponder is a small electronic radiofrequency device consisting of a microchip with all the electronic circuitry, a coil and a capacitor, all of them embodied into a glass or plastic cover to give water-proof protection. The transponder is activated by a radio signal (electromagnetic field) transmitted by a readout unit also called transceiver (from the words transmitter and receiver), and it reacts to this signal emitting a preprogrammed identification code (Sigrimis *et al.*, 1985; Collewet and Raoult, 1989).

The ISO coding memory of the pre-programmed, or read-only (R/O) transponder, is formed by a unique 64 bits code previously programmed in the factory, in which 38 bits are assigned to the identification number (translatable to a 20 digits number).

The code structure according to ISO 11784 standard is presented in Table 2. Nearly 275,000 million different identification codes can be programmed in these conditions for animal identification. At present the country code is provisionally replaced by a manufacturer's code given by the International Committee for Animal Recording (ICAR). Approved ICAR manufacturer's codes in 1996, in order of obtention, were: 985, Destron; 984, Nedap; 983, Texas Instruments; 982, Allflex; 981, Datamars; 980, Diehl-Ident; and 979, Earlsmere.

Most recently a new generation of programmable or read-and-write (R/W) transponders are also available but they are not yet included in the ISO standards. Programming of the identification code in this transponders can be done easily using a specially prepared reader.

Electronic identification of sheep and goat have been recently reviewed by Ribó (1996) and Nehring *et al.* (1996), indicating that injectable transponders, electronic ear-tags and ruminal bolus transponders are the devices used in sheep and goat identification trials in practice.

Injectable transponders

Sheep

Reduction in the size of electronic devices and the development of bio-compatible materials have made the use of small transponders injected into the body of the animals possible.

The term injectable transponders is preferred to implantable transponders to describe the way of application and to limit the size of the transponders to be applied. Today available injectable transponders are only embodied into a bio-compatible glass capsule and can be classified according to its length in: mini (<15 mm), small (15-25 mm), medium (25-40 mm) and big (>40 mm) transponders.

Numerous locations for transponders injected in animal identification tasks have been suggested, but there is a general agreement on the convenience of injecting the device subcutaneously into the animals' body. The main problems observed after injection are: bio-incompatibility, losses, occasional breakage and migration to other parts of the body (Spahr, 1992). The optimal transponder's location must allow an easy reading, provide protection from breakage or losses, and it must warrant specially that the transponder will remain in the injection area. The permanence of the transponder in the injection area will allow its easy and quick location and its recovery in the slaughter line.

Previous injection experiments made in pigs and cattle, indicate a preference for the left side of the animal and in the conjunctive tissue of the ear-base, which protects and fixes the transponder (Fallon and Rogers, 1991; Lambooij, 1991; Pirkelmann *et al.*, 1991). However in the ruminant species the head is separated during slaughtering, therefore the ear-base is not a convenient site when the permanent identification and traceability of the carcass is an objective. For these reasons other body sites have been suggested in sheep (Caja *et al.*, 1994a,b,c, 1997a; Marie *et al.*, 1995).

The first bibliographic references on electronic identification of adult sheep using injectable transponders come from a short trial (29 d) made by Kimberling *et al.* (1993), and a medium term trial (600 d) made by Jouveau and Potafeux (1993). Both used small transponders (FDX-A Destron, 18x3 mm) injected in the ear's *scutulum* (n=100) and *dorsum* (n=96), and ear's top (n=508) and *dorsum* (n=29), respectively. Results indicated a good readability in the short trial (97-99%), with 1% losses in the two body sites tested and 2% breakage in the *scutulum*, but decreased to 92% in the mid term trial (6.5% transponders failed by unknown cause).

A parallel experiment performed by Jouveau and Potafeux (1993) in ewe lambs (<1 year old) showed a very low readability (52%) probably due to the higher losses as a consequence of smaller ear size or to electronic failures of the transponders.

Recovery of transponders in the abattoir was only reported by Kimberling *et al.* (1993) that showed a high variability after slaughter, with 37-99% of transponders found in the skin and 60% found in the head, depending on the experimental group.

A similar experiment done by Hunt (1994) in lambs (n=40), injected in the ear *scutulum* (medial or posterior parts) using the same technology (FDX-A Destron, 18x3 mm), showed a 85-95% readability and 50-56% of transponders found in the skin and 33-40% found in the head.

Variability in localization of transponders in the abattoir can be attributed to transponder migration or to injection errors.

Table 1. Brand characteristics and main requirements for radio frequency identification of animals according to ISO 11784 and ISO 11785 standards (Caja *et al.*, 1997b)

Method of information exchange	FDX						HDX	
	A					B		
Activation freq. (kHz)	120	125	125	125	128	134.2	134.2	134.2
Brand	*Nedap*	*Avid*	*Destron 2X*	*Datamars*	*Trovan*	ISO-FDX	ISO-HDX	*Tiris, Allflex*
Modulation	AM	FSK	AM-FSK	PSK	PSK	AM or PSK	FSK	FSK
Return freq. (kHz)	117.7 - 119.5 120.5 - 122.3	109.4 - 112.5 137.4 - 140.6	109.4 - 112.5 137.4 - 140.6	111.1 138.9	64	129.0 - 133.2 135.2 - 139.4	124.2 (1) 134.2 (0)	124.2 (1) 134.2 (0)
Encoding	DBP	NRZ	Manchester	Manchester	DBP	DBP modific.	NRZ	NRZ
Bit rate (kbit/s)	1.875	2.5	1.25	1.25	8.0	4.194	7.7625 (1) 8.3875 (0)	7.7625 (1) 8.3875 (0)
Error detection algorithm	Parity	Parity	Parity	Parity	Parity	CRC-CCITT	CRC-CCITT	CRC-CCITT
Telegram (bits):								
Header	17 + 6	10	4	8	8	11	8	8
Identification	62	56	35	48	39	64	64	64
Error	43	16	5	6	17	16	16	16
Trailer			4			24	24	8 + 16
Control		6 + 8				13		
Total bits	128	96	48	62	64	128	112	112

Table 2. Transponder's code structure for animal identification according to ISO 11784 standard

No. of bit	Total (bits)	Information	No. of cases
1st	1	Use (1: animal; 0: non-animal)	2
2-15th	14	Reserve place for future applications	16,384
16th	1	Use additional block (1: yes; 0: no)	2
17-26th	10	Country code (according to ISO 3166)	1,024
27-64th	38	Identification code (20 digits)	274,877,906,944

For this reason Caja *et al.* (1994a,b, 1997a) and Marie *et al.* (1995) studied the migratory effects of medium size transponders (HDX Tiris, 32x3.8 mm), injected in different body sites (ear-base, neck, chest, armpit, groin and tail; n=26 for each body site) of adult ewes in a medium term experiment (250 d). Ewes were kept in a semi-stabulation system (grazing during the day and sheltered in the night) and X-ray photography was used to measure the actual migratory distance.

Results indicated that mean migration values in adult sheep were moderate and in the range of the length of the injector's needle used (6 cm). Migration rate was dramatically reduced after 45 d, indicating that the transponder was immobilized into a well formed connective capsule (Caja *et al.*, 1994a, 1997a; Nehring *et al.*, unpublished results). Increasingly higher migration values were observed with time in injections performed in the neck, chest and groin. Losses were only observed in the tail, that showed a very high value (19%), and approximately a 4% of breakages occurred in the tail and ear-base. Readability was in consequence: ear-base, 96%; neck, 100%; armpit, 100%; chest, 100%; groin, 100%; and tail, 77%.

This results were confirmed by Nehring *et al.* (1994, 1995) that indicated, in a bigger number of adult sheep using the same transponder type (HDX Tiris, 32x3.8 mm), readability values of transponders injected in: ear-base, 95% (n=99); neck, 92% (n=73); armpit, 100% (n=124); chest, 100% (n=44); groin, 100% (n=72); and tail, 89% (n=46) from 50 to 250 d post-injection. At slaughter, the losses of transponders in the abattoir were low in the ear-base (2%), armpit (4%) and neck (6%), the other body sites being >19%. The remaining 98% of ear-base injected transponders were found in the skin or head, but only 82% of armpit injected transponders were found in the armpit of the carcass (the 14% remaining was found in the skin).

To conclude, only armpit and ear-base, were recommend by Caja *et al.* (1994a,b,c, 1997a) and Nehring *et al.* (1994, 1995) as suitable body sites for the injection of electronic identification of adult sheep in field conditions.

Webber (1996), in a medium term (8 months) experiment in adult sheep (n=20) using small transponders (FDX-A Avid, 18x3.2 mm with parylene antimigratory coating), compared three positions on the ear (n=10), armpit (n=8), lower fore leg (n=4) and tail (n=8). According to the accessibility and practicality of use for different industries, he only proposed the ear, and indicated that while readability were on all sites acceptable (Avid power Tracker II) the situation read was not always possible.

In a second experiment in young lambs (1 to 5 d old; n=722), he compared three positions on the ear: ear-base (n=150), lower-ear (1 cm from the base; n=400) and mid-ear (n=172), as injection body sites using mini transponders (FDX-A Avid, 14x2 mm). A 4.6% of losses was reported by Webber (1996) in the first 10 d, indicating that 75% of losses occurred in the first 300 lambs and were associated with infection. Only ear-base, and not ear-body, was recommended in sheep.

In adult sheep, at medium scale and long term field trials using medium size injectable transponders (HDX Tiris, 32x3.8 mm), Caja *et al.* (1994b,c, 1997b), Ribó *et al.* (1995b) and Ribó (1996) demonstrated that armpit showed higher performance than ear-base as injection body site. This result comes from the follow-up of animals injected in a previous FEOGA project (Caja *et al.*, 1994c), on practical farm conditions during approximately 3 years. Eleven sheep farms under a performance recording program of the ANCRI breeders association in Catalonia (Spain) are involved in the trial.

The latest updated results (Table 3); (Caja *et al.*, 1997b) indicated readability values of 97.8% in the armpit (losses, 1.7%; breakages, 0.3%; failures 0.2%; n=4,063 sheep), and 93.5% in the ear-base (losses, 4.6%; breakages, 1.9%; failures 0.1%; n=1,053 sheep). The low breakage and failure values observed should be stressed and compared with previously cited references. The identification values were in all cases higher than values observed with conventional plastic ear-tag (mean losses from 11 to 17%).

The electronic identification using medium size injectable transponders (HDX Tiris, 32x3.8 mm) allowed the dynamic reading of sheep in the farm when a portable race-way equipped with a stationary reading unit (Gesimpex-S1000) and a frame antenna (Tiris, 94x52 cm) was used. Dynamic reading efficiency was 99% with transponders injected in the armpit and 96% in the ear-base. The speed of sheep passing throughout the race-way allowed the reading and recording of 2 animals/second.

Recovery of transponders performed by the farmer himself in culling or dead adult ewes in the farm, after localization of transponder by palpation, was feasible and easy. Mean recovery time varied between 58-65 and 67-78 s, in the ear-base and armpit, respectively. Losses in the whole recovery process are at present lower than 1%.

With regard to the identification of new born lambs, the effects of body site and age at injection on migration, readability and abattoir recovery using medium size transponders (HDX Tiris 32x3.8 mm) are nowadays under study (Ribó, 1996; Caja *et al.*, 1997b; Conill *et al.*, unpublished data). Two breeds are also considered as variation factor for data analysis. Present results show an interaction between lambs' age and body site, in transponders' losses in the farm, after injection. Mean values ranged from 3 to 7% (readability from 93 to 97%) but no breakages or failures were observed.

Recovery in the abattoir showed higher losses (from 9 to 26%) but lower recovery times (from 13 to 34 s) than in cattle. In consequence, the recovery times in transponders injected in lambs seems to be compatible with high abattoir yields (120 to 275 lambs/h). Results were less variable and more favourable in the armpit than in ear-base, and the injection of 32 mm transponders seems to be feasible at lamb's early ages. Coming results will improve the data analysis and conclusions.

Goat

Identification of goats using injectable transponders is more recent in literature than in sheep. First references are reported in the FEOGA project (Caja *et al.*, 1994c), from short term (90 d; Fonseca *et al.*, 1994a) and medium term (210 d; Fonseca *et al.*, 1994b; Ribó *et al.*, 1995a; Ribó, 1996) trials. These experiments included the comparison of injection feasibility and evaluation of migratory distances of medium size transponders (HDX Tiris, 32x3.8 mm) injected subcutaneously in different body sites of goat. Body sites tested were: ear-base, armpit, groin and tail.

The short term trial made by Fonseca *et al.* (1994a), comparing different body sites (n=90, in each body site), showed readability values of: 93% in the ear-base, 100% in armpit, 98% in groin and 89% in tail. Breakages and losses were higher in the ear-base (6 and 2%, respectively) and tail (4 and 7%, respectively).

Results agree with the conclusions reported in sheep, but migration showed higher values than observed in sheep (Ribó *et al.*, 1995a; Ribó, 1996) and showed a significant effect with time in the ear-base. To conclude the armpit was the recommended body site for subcutaneously injection of transponders in goat.

Medium and long term trials performed in adult goats, on practical farm conditions using the same medium size transponders (HDX Tiris, 32x3.8 mm) injected in the armpit, showed high readability values of 98% (n=1,362 goats; Fonseca *et al.*, 1994b) and 99% (n=1,936 goats; Caja *et al.*, 1997b; Peris *et al.*, 1977) approximately one year after injection. Differences in operator skill at injection (trained and untrained) were low and not significant (Caja *et al.*, 1997b).

This system of identification is at present used successfully in milk recording of goats in the ARCC breeding association of Catalonia (Spain), in which the total milk recording time by farm and data processing errors have been significantly reduced when compared with the manual recording (Peris *et al.*, 1996).

Table 3. Comparison of readability and reading efficiency of 32 mm transponder devices in sheep in field conditions (Caja *et al.*, 1997b)

Transponder type and body site	Time elapsed (months)	No. of readings (interval)	Transponders' partitioning, n (%)							Dynamic reading efficiency (%)†	Plastic ear-tag losses (%)
			Total farms	Unreadable			Recovered		Readable		
				Lost	Broken	Failed	Culling	Dead			
Injectable											
Armpit	27.2 (25 - 34)	7.4 (5 - 17)	4063 (8)	70 (1.72)	11 (0.27)	7 (0.17)	900 (22.2)	209 (5.1)	3975 (97.73)	99.9	498 (12.3)
				88 (2.17)			1109 (27.3)				
Ear base	24.3 (23 - 30)	5.7 (5 - 6)	1053 (3)	48 (4.56)	20 (1.90)	1 (0.09)	196 (18.6)	16 (1.5)	984 (93.45)	95.6	118 (11.2)
				69 (6.55)			212 (20.1)				
Ruminal bolus											
Ceramic††	14.5 (13 - 16)	10.5 (7 - 14)	463 (3)	0 (0)	0 (0)	0 (0)	20 (4.9)	55 (14.1)	463 (100)	100	80 (17.3)
				0 (0)			75 (18.3)				
Total	8 - 34	-	5579	-			1396		5422	-	696

†Using a race-way (50 cm width) with a Gesimpex-S1000 stationary reading unit (at 136 dBμV/m at 3 m) and a 94x52 cm antenna
††Ceramic bolus (Caja *et al.*, 1996b)

Electronic ear-tags

Sheep

The use of electronic ear-tag in adult ewes and lambs was first reported by Marie *et al.* (1995) and Caja *et al.* (1996a) and it is at present applied in some farms in the Roquefort area (France) for automatic feeding of concentrates in dairy ewes (Diependaele, 1955).

In the Marie *et al.* (1995) experiment, approximately 20 d old lambs (n=150) were tagged with medium size (HDX Allflex, 8 g) or small (FDX-A Nedap, 4.8 g) ear-button electronic transponders, placed in the internal face of the ear as the female piece of a plastic ear-tag. Results after 100 d indicated that cicatrization and durability during the rearing phase were satisfactory when the new born lambs were tagged with the small ear-button transponders. Total ear-tag weight (male and female parts) upper than 7 g was considered inadequate for young lambs.

In the second experiment, a group of adult ewes (n=67) hay fed and stabled in pens with auto-lock feeders, were identified with small ear-button electronic transponders (FDX-A Nedap, 4.8 g) during 6 months. Results indicated that all the transponders were readable and in place at the end of the experiment. More research is at present under development on the use of electronic ear-tags in automatic feeding and milk recording in dairy sheep (Barillet *et al.*; unpublished results).

In a recent experiment (Caja *et al.*; unpublished results) conducted in adult sheep (n=135) in semi-stabulation, using small ear-button electronic transponders (HDX Allflex, 4 g) coupled to a small disk male piece, 2% of failures was observed at the start of the experiment and were immediately replaced. Nevertheless, all the remaining electronic ear-tags are at present readable and in place 8 months after the application. Reading efficiency values are lower than 75% when dynamic readings are performed in a race-way equipped with a stationary reading unit (Gesimpex-S1000 with a 94x52 cm antenna). Reasons to explain this low reading efficiency are the size of the antenna inside the small ear-button transponders and the characteristics of the reading unit used. First trials made with a high field strength stationary reading unit have shown that a 100% reading efficiency can be achieved if reading conditions are improved.

The main advantages of electronic ear-tags versus injectable transponders are related to its easy recovery and reutilization in the farm, in the aim to reduce the cost of the identification system. The drawbacks of the system are the easy removal and exchange of the identification number between animals, making this system inadequate as a tamper-proof or anti-fraud method.

Goat

No literature references are available on the use of electronic ear-tag in goats. A recent experiment is under development (Caja *et al.*; unpublished results) in dairy goats (n=35) using small ear-button electronic transponders (HDX Allflex, 4 g). All electronic ear-tags are readable and in place at present 8 months after the application.

Ruminal bolus transponders

Sheep

The idea to use a ruminal bolus as a carrier of electronic devices comes also from the 70's, but has only recently received attention for electronic identification in livestock. The main problem in practice was the low bolus' retention in the fore-stomachs of the ruminants. First work on the use of ruminal bolus in sheep was done in the frame of a previous FEOGA research project (Caja *et al.*, 1994c) showing variable results depending on the bolus characteristics (Ribó *et al.*, 1994a).

Recently a new prototype of ruminal bolus in ceramic material was designed to be used indistinctly in sheep, goat and cattle at different ages (Caja *et al.*, 1996b). The bolus (under an European patent) was designed in atoxic high density ceramic material to place inside different types of glass encapsulated transponders. Dimensions of the bolus (7x2 cm approximately) made possible its oral administration to heavy lambs and to adult sheep and ensure its permanent tenure in the fore-stomach of sheep and goat during the life-span of the animals.

Two brands of different radiofrequency technologies of glass encapsulated transponders (HDX Tiris, 32x3.8 mm; and FDX-A Nedap, 28x3.6 mm) have been tested inside the bolus (Caja *et al.*, 1996a). Reading distances of the transponders inside and outside the bolus, with different reading units used, were unchanged. High density ceramic material used in the bolus manufacturing did not affect the characteristics of the reading signal in both radiofrequency systems used.

Oral administration of bolus reported by Caja *et al.* (1996b) was easy and safe, but some difficulties were found in lambs <20 kg of live weight. For this reason the application in lambs >25 kg is recommended in practice. Average time of administration was 24 s/animal in sheep and goat (only 1 operator). No negative reaction or behaviour alteration were observed in any animal after bolus administration and parturition took place normally in the adult and ewe-lambs identified with ruminal bolus and that were mated in the previous season. Previous trials with inadequate bolus' design showed regurgitation and expulsion of the bolus during the following year (Ribó *et al.*, 1994b), but in any case the bolus passed into the *omasum*, *abomasum* or intestines.

Updated results on experiments conducted in adult sheep with this new ceramic ruminal bolus equipped with medium size glass encapsulated transponders (HDX Tiris, 32x3.8 mm) are included in Table 3 (Caja *et al.*, 1996a,b, 1997b). No losses, breakages or failures were observed one year after application in grazing or semi-stabled sheep (n=463). Two cases of bloat and some diarrhoea occurred during the experimental year, but all bolus were still in place in the sick animals. In consequence, the retaining rate of the bolus was 100% in all situations.

Transponders in ceramic bolus (HDX Tiris, 32x3.8 mm) showed a 100% reading efficiency in restrained animals, with different hand-held readers, and in moving animals walking throughout a race-way equipped with a stationary reading unit similar to the previously described (Gesimpex-S1000 and a frame antenna Tiris, 94x52 cm).

Most bolus (>95%) were localized in the *reticulum* after application, using a short reading hand-held reader (Gesreader I), and were still in place after 1 year. The anatomical localization of the bolus in the *reticulum* was verified by X-ray photography in a sample of lambs and adult sheep (n=4; Caja *et al.*, 1996b) and after slaughtering (n=84; Caja *et al.*, 1997b). For this reason the term reticular bolus seems to be more appropriate than rumen bolus transponder.

Application of bolus in lambs (n=20; 20-22 kg live weight), reared intensively with concentrate and straw *ad libitum* until slaughter at 25 kg live weight, showed that lamb post-weaning growth rate before (231 g/d) and after (329 g/d) the bolus administration were unaffected when compared to untreated lambs (Caja *et al.*, 1996b). Differences between observed and predicted (by linear regression) weights after bolus application were non significant.

All bolus were recovered easily and quickly (5 to 8 s) after lamb's slaughter in the offal plant of the abattoir. Examination of the rumen-reticulum wall after slaughter showed that the epithelium was unaffected by the presence of the bolus.

The bolus showed that it can be used in combination with management practices in farm conditions, such as weighing with automatic scales and dynamic reading in conventional race-ways (Caja *et al.*, 1996b). The easy and safe recovery in the abattoir recommend the use of transponders inside of bolus as a tamper-proof system for electronic identification in sheep heavier than 25 kg. Development of a new bolus design for lighter lambs is under research (Caja *et al.*; unpublished results).

A bigger plastic-iron ruminal bolus (Nedap, 10.2 cm with a FDX-A 70 mm glass encapsulated transponder inside), initially designed for cattle, has also been successfully used in adult sheep (Caja *et al.*, 1996a). Main advantages and drawbacks of this bolus are respectively the bigger reading distance and the higher cost and breakability of the transponder and capsule when compared to ceramic bolus. A comparative trial performed by two research groups in adult sheep (Caja *et al.*, 1996a) is discussed later.

Goat

A parallel experiment at medium term is conducted in adult dairy goats (n=35) using the ceramic bolus (Caja *et al.*, 1996b, 1997b) with medium size electronic transponders (HDX Tiris, 32x3.8 mm) inside.

All bolus transponders are readable and in place at present, after one year from the application, and goats are apparently unaffected in milk yield and behaviour.

Comparison of different devices for electronic identification of dairy sheep

Two comparative trials using electronic ear-button tags, injectable and ruminal bolus passive transponders were carried out during a medium term trial, in two experimental dairy sheep farms (Caja *et al.*, 1996a).

In the first trial (1: INRA-La Fage), 67 Lacaune dry ewes were tagged using four different devices based in the Nedap radiofrequency technology (FDX-A, 120 kHz) during a period of 4-6 months. All animals were initially tagged with a small electronic ear-button transponder (FDX-A Nedap, 4.8 g) as the female piece of plastic ear-tags (Allflex, 1.8 g).

Three experimental groups where randomly formed according to devices: Group A1 (n_1=29), injected subcutaneously by untrained operators with medium size transponders (FDX-A Nedap, 28 mm) in the left armpit; Group B1 (n_1=20), tagged with the same transponders' type placed into ceramic ruminal bolus; and Group C1 (n_1=18), with big size transponders (FDX-A Nedap, 70 mm) in Nedap plastic-iron ruminal bolus (10.2 cm length).

Ewes in trial 1 were stabled in a group during the entire experiment and hay fed in auto-lock feeders. Static readings were performed at the start and at the end of the trial. A test of readability with the ewes in a double-24 stalls milking parlour (Casse 2x24 system) was conducted by two operators with the same Nedap hand-held stick reader and time and feasibility of reading from the front (head) or rear (pit) of the animal evaluated.

In a second step, after 2 months from start, ewes from group A1 (n_1=29) were split into two subgroups and tagged with either B (n_2=13) and C (n_2=16) ruminal bolus types. Furthermore in a third step, ewes from B1 (n_1=20) and C1 (n_1=18) were also tagged with transponders injected in the left armpit (FDX-A Nedap, 28 mm). Ewes were slaughtered in a commercial abattoir (approximately at 100 ewes/h) and traceability and recovery at the end of the slaughter line of different devices evaluated. All carcass were checked with a high sensitivity metal detector (Tiris Type GM17) to find broken or failed transponders.

In the second trial (2: UAB-Bellaterra) a total of 171 Lacaune and Manchega dry ewes were tagged using two different devices based on Texas Instruments radio frequency technology (HDX, 134.2 kHz) during a period of 6 months. Ewes were tagged with medium size transponders (HDX Tiris, 32 mm) and assigned to two experimental groups: Group A2 (n=110), injected in the right armpit; and Group B2 (n=61), tagged with same transponder type placed into small ceramic ruminal bolus.

Ewes in trial 2 were grazing by day and sheltered in group by night, and supplemented with hay in auto-lock feeders, during the entire experiment. Static readings using a Hokofarm Portoreader hand-held reader were performed at the start and the end of the trial and a test of readability with ewes in a double-12 stalls milking parlour (Casse 2x12 system) was also conducted by four operators, two of them the same as in trial 1. Dynamic readings were also performed monthly using a race-way (50 cm width) with a Gesimpex-S1000 stationary reading unit connected to a 94x52 cm frame antenna (Tiris).

A static reading test in laboratory conditions was also made with different readers compatible with the FDX-A Nedap (Nedap id-logger and Nedap stick) or HDX Texas Instruments technologies (Hokofarm Portoreader and Tiris Ri-hhu-w2dc) to show the limits of reading distance in a sample of all the devices used.

Results showed that a total of 7.5% in A1 and 2.3% in A2, injected transponders were lost. In addition 1.5% in A1 failed (no broken transponders were observed). In consequence readability at the end of the experiment was higher in A2 (97.7%) than in A1 (91.0%). Losses after injection for 28 mm transponders in untrained operators were higher in the second injection compared to the first (14.3 *vs* 3.6%) because a strong operator effect. The lowest values of losses after 6 months were obtained with 32 mm injectable transponders and trained operators in agreement with Caja *et al.* (1994c, 1997b). No losses, breakages or failures were observed in all bolus types (B1, B2 and C1) or in ear-button tags, all of them showing in consequence a readability of 100% at the end of the trial. No problems of cicatrization were observed in ewes with the ear-button tags in agreement with Marie *et al.* (1995).

Results of the static reading test performed in laboratory conditions on devices used showed that reading distance varied between different hand-held units and with type and orientation of transponders, being in averages: A1 and B1 (id-logger, 5-14 cm; and, stick, 4-21 cm), C1 (id-logger, 15-23 cm; and, stick, 20-43 cm), A2 and B2 (Hokofarm, 9-30 cm; and, Tiris, 15-46 cm). It is important to take into account that these results depend on the global system used (reader plus transponder), thus a modification of the reader characteristics may change the reading distances.

Readability in the milking parlour was feasible depending on the transponder type and localization in the animal as shown in Table 4. Easier reading was performed with front reading in ear-button tags that were localized quickly by sight, followed by rear reading of 32 mm transponders injected in the armpit (A2) or into ceramic ruminal bolus (B2) and Nedap bolus (C1). In these last cases the hand-held reader stick antenna was placed in the ventral or lateral side of the animal. Rear reading (from the parlour pit) had the advantage to being more feasible for people milking and recording milk production with manual jars. Nevertheless front or rear reading solutions may be suitable with an automatized milk recording system (Ricard *et al.*, 1995). All electronic reading and automatic recording times obtained in this work (2.22 to 3.98 s/ewe) are lower than times for manual reading and recording generally reported in dairy ewes locked in a milking parlour.

Table 4. Reading feasibility and time† of different transponder devices in a dairy sheep milking parlour (Casse system) depending on the hand-held reader position (Caja *et al.*, 1996)

Device characteristics and localization		Front (head)	Rear (pit)
Ear-button tag (ear)	Nedap-4 g	Easy 2.22 s/ewe (1.9 - 2.8)	Not possible
Injectable (in the armpit)	A1 (Nedap-28 mm)	Medium 3.50 s/ewe (2.8 - 4.2)	Easy 3.06 s/ewe (2.6 - 3.5)
	A2 (Tiris-32 mm)	Medium 3.79 s/ewe (2.9 - 4.5)	Easy 2.89 s/ewe (2.4 - 3.5)
Ruminal bolus (rumen-reticulum)	B1 (Ceramic-28 mm)	Not possible	Easy 3.15 s/ewe (2.7 - 3.5)
	B2 (Ceramic-32 mm)	Medium 3.98 s/ewe (3.4 - 4.8)	Easy 2.94 s/ewe (2.4 - 3.8)
	C1 (Nedap-70 mm)	Easy, but possible confusion between successive ewes††	Easy 2.96 s/ewe (2.6 - 4.0)

†Including the displacement time of operator
††Due to the high reading distance

Dynamic readings in a race-way of ewes identified with 32 mm transponders injected in the armpit (A2) or placed into ceramic ruminal bolus (B2) showed a 100% efficiency in both devices.

Recovery of the devices in the abattoir, in trial 1, was 100% for the bolus (B1 and C1) and 98% for the injectable transponders (A1) arriving at the abattoir (n=61). Most transponders were recovered from skin

(70%) and only 30% were retrieved from carcass at the end of the slaughter line. No failed or broken transponders were found with the metal detector in the carcasses.

Mean recovery time (s/ewe) in bolus and in injected transponders found in the carcass were not different [(12.5; n=67) *vs* (10.5; n=17), P>0.05, respectively]. Injected transponder recovery's time was not measured when recovered from the skin (n=42) and bolus' recovery was easier and showed a smaller range of variation than injected (5-36 *vs* 2-56 s/ewe).

In conclusion the electronic identification with the devices used in this experiment proved to be a reliable and useful tool for management and milk recording in dairy sheep. Both bolus and ear-button tags appeared to be safe and useful devices for identification and milk recording, but the choice between devices may depend also on other on farm automation applications (i.e. feeding, weighing, race-way reading and siding, etc.) and other considerations (i.e. veterinary and market control, tamper-proof, etc.).

Furthermore, to avoid the risk of failures and losses, we recommend at present to maintain a second manual and visual tagging (plastic ear-tag) to make the system completely reliable.

The IDEA project for sheep and goat

With the aim of answering the question proposed in Article 10 of the Directive 92/102/EEC (Identification and registration of animals), a call for participation in a large scale project on electronic identification of animals (IDEA: identification-electronic-animals) was made public by the agriculture services of the European Commission (DG VI: Agriculture) in July 1996.

Article 10 of the Directive provides that the Council of the European Union: "... in the light of the experience gained, has to reexamine the Directive in order to define a harmonized County-wide identification and registration system and to decide on introducing an electronic identification system based on the progress made in this field by the International Standards Organization (ISO)".

For this purpose the IDEA project was prepared by the FEOGA Unit of the DG VI and the Institute for Systems Informatics and Safety (ISIS) of the Joint Research Center (JRC) of Ispra (Italy), and it was intensively discussed with a working group of experts in animal and electronic identification, during 1995-96.

The main objectives of the IDEA project are to validate: the application technique of the electronic identification device, the transponder type and the reading materials and methods throughout the animal's life-span, the recovery of transponders after slaughter of the animal, the organizational structure for identification and registration of animals and for data management, and the flow of information between the different levels of responsibility. A total number of 1,000,000 animals (cattle, sheep and goat) will be electronically identified during 1997-99 according to the IDEA objectives.

A laboratory protocol was elaborated by the JRC to test all the material and equipment to be used in the IDEA project and several certification tests, under manufacturer's demand, were performed during the last quarter of 1996 in the ISIS laboratories. Transponders used in the IDEA project must be ISO agreeing and should be able to reach a 100% readability at a reference reading distance of 80 cm, when placed at the optimal orientation and operated with the adequate stationary readout unit (at an electromagnetic field strength <148.8 dBμV/m at 3 m, according to European Telecommunication Standards Interim regulations: pr I-ETS 300 330).

Nowadays 7 European countries (France, Germany, Ireland, Italy, Portugal, Spain and The Netherlands) showed interest into participating in the IDEA project and more than 400,000 sheep and goat are expected to be electronically identified in the next few years, using different types of ISO agreeing electronic transponders placed inside of bolus and ear-tags. Injectable transponders were discarded for sheep and goat in the IDEA project due to the recovery losses observed in the abattoir, as discussed before.

Results of the project will allow us to establish more conclusions on the advantages and drawbacks of the use of electronic identification in field conditions.

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