Long-term performance of visual and electronic identification devices in dairy goats

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ABSTRACT

Dairy goat kids born during a 3-yr period ($n = 97$) and their mothers ($n = 29$) were used for a long-term evaluation of the performance of 9 types of identification (ID) devices. Kids wore multiple ID devices: visual ear tags (V1, tip-tag, $n = 47$; V2, official, $n = 50$), electronic ear tags (E1, button-button, $n = 46$; E2, flag-button, $n = 46$), electronic rumen boluses (B1, mini-bolus 14 g, $n = 92$; B2, mini-bolus 20 g, $n = 28$; B3, standard bolus 75 g, $n = 34$) and glass-encapsulated transponders injected in the forefeet (T1, 15 mm, $n = 75$; T2, 12 mm, $n = 100$). Visual ear tags were applied at birth and removed in yearlings, whereas electronic ear tags were applied after bolusing with B1 (6.7 kg BW and 30 d, on average); B2 were administered in the event of a B1 loss, and B3 in case of a B2 loss and in goat does. At d 60 of age, kids were allocated into 2 groups to evaluate the effects of rearing system on ID. Treatments were: weaned ($n = 46$), and not weaned ($n = 46$) where kids suckled a milk substitute until d 150. Readability of ID devices (read/readable $\times 100$) was monitored from 1 to 3 yr of age, depending on device and year of birth. Long-term readability was analyzed using a nonparametric survival analysis. A total of 3.3% infections and 6.5% tissue reactions were reported for electronic ear tags, but ears were fully healed in yearlings. Weaning numerically reduced B1 losses at d 150 (weaned, 84.8% vs. not weaned, 73.3%). Readability of visual ear tags in yearlings (V1, 82.9%; V2, 94.0%) was lower than for electronic ear tags (E1 and E2, 100%). Mini-bolus readability in yearlings did not differ by type (B1, 71.4%; B2, 84.6%) or with visual ear tags. No effect of inject type was reported (T1, 92.0%; T2, 96.0%). Survival analysis after yr 3 gave the greatest readability value for E1 (100%), which did not differ from B3 (96.8%). The lowest readability was estimated for B1 (66.3%),

followed by E2 (79.8%), B2 (81.4%), and T1 (90.4%). In conclusion, button-button electronic ear tags and standard boluses were the more efficient devices under our conditions, their readability values being greater than injects, electronic mini-boluses, and visual and flag-button electronic ear tags. Transponders injected in the forefeet and mini-boluses used here are not recommended in practice. Further research on E1 and B3 electronic devices should be done in a higher number of goats to confirm the current results.

Key words: bolus, ear tag, electronic identification, goat

INTRODUCTION

Electronic identification of sheep and goats has become an important issue in the European Union since the publication of Regulation CE 21/2004 (recently amended by SANCO/1427/2008), which establishes a double identification (ID) system for replacement animals with both a plastic ear tag and a second device to be chosen by each member state. When the sheep and goat population within a member state is greater than 600,000 animals, the second means of ID must be a passive radio-frequency device. Double ID was expected to be mandatory in 2008 but has been put off until 2010, although it has been officially deployable since July 2005. In Spain, the electronic bolus has been used as the second means of ID since January 2006 (Real Decreto 947/2005).

Optimum retention of boluses in sheep and cattle has been achieved by optimizing their physical features (Caja et al., 1999; Fallon, 2001; Ghirardi et al., 2006). However, bolus retention in the case of goats has shown remarkable variability in practice, ranging from 89.7 to 99.6% (JRC, 2003; Capote et al., 2005; Pinna et al., 2006). That is why current Spanish legislation (Real Decreto 947/2005) permits the use (under authorization) of transponders injected in the metacarpus (forefoot) in goats. Although injection to this body site may prevent carcass contamination, animals cannot be used for consumption. Little information is available on the comparison of injectable transponders, electronic ear

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Figure 1. Electronic and visual devices used for the identification of dairy goats. V1 = tip-tag ear tag (Azasa-Allflex, Madrid, Spain); V2 = official tamper-proof ear tag (Azasa-Allflex); B1 = mini-bolus 13.7 g and 51.0×10.5 mm (Rumitag, Esplugues de Llobregat, Spain); B2 = mini-bolus 20.1 g and 56.4×10.5 mm (Rumitag); B3 = standard bolus 75 g and 68.2×21.0 mm (Rumitag); E1 = ear tag made of plastic button male piece (Azasa-Allflex) and electronic button female piece (Allflex Europe, Vitré, France); E2 = ear tag made of plastic flag male piece (Azasa-Allflex) and electronic button female piece (Allflex Europe); T1 = injectable transponder 15×2.1 mm (Avid Microchip España, Barcelona, Spain); T2 = injectable transponder 12×2.1 mm (Cromasa, Berriojar, Spain).

tags, and boluses in goats. In contrast to goats, over 99% retention has been achieved in lambs by using small size boluses (Garín et al., 2005; Ghirardi et al., 2007). No information is available on the use of electronic ID devices in replacement goat kids. The aim of this study was to investigate the long-term performance of visual and electronic ID devices applied in kids and dairy goats, as well as to evaluate the influence of rearing management conditions on the variability of the retention rate of small size electronic boluses.

MATERIALS AND METHODS

The experimental procedures and animal care conditions were approved by the Ethical Committee on Animal and Human Experimentation (Reference CEEAH 606/06) of the Universitat Autònoma de Barcelona. A total of 29 goat does and 97 goat kids of Murciano-Granadina dairy breed from the Experimental Farm of the Servei de Granges i Camps Experimentals (S1GCES), Universitat Autònoma de Barcelona, were used. Goat does were bred for an annual kidding season in the autumn and kidded during fall of 2004 ($n = 27$), 2005 ($n = 18$), and 2006 ($n = 18$), giving birth to 45, 26, and

26 kids, respectively. Kids were under study for 3, 2, or 1 yr depending on the year of birth.

Visual Identification

Each kid was identified at birth with 1 visual ear tag applied on the left ear. Two types of rectangular visual ear tags made of plastic (Figure 1) from the same manufacturer (Azasa-Allflex, Madrid, Spain) were used; ear tags features (weight, flag dimensions and pin dimensions) were “tip-tag” ear tag (V1; 1.4 g, 35.5×9.3 mm, 15.5×3.9 mm; opened female piece; $n = 47$) commonly used by the farmers for their low cost; and, official tamperproof ear tag (V2; 2.8 g, 40×14.5 mm, 22×5 mm; closed female piece; $n = 50$) made to fulfill the new requirements of the European Union Regulation 21/2004. Both V1 and V2 ear tags were considered temporary ID and were removed at 12 mo of age when yearling kids joined the breeding herd. All ear tags were printed with both a serial animal number (7 digits) and the holding number (14 digits) as required by Regulation 21/2004.

Goat does wore 2 flag plastic ear tags of large size (48×38 mm, yellow color; Azasa-Allflex) in the left ear.

These large ear tags were manually marked with individual codes of 3 digits (27 × 10 mm each) with black plastic ink (Allflex Tag Pen, Dallas, TX) and were used for milk recording (Ait-Saidi et al., 2008).

Rearing Treatments and Management

Kids were separated from their mothers in the first 8 h after birth, moved to straw-bedded pens (0.5 m² per kid) and fed colostrum 3 times a day until d 3. After d 3, kids were provided ad libitum milk replacer (CP, 23.8%; ether extract, 25.0%; crude fiber, 0.3%; ash, 6.6%; F 463, Sofivo, Condé sur Vire, France) in a concentration of 150 g/L until wk 8 by using an automatic milk dispenser (Model M-E250, Industrias J.R., Valdelafuente, Spain). From wk 3 of age, kids were also fed ad libitum with barley straw and a commercial concentrate (CP, 17.4%; ether extract, 3.3%; crude fiber, 4.1%; ash, 5.8%; O-118-G, La Gironina, Sant Gregori, Spain). Kids had free access to water as well. To evaluate the effect of rearing management on losses of ID devices administered at early ages, kids of 60 ± 3.1 d (10.2 ± 0.2 kg BW) were allocated into 2 balanced groups according to BW and randomly assigned to 2 experimental rearing treatments: weaned (**W**; n = 46), where kids were weaned with no transition period; and not weaned (**NW**; n = 46), where each kid received a daily (1700 h) supplement of approximately 1 L of a 1:1 dilution of goat milk in warm water (35°C) until 5 mo of age. Diluted milk supplement was administered by using buckets (9 L) with rubber teats, as described when attempting to maintain an active esophageal groove reflex (Ørskov et al., 1970). This conditioned reflex is a physiological mechanism of suckling ruminants to allow milk to by-pass the reticulorumen and reach the abomasum. Rubber nipples were placed at approximately 25 cm from the ground to allow for a natural position of suckling kids; that is, with the head and cranial esophagus in a lower position with respect to thoracic esophagus and forestomachs.

Concentrate was gradually replaced, from 2 to 4 mo of age, by whole barley grain and alfalfa pellets (1:1) ad libitum. At the age of 4 mo, kids passed to a semi-confined system, grazing 6 h daily (0900 to 1500 h) in cultivated Italian ryegrass pasture and supplemented with a dehydrated mixture of whole-plant corn and alfalfa hay (1:1) fed ad libitum, and a commercial concentrate (CP, 17.5%; ether extract, 3.8%; crude fiber, 4.0%; ash, 7.1%; 1.53 Mcal of NE_L/kg) according to the physiological stage. At the age of 18 mo, 47 (51%) animals were sold to 2 nearby herds and they continued to be monitored at least every 3 mo until the end of the study, or until death or slaughter.

In addition, 29 adult goats were used as a control for long-term retention of ID devices. Animals that died during the study were sent to the Pathology Service of the Universitat Autònoma de Barcelona for necropsy.

Electronic Identification Devices and Administration Procedures

Ruminal Boluses. Three types of cylindrical boluses (Rumitag, Esplugues de Llobregat, Spain) were used (Figure 1). Boluses were made of nontoxic, nonporous, and highly dense ceramic materials and their features were as follows [material, weight, length × o.d., and specific gravity]: bolus 1 (**B1**; zirconia, 13.7 g, 51 × 10 mm, and 3.5; n = 92), bolus 2 (**B2**; zirconia, 20.1 g, 56 × 11 mm, and 3.9; n = 28), and bolus 3 (**B3**; alumina, 75.0 g, 68.2 × 21.0 mm, and 3.4; n = 34). The first 2 types were small boluses specially designed to be administered to lambs and kids at early ages. The third type was a standard-size bolus previously used for cattle, sheep, and goats (JRC, 2003; Capote et al., 2005; Pinna et al., 2006) and used as a control. Each bolus contained a half-duplex (**HDX**), read-only, glass-encapsulated transponder of 32 × 3.8 mm (Ri-Trp-RR2B-06, Tiris, Almelo, the Netherlands). In kids born after July 2005, transponders included the country (Spain, 724), species (sheep and goat, 04) and the autonomous community (Catalonia, 09) codes and a 10-digit serial number, according to the current Spanish legislation (Real Decreto 947/2005) and in agreement with ISO 11784 and 11785 standards on animal electronic ID (ISO, 1996a, 1996b). For the rest of the animals, ISO transponders with the ICAR (2008) official manufacturer code (Rumitag, 964) and a 12-digit serial number were used.

For B1, to determine the minimum age and BW at safe bolusing, application was attempted on kids older than 15 d of age twice weekly. Boluses were administered by a trained operator by using an adapted balling gun (Rumitag). For bolus administration, kids were restrained between the operator's legs, holding the animal caudally to its shoulder blades. Then, the operator bent down and introduced the balling gun laterally into the animal's mouth while holding with the other hand its lower jaw at the region without teeth (diastema). The bolus was released into the bottom of the oropharyngeal cavity (base of the tongue) to stimulate the involuntary swallowing reflex, as described by Caja et al. (1999). If swallowing difficulties were observed, the bolus was expelled by means of an upward external massage on the throat and administration was delayed until the following bolusing session. To solve difficulties in the passage of a swallowed bolus through the esophagus tract, a plastic probe (length × o.d., 500 × 10 mm) was

prepared and used if necessary to gently push the bolus into the reticulorumen as previously done by Garín et al. (2005) and Ghirardi et al. (2007) in suckling lambs. The B2 bolus was administered in case of a loss of a B1 bolus by using the same procedures described above. Likewise, B3 boluses were administered in the event of a B2 loss. The B3 were administered by 1 operator and 1 assistant when animals had a BW greater than 20 kg, as indicated by Caja et al. (1999). Adult goats used as a control were identified with B3 boluses when yearlings, before joining the rest of the herd; one goat was rebolused with B3 before starting the study.

Electronic Ear Tags. Along with the B1 bolus administration, each kid was tagged with an electronic ear tag (Figure 1) on the right ear. One type of ear tag button female piece (**F**; weight 4.1 g, o.d. 24 mm, and height 11 mm; Allflex Europe, Vitré, France; $n = 92$) containing an HDX transponder was used. Transponder serial numbers included the manufacturer code (Allflex, 982) and worked in accordance with ISO standards (ISO, 1996a,b). Two types of male pieces were used: **E1** button type (Azasa-Allflex, Madrid, Spain; weight 1.8 g, button o.d. 28.5 mm, pin length $\times$ o.d. 20.5×5.5 mm; $n = 46$) and **E2** flag type (Azasa-Allflex; 3 g; flag length $\times$ width 48.5×42 mm, pin length $\times$ o.d. 20.5×5.5 mm; $n = 46$). Ear tags were applied to the middle of the ear at one third from the ear base, using tagger pliers recommended by the manufacturer (Universal Total Tagger, Allflex Europe); the F piece was placed on the internal side of the ear.

Injectable Transponders. A total of 175 full-duplex (**FDX-B**) read-only and glass-encapsulated transponders from 2 manufacturers were injected subcutaneously in the forefeet of 91 goat kids at 90 d of age. Transponders were (Figure 1): transponder 1 (**T1**; Avid Microchip España, Barcelona, Spain; length $\times$ o.d. 15×2.1 mm; $n = 75$) and transponder 2 (**T2**; Cromasa, Berriozar, Spain; 12×2.1 mm; $n = 100$). Serial numbers of transponders followed ISO standards (ISO, 1996a, b) and included the manufacturer code (Avid, 977; Cromasa, 953).

Injections of T1 were done using sterile single-use disposable syringes (Avid Microchip España) equipped with 31×2.8 -mm needles with a bevel length of 10.3 mm (Figure 1). Injections of T2 were done using a single-shot injector (Cromasa) with multiple-use 23×2.5 -mm needles with a bevel length of 3 mm. In this case, each needle was replaced after 20 to 25 injections. The T2 were presented in 20-unit dispensers (Identron-GT 212; Cromasa) and individually covered in an iodine solution; each transponder was charged by introducing the injector needle into the transponder dispenser, resulting in the needle being immersed in the iodine solution before each injection. To perform

the injections, 1 assistant restrained the animals on its back on a V-shaped restraining table, stretching out their extremities. The operator then held the forefoot and injected the transponder subcutaneously in a downward proximo-distal direction into the rear face of the metacarpal area, resulting in the transponder being placed at 1 to 2 cm over the proximal sesamoid bones (ossa sesamoidea proximalia). A gentle external pressure with a finger was exerted on the injection site when withdrawing the needle to diminish the backward movement of transponders during this process. After injection, a topical antibiotic (Veterin Tecnico, Laboratorios Intervet, Salamanca, Spain) was sprayed on the injection site. All injections were performed by previously trained operators.

Monitoring of Kids and Identification Devices

Kids were weighed weekly until 60 d of age by using a portable scale with an accuracy of 10 g (FX-31, Allflex NZ, Palmerston, New Zealand). Kids were thereafter weighed every second week until 150 d old by using a Tru-Test AG 500-02 (Pakuranga, Auckland, New Zealand) electronic scale with an accuracy of 100 g. Electronic devices were read in static conditions (animals restrained) by using ISO hand-held transceivers (Gesreader 2S, Runitag) which were able to read ISO HDX and FDX-B transponders at a minimum distance of 12 and 20 cm for ear tags and boluses, respectively, as specified in the technical guidelines for the implementation of European Regulation 21/2004. Each electronic device was read immediately before and after administration to check possible breakages or electronic failures during administration procedures. Readings were performed with the reader at a close distance to the device being checked to avoid interferences with other transponders applied in the same animal. At postadministration readings, individual kid data was typed and stored into the reader. For the boluses, a directional caudo-cranial sweep on both sides of abdomen area was performed with the reader to check the proper descent of bolus into the reticulorumen. Age and BW at administration of ID devices were registered as well as time required for administration of boluses and injectable transponders. Any incidents during administration procedures were also recorded.

Readings were taken at every weighing session under static conditions, until 150 d of age. From 5 to 18 mo of age all devices were read and checked monthly, and thereafter every 2 mo. In addition to losses, ear tags were monitored for electronic failure and damage (breakage, signs of nibbling, etc), as well as kid healthiness (hair appearance, growth, normal behavior, etc) and ear tissue reactions. When evaluating the performance of

injectable transponders, differentiation among losses, breakages, and electronic failures was determined by palpation as described by Conill et al. (2000), and an electronic failure was assumed when the transponder was deemed neither lost nor broken. Boluses applied in adult goats (B3) were read with the same regularity as devices applied in kids.

Performance of ID devices was expressed as readability, being:

$$\text{Readability} = (\text{no. of read devices} / \text{no. of readable devices}) \times 100.$$

Unreadable devices included losses, failures, and devices with damage that made them unreadable.

Dimensions of a total of 50 F pieces and 50 male pieces (E1, $n = 25$; E2, $n = 25$) of the electronic ear tags were measured by using an electronic digital caliper (accuracy = 0.03 mm; Shaodong Feiyue Hardware Tools Factory, Yiwu, China). The mechanical resistance of the locking system of these devices was measured by suspending a ballast and applying progressive weights (0.1 kg) until achieving 40 kg.

Statistical Analyses

Least squares means of age and BW at administration of devices were obtained with the GLM procedure of SAS (v. 9.1, SAS Inst. Inc., Cary, NC). Factors considered were type of ID device, year of birth, and the interaction type of ID device $\times$ year of birth. Non-significant ($P > 0.20$) effects were removed from the model. Data on physical features and resistance of the locking system of electronic ear tags were analyzed with the GLM procedure of SAS.

Losses, electronic failures, and readability of ID devices were analyzed with the CATMOD procedure of SAS on the basis of the categorical nature of these variables. A logit model with an estimation method of maximum likelihood (Cox, 1970) was used, evaluating the effects of type of ID device, year of birth, and the interaction type of ID device $\times$ year of birth. For the B1 and B2 bolus, effect of rearing treatment (W vs. NW) was also included. Significance was declared at $P < 0.05$ and interactions that were not significant ($P > 0.20$) were removed from the final models. Statistical analyses did not allow for comparisons with ID devices with no registered losses (100% readability).

For the analysis of readability at the end of yr 3, the Kaplan-Meier nonparametric survival analysis was considered preferable to the logit model to avoid the possible bias produced by the low number of animals monitored. A log-rank test of equality across strata (ID

devices) was performed with the LIFETEST procedure of SAS. This analysis permitted the comparison of the longitudinal readability of ID devices throughout the entire period of study without excluding right censored data (data from animals that left the study before a device failed), according to Cantor (2003) and Kleinbaum and Klein (2005), as well as the Kaplan-Meier estimates of readability for each type of device used. Survival monitoring started at device administration and, as continuous goat monitoring was not possible, time of device unreadability was registered as interval-censored data. In addition to Kaplan-Meier's readability estimates, survival curves for each ID device were also produced.

RESULTS AND DISCUSSION

Administration of Identification Devices

Total number of ID devices and administration records are shown in Table 1. Both V1 and V2 visual ear tags were inserted in kids of 1 d of age without incidents. Five kids (5.2%) died during the first 2 wk of suckling before being assigned to the extended rearing treatments, and 5 more kids (5.2%) died during yr 1 of the long-term study. Overall yearling mortality was 10.3%, which was lower than the average values reported under similar management conditions (15 to 20%; Daza, 2004). No relationship was established between kid casualties and the ID system used despite the long-term presence of boluses in the forestomachs and of injectable transponders in the pastern. The data from kids that died ($n = 5$) before being identified with electronic ID devices were eliminated from the study and only 92 kids were used.

Electronic Boluses. Four cases (4.3%) of bolus blockage into the esophagus occurred during administration of B1 in 1 mo of age suckling kids (Table 1). Within a few minutes of bolusing these kids showed profuse foamy sialorrhea along with nasal discharge, dyspnea, and apathy. Similar findings have also been reported when studying the minimum age and BW at mini-bolus administration in fattening lambs (Ghirardi et al., 2007). External palpation and directional caudo-cranial readings with a hand-held reader were carried out to confirm the bolus blockage. The esophageal probe was used to gently push the bolus into the reticulorumen as indicated by Garín et al. (2005) and Ghirardi et al. (2007). Affected kids fully recovered and no further incidents or secondary effects were reported. Safe bolus administration at early ages mainly depends on the anatomical development of the pharynx and esophagus and on the dimensions (length and o.d.) of boluses used. With regard to kid anatomical development, BW seems

Table 1. Identification devices¹ administered to kids (n = 97) and adult dairy goats (n = 29) during a 3-yr study

Item	Visual ear tags ^{2,3}		Electronic boluses			Electronic ear tags ⁴		Injectable transponders	
	V1	V2	B1 ⁵	B2 ⁶	B3 ⁷	E1	E2 ⁵	T1	T2
Devices, n	47	50	92	28	34	46	46	75	100
Administration records									
Age, d	1	1	30 ± 1	171 ± 26	Adult	30 ± 1	30 ± 1	90 ± 4	92 ± 4
BW, kg	2.1 ± 0.1 ^a	2.3 ± 0.1 ^a	6.8 ± 0.1 ^b	19.3 ± 3.9 ^c	43.6 ± 1.2 ^d	6.9 ± 0.1 ^b	6.8 ± 0.1 ^b	14.6 ± 0.3 ^c	15.1 ± 0.3 ^c
Time, s	—	—	28 ± 1 ^a	26 ± 1 ^a	—	—	—	34 ± 1 ^b	37 ± 1 ^b
Incidents, n	0	0	4 ⁸	0	0	3	3 ⁹	4 ¹⁰	6 ¹¹

^{a-d}Within a row, values with different superscripts differ ($P < 0.05$).

¹V1 = tip-tag ear tag (Azasa-Allflex, Madrid, Spain); V2 = official tamper-proof ear tag (Azasa-Allflex); B1 = mini-bolus 13.7 g and 51.0 × 10.5 mm (Rumitag, Esplugues de Llobregat, Spain); B2 = mini-bolus 20.1 g and 56.4 × 10.5 mm (Rumitag); B3 = standard bolus 75 g and 68.2 × 21.0 mm (Rumitag); E1 = ear tag made of plastic button male piece (Azasa-Allflex) and electronic button female piece (Allflex Europe, Vitre, France); E2 = ear tag made of plastic flag male piece (Azasa-Allflex) and electronic button female piece (Allflex Europe); T1 = injectable transponder 15 × 2.1 mm (Avid Microchip España, Barcelona, Spain); T2 = injectable transponder 12 × 2.1 mm (Cromasa, Berriozar, Spain).

²Applied on the left ear at 1 d of age.

³Five goat kids died during the first 2 wk of the suckling period.

⁴Applied on the right ear just after B1 administration.

⁵One goat kid died at 79 d of age because of pneumonia.

⁶Administered after detecting a B1 being lost.

⁷Administered after detecting a B2 being lost (n = 5) as well as in adult goats (n = 29).

⁸Boluses were blocked in the esophagus and gently pushed with a probe (500 × 10 mm) to the reticulorumen without health consequences.

⁹Profuse bleeding in 3 ears which stopped within a few minutes, 3 more ears showed infection with purulent secretion that healed at 2 mo. Six more ears showed tissue reaction (swelling and irritation) to ear tags but fully recovered at 6 mo.

¹⁰Bleeding after injection without posterior infection.

¹¹Bleeding after injection without posterior infection was observed and 1 kid more showed limping that recovered 1 d later.

to be more accurate than age to assess the threshold for the safe administration of boluses. The BW and age at which B1 administration was possible were 6.8 kg and 30 d on average (Table 1). Using the same bolus type, Ghirardi et al. (2007) reported a BW at administration of 8.6 and 9.6 kg in lambs of local and dairy breeds, respectively. Using standard boluses of 66 × 20 mm (65 g), Caja et al. (1999) recommended a BW greater than 20 and 25 kg for goats and sheep, respectively. Our results confirmed that boluses can be administered at an earlier age and lower BW in goats than in sheep.

A total of 19 B1 were lost by 5 mo of age (readability 79.1%; Table 2) and were replaced by B2, which were administered at 14.9 ± 0.3 kg of BW and 105 ± 7 d on average. No administration incidents were observed at this time. In addition, another 7 and 2 B1 were lost and replaced by B2 by yr 1 and 3 of the experiment, respectively, with a total of 28 B2 boluses administered (Table 1 and 2). Time needed for bolus administration, reading, and recording of ID data into the reader did not differ between B1 and B2 boluses (Table 1; $P = 0.505$) and was lower than that reported by Ghirardi et al. (2007) for mini-bolus administration in lambs; however, those authors included restraining time in the application time.

After 1 yr of age, yearling kids having lost B2 (n = 4) were administered B3 and no incidents were reported. Time for B3 administration was not recorded.

Electronic Ear Tags. Three cases (3.3%) of profuse bleeding that stopped within a few minutes were observed after ear tag insertion. Whereas 90.2% of ears were completely healed at 2 mo after tagging, 3 (3.3%) ears showed infection with purulent secretion and 6 (6.5%) more ears showed a marked tissue reaction to the attached ear tags. Tissue reaction appeared as perceptible swelling of the ear and noticeable irritation under the ear tag but without bleeding or apparent signs of infection. Edwards et al. (2001) tested both plastic and metal ear tags in sheep and only reported the presence of tissue reaction to the metal tags. In our study, these findings remained apparent until 4 mo and then progressively decreased until eventually disappearing at 6 mo postapplication. Length of healing period did not affect the size of the hole made at ear tagging, although some cases of increased ear thickness and hair loss around the tagging hole were observed. Ear tag readability was not affected by the healing process.

Injectable Transponders. Size of injectable transponders was a relevant shortcoming for the injection in the rear metacarpal area of kids. Experiments carried out so far in this body site have evaluated the use of injectable transponders varying in length (12 to 15 mm) and o.d. (2.1 to 3 mm) in lambs and in adult sheep and goats (Abecia et al., 2004; MAPA, 2007). In our study, transponders of 15 × 3 mm were anticipated to be too large to be used in kids and only 2.1 mm

Table 2. Long-term performance of identification devices¹ in kids (n = 97) and adult dairy goats (n = 29) during a 3-yr study

Item	Visual ear tags ²		Electronic boluses			Electronic ear tags ³		Injectable transponders	
	V1	V2	B1 ⁴	B2 ⁵	B3 ⁶	E1	E2 ⁴	T1	T2
Birth to 5 mo of age									
Administered, n	41	50	91	19	—	46	45	75	100
Readable, n	35	49	72	19	—	46	45	69	97
Readability, ⁷ %	85.4 ^{ac,x}	98.0 ^{bc,y}	79.1 ^a	100	—	100	100	92.0 ^{cd}	97.0 ^{bd}
6 to 12 mo of age									
Previous, n	41	50	91	19	29	46	45	75	100
Administered, n	0	0	0	7	4	0	0	0	0
Readable, n	34	47	65	22	33	46	45	69	96
Readability, %	82.9 ^{ab}	94.0 ^{ac}	71.4 ^b	84.6 ^{ab}	100	100	100	92.0 ^{ac}	96.0 ^c
1 to 2 yr of age									
Previous, n	—	—	66	22	32	33	33	66	50
Administered, n	—	—	0	2	1	0	0	0	0
Readable, n	—	—	44	20	32	33	31	60	48
Readability, %	—	—	66.7 ^a	83.3 ^{ab,x}	97.0 ^b	100	93.9 ^b	90.9 ^b	96.0 ^{b,y}
2 to 3 yr of age									
Previous, n	—	—	23	8	28	10	13	42	—
Administered, n	—	—	0	0	0	0	0	0	—
Readable, n	—	—	16	7	27	10	12	39	—
Readability, %	—	—	69.6 ^a	87.5 ^{ab}	96.4 ^b	100	92.3 ^{ab}	92.9 ^b	—

^{a-d}Within a row, values with different superscripts differ ($P < 0.05$).

^{x,y}Within a row, values with different superscripts differ ($P < 0.10$).

¹V1 = tip-tag ear tag (Azasa-Allflex, Madrid, Spain); V2 = official tamper-proof ear tag (Azasa-Allflex); B1 = mini-bolus 13.7 g and 51.0 × 10.5 mm (Rumitag, Esplugues de Llobregat, Spain); B2 = mini-bolus 20.1 g and 56.4 × 10.5 mm (Rumitag); B3 = standard bolus 75 g and 68.2 × 21.0 mm (Rumitag); E1 = ear tag made of plastic button male piece (Azasa-Allflex) and electronic button female piece (Allflex Europe, Vitré, France); E2 = ear tag made of plastic flag male piece (Azasa-Allflex) and electronic button female piece (Allflex Europe); T1 = injectable transponder 15 × 2.1 mm (Avid Microchip España, Barcelona, Spain); T2 = injectable transponder 12 × 2.1 mm (Cromasa, Berriozar, Spain).

²Applied on the left ear at 1 d of age, and removed in yearlings.

³Applied on the right ear just after B1 administration.

⁴One goat kid died at 79 d of age because of pneumonia.

⁵Administered after detecting a B1 being lost (n = 28).

⁶Administered after detecting a B2 being lost (n = 5) as well as in adult goats (n = 29).

⁷Readability of ear tags included retention and reading (visual or electronic).

o.d. were used. Age and BW at which T1 and T2 were injected are shown in Table 1. Four (5.3%) and 6 (6%) cases of bleeding after injection were observed for T1 and T2, respectively. Only 1 case (1%) of limping was observed after injecting a T2 transponder; the limping disappeared the following day with no treatment. No inflammation or signs of infection were observed and injection wounds totally healed within the following 2 wk. Time required for injection, reading, and animal data recording (Table 1) did not differ between T1 and T2 ($P = 0.122$) and averaged 36 ± 1 s. Abecia et al. (2004) reported values of injection time also ranging from 30 to 40 s in lambs and adult sheep, including restraining time but without taking into account time for reading and storing ID data.

Effects of Kid Rearing on Readability of Identification Devices

A total of 6 NW kids (13%) refused to suckle the milk from buckets during the rearing treatments, and

were bottle fed. Kid daily growth was greater in NW during the first 2 wk of treatment (data not shown) but BW at the end of the rearing treatments (5 mo of age) did not differ between groups (W, 18.2 ± 0.4 kg; NW, 18.6 ± 0.6 kg; $P = 0.826$).

Regarding ID devices, 6 losses of V1 (14.6%) were reported by the end of the rearing treatments. Ear tag losses occurred without producing split ears and were not related to year and rearing treatments ($P > 0.05$). No losses of V2 were observed during this period, most likely because of an improved design and the tamper-proof closing system. Nevertheless, 1 (2.0%) V2 showed severe damage caused by bites, and was unreadable. As a consequence, readability of V1 (85.4%) and V2 (98.0%) at 5 mo tended to differ ($P = 0.053$). No losses or failures were observed for E1 and E2 during the whole rearing period and readability for electronic ear tags was 100%. Nevertheless, 4 (8.7%) cases of damage to the flag piece of E2 were registered.

With regard to bolus readability, no differences between years were observed ($P = 0.881$) and annual

Table 3. Effect of extending the suckling period until 5 mo of age on the readability of electronic mini-bolus¹ in goat kids (values are averaged data for 3 yr)²

Bolus, n	Rearing treatment		Overall	P-value
	Weaned	Not weaned ³		
Administered	46	45	91	—
Lost	7	12	19	—
Read	39	33	73	—
Readability, %	84.8	73.3	79.1	0.184

¹B1 mini-bolus (13.7 g, 51.0 × 10.5 mm; Rumitag, Esplugues de Llobregat, Spain).²Year effect was not significant ($P = 0.881$).³One goat kid died at 79 d of age because of pneumonia.

data were joined. The anatomical changes produced in the reticulorumen during the esophageal groove reflex activation did not affect bolus retention in the suckling kids, although a numerically greater retention of B1 at 5 mo of age was observed in W versus NW kids (Table 3). Ghirardi et al. (2007) reported 99.4% retention of B1 boluses in weaned and fattened lambs. Although no losses could be observed in situ in our study, bolus losses by regurgitation have been observed in calves being fed milk from buckets (J. J. Ghirardi, unpublished data).

Regurgitation is recognized to be the main mechanism of bolus losses (Riner et al., 1982; Caja et al., 1999; Garín et al., 2005), although intestinal passage after going through the critical barrier of the reticulo-omasal orifice cannot be discarded, especially when dealing with mini-boluses (Garín et al., 2005; Ghirardi et al., 2007). Studies on slaughtered animals indicate that, at the same BW (24 kg), the diameter of the reticulo-omasal orifice in kids (Martín et al., 2004; 24.0 mm) is approximately twice the diameter in lambs (Ghirardi et al., 2007; 14.2 mm) and twice the outer diameter of the B1 mini-boluses used (10 mm o.d.). Losses by intestinal passage could be exacerbated in goats if less selective passage through the reticulo-omasal orifice occurs (Katoh et al., 1988; Clauss and Lechner-Doll, 2001). Regarding feeding management, an abrupt diet change may also increase bolus losses (AMLC, 1995; Ghirardi et al., 2007). Garín et al. (2005) found no effect on losses of small size boluses when applied in lambs 1 wk before and after weaning. In our results, no effect on bolus retention could be established with the 2 weaning systems used (60 and 150 d of age) and after the kids started grazing (4 mo of age).

Losses of B1 bolus started at 2 mo of age (1 mo after administration) whereas the first loss of B2 was registered at 7 mo of age (5 mo after administration) which agrees with their features, the B1 being smaller and lighter than B2.

First Year Readability

Readability after 1 yr of application is considered the key value for the official approval of ID devices in livestock (ICAR, 2007). Devices approved by ICAR must fulfill a readability >98%. Actual readability values of the different ID devices throughout our study are shown in Table 2. All the visual ear tags readable at mo 5 were retained at 12 mo of age. From them, 1 V1 and 2 V2 showed severe damages caused by biting, but no readability differences between V1 and V2 were detected (82.9 vs. 94.0%, respectively; $P = 0.107$) at the end of the first year, when they were removed. Visual tags did not fulfill the ICAR requirement for official use.

Losses of B1 and B2 mainly occurred during the first year, resulting in a readability numerically greater in B2 than B1 (84.6% vs. 71.4%, respectively; $P = 0.182$), which was unsatisfactory for official use according to ICAR requirements; no more administrations of B1 and B2 were performed after being lost. By contrast, the standard-sized B3 used as control device in adult goats were fully readable (100%) at the end of yr 1 and are suitable for official use.

No electronic failures or losses were observed for electronic ear tags during the first year of the study, showing 100% readability and fulfilling the ICAR requirements.

With regard to transponders injected in the distal area of the forefeet, no difference in readability during the first year was detected between T1 and T2 (92.0 vs. 96.0%; $P = 0.268$), but their readability values were below the 98% required for ICAR approval. No breakages or electronic failures were registered at the end of the first year. Most losses of T1 and T2 (90.9%) occurred during the first 2 wk after injection, similar to results from lambs identified in the same body site with 12-mm transponders (Abecia et al., 2004). These early losses were mainly caused by the backward movement of transponders through the channel of injection before

the injection wound was totally healed, as observed in other species (Conill et al., 2000; Caja et al., 2005). Furthermore, 98.4% of T1 and 100% of T2 losses were registered within 6 mo of injection.

Long-Term Readability of Identification Devices

Actual readability values of the different ID devices after the first year are shown in Table 2. Bolus losses decreased after the first year and steadied during yr 2 and 3. Readability of B1 was less than B2, although only value at yr 3 differed ($P < 0.05$). No difference between B2 and B3 was detected during the study, although B1 readability was less than that of B3 ($P < 0.05$). As a consequence, only B3 fulfilled the requested ICAR value for official use.

With regard to electronic ear tags, a total of 3 losses of E2 were registered after the first year; 2 of them during yr 2 and 1 during yr 3. This last loss was directly observed in the head-locker of the milking parlor during milking, when the male-female mechanism of the ear tag unlocked. No electronic failures were observed for E1 and E2 during the entire study.

During the measurement of the external features of the F button pieces of E1 and E2, which were supposed to be identical, small differences in the internal surface of the coupling orifice were observed between devices. Measurement results showed 2 types of button F pieces:

34% with beveled orifices of 6.7 ± 0.1 mm, and 64% with straight orifices of 6.4 ± 0.0 mm ($P < 0.001$). The beveled ear tags were able to be manually unlocked by pulling out the male piece (strength required for opening, 9.9 ± 1.0 kg) but not in the straight ones (male pin broke at 30.2 ± 0.7 kg), the difference being significant ($P < 0.001$). According to ICAR (2007), ear tag unfastening force should be greater than 280 ± 20 N (approximately 28.5 ± 2 kg). In addition, a slight difference in the outside diameter of the pin tip of the male piece was also observed in our study, E2 being greater than E1 (7.6 ± 0.01 vs. 7.5 ± 0.01 mm, respectively; $P < 0.001$). A negative relationship was established between opening strength of ear tags and the diameter of the orifice of F piece ($r = -0.73$; $P < 0.001$).

Because no split ears were observed for E2 losses, we concluded that losses occurred by unlocking the E2 ear tags. Moreover, 3 E2 flag pieces (9.1%) showed biting damage. Similar damage was also found in 2 E2 that were eventually lost. The use of E1 (button-button) ear tags prevented losses and nibbling.

Injectable transponders showed 1 additional loss of T1 during the second year and readability values ranged from 91 to 96% (Table 2). No differences were detected between T1 and T2, both values being inadequate for official use according to the ICAR requirement. Apart from losses, the main limitation observed for injection

Figure 2. Kaplan-Meier survival distribution functions for visual (—) and electronic ear tags (....) in dairy goats; censored data: V1 (●), V2 (▲), E1 (○), and E2 (△). V1 = tip-tag ear tag (Azasa-Allflex, Madrid, Spain); V2 = official tamper-proof ear tag (Azasa-Allflex); E1 = ear tag made of plastic button male piece (Azasa-Allflex) and electronic button female piece (Allflex Europe, Vitré, France); E2 = ear tag made of plastic flag male piece (Azasa-Allflex) and electronic button female piece (Allflex Europe).

in the metacarpal area was the lack of room for larger transponders; the use of small transponders results in small reading distances which compromises the efficiency of the recording and monitoring practices. Suitably designed transponders should permit implementation of farm automation; for example, high throughput inventorying, sorting for group or individual treatments, performance recording (weighing, milk recording), feeding according to production. Efficient electronic reading in semi-automated milk recording has proved to reduce labor costs and improve data accuracy in dairy goats (Ait-Saidi et al., 2008). Moreover, another issue when small-sized injectable transponders are used is the difficulty of ensuring that all transponders are removed from carcasses at slaughter.

Long-term readability values estimated by using the Kaplan-Meier nonparametric survival analysis are shown in Figures 2 and 3, and their values are summarized in Table 4. Kaplan-Meier's estimated readabilities were generally lower than actual values, as a consequence of the late losses of ID devices. We considered the Kaplan-Meier's estimates as better indicators of readability because they avoided the bias produced by the low number of animals monitored at long-term (i.e., readability at yr 3 greater than at yr 2). The differences between actual and estimated values at yr 3 averaged 4.1%, ranging between 0 and 6.1%, except in E2, for which the estimated readability was 12.5% lower than

actual. Fosgate et al. (2006) also carried out a 2-yr survival analysis for ear tag retention in water buffalo showing that long-term retention (21.7% on average) was accurately estimated in both ears by the Kaplan-Meier's method.

At the end of the study, B3 estimated readability (96.8%) was greater ($P < 0.05$) than B1 (66.3%) and B2 (81.4%) estimates, whereas no difference was detected between B1 and B2 ($P = 0.126$). Our results agreed with the readability values previously reported for boluses (JRC, 2003; Capote et al., 2005; Pinna et al., 2006) and confirm the importance of bolus features for assuring their retention and readability in the reticulorumen, not only in cattle and sheep (Caja et al., 1999; Fallon, 2001; Ghirardi et al., 2006) but also in goats (Carné et al., 2007).

The E1 electronic ear tag showed 100% estimated readability at the end of the 3-yr study, which differed ($P = 0.022$) from the E2 estimated readability (79.8%). Observed E2 late losses as a consequence of aging deterioration is an aspect to be taken into account when comparing the long-term readability of ear tags and some other devices applied internally to the body (bolus and injectable transponders).

Apart from E1 ear tags (100%), the device with greater readability estimates at the end of the study was the B3 bolus (96.8%) and no differences could be established ($P > 0.05$) between them. Lower readability

Figure 3. Kaplan-Meier survival distribution functions for electronic ruminal boluses (—) and transponders injected in the forefeet (....) in dairy goats; censored data: B1 (●), B2 (▲), B3 (■), T1 (○), and T2 (△). B1 = mini-bolus 13.7 g and 51.0 × 10.5 mm (Rumitag, Esplugues de Llobregat, Spain); B2 = mini-bolus 20.1 g and 56.4 × 10.5 mm (Rumitag); B3 = standard bolus 75 g and 68.2 × 21.0 mm (Rumitag); T1 = injectable transponder 15 × 2.1 mm (Avid Microchip España, Barcelona, Spain); T2 = injectable transponder 12 × 2.1 mm (Cromasa, Berrioazar, Spain).

Table 4. Readability of identification devices in goats, estimated by Kaplan-Meier nonparametric survival analysis at the end of the study¹

Item	Visual ear tags		Electronic boluses			Electronic ear tags		Injectable transponders	
	V1	V2	B1	B2	B3	E1	E2	T1	T2
Devices, n	45	52	92	28	34	46	46	75	100
Time, yr	1	1	3	3	3	3	3	3	2
Censored data, n ²	38	49	64	23	33	46	43	68	96
Events, n ³	7	3	28	5	1	0	3	7	4
Estimated readability, %	83.1	94.0	66.3 ^c	81.4 ^{cd}	96.8 ^{ab}	100 ^a	79.8 ^{bd}	90.4 ^{bd}	96.0

^{a-d}Only for devices monitored until yr 3, values with different superscripts within a row differ ($P < 0.05$).

¹V1 = tip-tag ear tag (Azasa-Allflex, Madrid, Spain); V2 = official tamper-proof ear tag (Azasa-Allflex); B1 = mini-bolus 13.7 g and 51.0 × 10.5 mm (Rumitag, Esplugues de Llobregat, Spain); B2 = mini-bolus 20.1 g and 56.4 × 10.5 mm (Rumitag); B3 = standard bolus 75 g and 68.2 × 21.0 mm (Rumitag); E1 = ear tag made of plastic button male piece (Azasa-Allflex) and electronic button female piece (Allflex Europe, Vitré, France); E2 = ear tag made of plastic flag male piece (Azasa-Allflex) and electronic button female piece (Allflex Europe); T1 = injectable transponder 15 × 2.1 mm (Avid Microchip España, Barcelona, Spain); T2 = injectable transponder 12 × 2.1 mm (Cromasa, Berriozar, Spain).

²Devices in which the event was not observed during the study or which left the study earlier than yr 3.

³Devices unreadable.

was estimated for B1 (66.3%), followed by E2 (79.8%), B2 (81.4%) and T1 (90.4%), the latter 3 ones not differing ($P > 0.05$).

CONCLUSIONS

According to our results, electronic ear tags (E1 and E2) and the standard bolus (B3) were the only ID devices that had greater than 98% readability at 12 mo after application as recommended by the International Committee for Animal Recording (ICAR, 2007) and the Spanish Committee for Animal Electronic Identification (MAPA, 2007).

The use of injectable transponders in the metacarpal area is not recommended in practice because of losses. Physical features of electronic ruminal boluses dramatically affect their retention, and therefore their readability. No differences in bolus retention were detected according to rearing management and feeding. Improvement of electronic bolus retention in goats needs to be achieved before generalizing its use. In contrast to the rest of devices tested, button-button electronic ear tags of appropriate design and technology proved to be efficient devices for goat identification, although because of the small number of animals and devices used in this experiment, we recommend the confirmation of the results on a larger scale.

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