Suitability of electronic mini-boluses for the early identification of goat kids and effects on growth performance and development of the reticulorumen1,2

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ABSTRACT: A total of 60 twin-goat kids (30 male and 30 female) of the Canary Island Majorera dairy breed were used in 2 experiments to evaluate 2 types of electronic identification mini-boluses and their effects on rearing performances and reticulorumen development. Electronic identification mini-boluses were cylindrical and made of ceramic materials (B1, 9.0 g and 38.5 × 9.5 mm; B2, 16.3 g and 42.2 × 12.2 mm), contained a 32-mm half-duplex passive transponder, and were administered to kids at different BW. In Exp. 1, treatments were 1) control, without bolus (n = 15) and 2) identified with B1 at 4.8 kg of BW (n = 15). In Exp. 2, treatments were 1) control, without bolus (n = 15) and 2) identified with B2 at 5.6 kg of BW (n = 15). Kids were penned separately, according to mini-bolus treatments, fed a milk replacer daily, and slaughtered at 10 kg of BW. Milk replacer intake was recorded individually twice weekly and boluses read weekly until slaughter. The full and empty stomach complex was measured immediately after slaughter, and mini-bolus location was recorded. Samples of the reticulum and rumen wall were taken to measure the number and length of the papillae and crest. Despite the light BW of kids at time of mini-bolus treatment, no negative effects (P > 0.05) of B1 and B2 mini-boluses were observed on milk intake, growth rate, or G:F in either experiment. No kid mortality or mini-bolus losses were observed during either experiment. All mini-boluses were retained until slaughter, and all were found in the rumen upon dissection, except one B2, which was found in the reticulum. Mini-bolus treatment did not affect (P > 0.05) the weight of full and empty reticulorumen or the number of papillae and crest size of the reticulum epithelium. Moreover, the B1-treated kids showed a greater number of papillae in the rumen wall than the control kids (22.4 ± 1.0 vs. 18.9 ± 0.9 papillae/cm, respectively; P < 0.05) in Exp. 1. In conclusion, the use of mini-boluses was suitable for the electronic identification of growing kids from early ages (wk 2 to 5 of age and 5 to 6 kg of BW) and did not produce negative effects on their growth performances or on reticulorumen development. These results support the use of properly designed boluses as a unique identification device for the entire lifespan of goats.

Key words: electronic identification, goat kid, reticulorumen, rumen bolus, transponder

INTRODUCTION

Sheep and goat identification (ID) is currently an important issue in the European Union (EU) because of their population size and the implementation of measures for controlling disease outbreaks and food traceability. The EU Regulation CE 21/2004 (amended by CE 933/2008) established ID of sheep and goats >6 mo of age with both a plastic ear tag and a second device chosen by the member states. In Spain, boluses containing a radio frequency passive transponder were the second device chosen (Real Decreto 947/2005), but later Real Decreto 1486/2009 approved the use of other electronic-ID devices in goats (e.g., injectables, ear

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tags, and leg bands), because of reported variability of bolus retention in Spanish goats (MAPA, 2007). However, retention of electronic-ID ear tags (80 to 100%; Carné et al., 2009a) and boluses (66 to 100%; Capote et al., 2005; Pinna et al., 2006; Carné et al., 2009a,b) vary according to features and dimensions. Compared with visual ear tags, boluses were retained longer in goats in Spain (Carné et al., 2009a) and the United States (Carné et al., 2009b).

It has been suggested that preruminant goat kids may be unable to retain mini-boluses in their rudimentary forestomach. Although Carné et al. (2009a) reported no negative effects of administering 14- or 20-g mini-boluses to kids older than 1 or 5.5 mo, respectively, they recommend that kids should be at least 30 d of age or 7 kg of BW before administering 14-g mini-boluses.

To our knowledge, there are no data on effects of ID boluses on reticulorumen in milk-fed goat kids. Therefore, the objectives of this study were to investigate the suitability of early administration of 2 types of electronic mini-boluses in milk-fed kids and to evaluate subsequent effects of mini-bolus administration on growth performance and reticulorumen development.

MATERIALS AND METHODS

The experimental procedures and animal care conditions were approved by the Universidad de Las Palmas de Gran Canaria Ethical Committee.

Bolus Transponders

Two cylindrical, mini-bolus prototypes, made of different ceramic materials by Rumitag (Esplugues de Llobregat, Barcelona Spain) according to the patents of European Community et al. (1998) and Caja et al. (2001, 2005), were used in Exp. 1 and 2. Weight, length × o.d., and specific gravity, respectively, of the 2 mini-boluses were B1 = 9.0 g, 38.5 × 9.5 mm, and 3.38, and B2 = 16.3 g, 42.2 × 12.2 mm, and 4.59. Boluses contained a 32.5 × 3.8-mm, passive, half-duplex, glass-encapsulated transponder (Ri-Trp-RR2B-06, Tirris, Almelo, the Netherlands), which operated at a low frequency [134.2 kHz; International Organization for Standardization (ISO) 11784 standard on animal ID] and were encased using epoxy resin (MP Super, Ceys, Barcelona, Spain).

Animals, Treatments, and Feeding

Sixty-two newborn, twin goat kids of the Canary Islands Majorera dairy breed at the Experimental Farm of the Universidad de Las Palmas de Gran Canaria (Arucas, Gran Canaria, Spain) were used in 2 consecutive experiments, which lasted approximately 2 mo each during the winter. Kids were selected from 2 consecutive kidding periods (February and March) after natural breeding and were born within a 3-wk kidding interval. Only twin kids were used to reduce BW variability within groups. Kids were separated from their mothers immediately after birth, dried, and processed (weighed, navel disinfected, and identified with collars). Refrigerated goat colostrum was fed twice daily for 2 d at a rate of 100 mL/kg of BW (Argüello et al., 2004b). From d 3 to slaughter, goat kids were fed milk replacer [reconstituted at 16% (wt/wt) DM, 95.5%; CP, 23.6%; ether extract, 22.7%; DM basis; Saprogal, La Coruña, Spain] for ad libitum intake, twice daily (0800 and 1900 h), using nipple buckets. Consistent with traditional milk-fed kid production, no concentrate or forage was fed to the kids, only the reconstituted milk replacer. Two kids died during wk 1 of life (3.0% mortality rate). At wk 2 of age, kids of each kidding period (n = 30) were allocated into 2 balanced groups according to sex and BW for each experiment. Experimental groups consisted of 8 male and 7 female kids in Exp. 1 and of 7 male and 8 female kids in Exp. 2.

Treatments in Exp. 1 were 1) control, without bolus (n = 15) and 2) identified with B1 mini-boluses (n = 15) at 4.8 ± 0.1 kg of BW. Treatments in Exp. 2 were 1) control, without bolus (n = 15) and 2) identified with B2 mini-boluses (n = 15) at 5.6 ± 0.2 kg of BW. Feeding, management, and measurement and recording procedures were similar in both experiments.

Kids were weighed at birth and twice weekly during the rearing period with an electronic scale (Dina, Barcelona, Spain; accuracy, 20 g) to determine BW changes from bolus administration to slaughter. Milk replacer intake was measured individually by using a double weighing method (before and after milk replacer feeding), with a 30-min interval, twice each week (Monday and Thursday) during the morning and afternoon feeding. During the rearing period, kids had free access to water bowls, but water consumption was prevented during the milk replacer intake measurements.

All kids were processed in a commercial slaughterhouse (Matadero Municipal, Ingenio, Gran Canaria, Spain), in accordance with EU Directive 93/119/EC, when they reached 10 ± 0.2 kg of BW. Slaughter consisted of electrical stunning, suspension by the right hind shank, bleeding, tarsus and metatarsus removal, suspension by both Achilles tendons, skin removal, head removal, evisceration, weighing, and carcass ID.

Mini-Bolus Administration, Reading, and Recording Procedures

The B1 and B2 mini-boluses were orally administered by hand (protected by gloves but without using a balling gun). The same operator, previously trained in a short session, performed all the bolus administration. For bolus administration, kids were firmly restrained maintaining their head in the natural position, and the bolus was positioned manually at the bottom of the oropharyngeal cavity (base of the tongue), as indicated by Caja et al. (1999) and Carné et al. (2009a).
The mouth of the kid was maintained closed until the mini-bolus was swallowed. Bolus administration was simulated in the control groups by the same procedure but without positioning a mini-bolus at the base of the tongue.

All of the mini-boluses were read immediately before and after administration, at 24 h, and at weekly intervals until the kids reached the slaughter weight (10 kg of BW) by using a hand-held ISO transceiver (Gesreader 2S, RumiTag).

Kids were fasted for 12 h before slaughter, but had free access to water. Mini-boluses were also read before kids left the farm to the slaughterhouse and at the beginning of the processing line using the same hand-held reader. Mini-bolus location in the reticulorum was recorded after slaughter and the boluses recovered on retrieval.

**Statistical Analyses**

Experimental growth performance, milk conversion rate, and anatomical and histological data of the stomach complex were analyzed as a 2 × 2 equilibrated block design using the GLM procedure (SAS Inst. Inc., Cary, NC). The model included the effects of treatment (with or without mini-bolus), experiment (1 or 2), and corresponding interaction. Birth BW was included as a covariate in the model that was used to analyze age at slaughter, milk replacer intake, and G:F of the kids. Body weight at slaughter was included as a covariate in the model used to analyze the anatomical variables of the stomach complex. A direct comparison of kid growth rate of the control groups in both experiments was also made. Statistical significance was declared at \( P < 0.05 \), and after a significant \( F \)-test, adjusted least squares means were separated using the Tukey test of SAS.

**RESULTS AND DISCUSSION**

**Mini-Bolus Administration and Kid Performance**

Body weight at mini-bolus administration was determined from the smallest threshold values that were described in previous experiments using milk-fed kids (Carné et al., 2009a) and suckling lambs (Garín et al., 2003, 2005; Ghirardi et al., 2006, 2007). The earliest ID was performed by Garín et al. (2003) in Manchega lambs at 5.2 kg of BW and 1 wk of age using 5.2-g and 9.3-mm o.d. mini-boluses. Murciano-Granadina kids were identified by Carné et al. (2009a) at 6.8 kg of BW and 30 d of age using 13.7-g and 10-mm o.d. mini-boluses. Similar mini-boluses were used by Ghirardi et al. (2007) to identify lambs of Manchega, Lacaune, and Ripollesa breeds at 8.6 to 9.6 kg of BW and 21 to 33 d of age, depending on the breed.

After the first ID attempts in a previous sample of Majorera goat kids during operator training, we realized that a safe administration of B1 and B2 mini-boluses was possible at lighter BW than previously indicated in lambs. This was a consequence of the smaller o.d. of the mini-boluses used and the greater ability of kids, compared with lambs, to swallow the mini-boluses. Mean BW and ages at which mini-boluses were administered to our kids (Table 1) were on average 4.8 ± 0.2 kg and 16 d, respectively, for B1 and 5.6 ± 0.4 kg and 34 d, respectively, for B2. These BW, but not ages, were less than previously reported values in suckling lambs (Garín et al., 2003, 2005; Ghirardi et al., 2007) and agreed with Caja et al. (1999) in which bolus administration was concluded to be easier in goats than in sheep.

Despite the light BW at administration, no esophageal obstructions or negative effects on apparent kid behavior and health were observed in young, milk-fed kids after mini-bolus were administered. Moreover, no kid mortality was observed during Exp. 1 and 2. These results support the conclusion that adequately designed mini-boluses can be applied safely in small ruminants less than 5 wk of age (Ghirardi et al., 2007; Carné et al., 2009a). Moreover, BW was a more adequate criterion than age for bolus administration in lambs and kids.

In Exp. 1 and 2, mini-bolus treatment did not affect \( (P > 0.05) \) growth performance from ID day to slaughter, age at slaughter, intake, or G:F (Table 1). These results are similar to those previously reported for artificially reared Majorera kids (Argüello, 2000; Argüello et al., 2004a).
No mini-bolus losses were observed during either experiment, and 100% of mini-boluses were recovered in the slaughterhouse after slaughter of kids. Early losses of mini-boluses were detected at wk 3 of age by Garín et al. (2005) in suckling lambs identified with lightweight mini-boluses (5.2 g). Retention rate of lightweight mini-boluses in lambs was <70% at approximately 60 d of age (Garín et al., 2003, 2005). Carné et al. (2009a) detected the first losses of mini-boluses (13.7 g) at 2 mo of age in Murciano-Granadina kids and a retention rate of approximately 97%, although the mini-bolus retention rate dramatically dropped during the first year of age, being only 79% at 5 mo and 71% at 1 yr of age. On the contrary, Ghirardi et al. (2007) reported 100% retention rate until slaughter at 3 mo of age when mini-boluses, similar to B2 (16.2 g) reported in the current study, were used in lambs of different breeds, which agrees with the current results. Retention of 100% until 6 mo of age was also reported by Carné et al. (2009a) in Murciano-Granadina kids identified with 20.1-g mini-boluses, but their retention rate also dropped thereafter (85% at 1 yr).

Despite the fact that goat kids were hung upside-down during the slaughtering process, percentages of mini-bolus retrieved in the reticulum were 0 and 7% (100 and 93% in the rumen, respectively) for B1 and B2, respectively. This result showed that reticulorumen motility was not fully functional in the first weeks of life due to the exclusive milk feeding and because sucked milk passed directly to the abomasum through the esophageal groove (Church, 1969; Lane et al., 2000). Caja et al. (1999) showed by x-ray the retention of standard boluses in the reticulum of a preruminant calf of 1 wk of age, and Fallon (2001) stressed that the suitable technique for safe administration of electronic boluses to newborn calves should aim to introduce them into the reticulorumen but not into the abomasum. Foreign bodies present in the abomasum of calves have been shown to cause severe harm and may result in the occlusion of the omasal, abomasal, or pyloric orifice (Welchman and Baust, 1987).

Few B2 mini-bolus were located in the reticulum at slaughter, most likely as a result of the greater kid age observed in Exp. 2. Our results differ markedly from those of Garín et al. (2003, 2005) and Ghirardi et al. (2007) in fattening lambs, who reported a range of 80 to 92% mini-boluses located in the reticulum at slaughter (24 kg of BW and at approximately 70 d of age). This pattern of distribution is in accordance with the sequence of reticulum-rumen motility described by Dziuk (1984) for high-density feed particles. Mini-boluses appear to be located in the reticulum at approximately 10 wk of age in both goat and sheep.

**Stomach Complex Development**

The external and internal examination of kid stomach complex at slaughter after 12 h of fasting did not reveal any kind of alteration or abnormality, and their appearance was similar for control and mini-bolus-
applied goat kids \((P > 0.05; \text{Table 2})\). No injuries or dystrophy was observed in the reticulorumen of all the processed goat kids.

**Reticulorumen Histology**

No effect of mini-bolus administration was found in Exp. 1 and 2 \((P > 0.05)\) on primary and secondary reticulum crest size or on reticulum papillae \((0.62 \pm 0.02 \text{ mm}, 0.17 \pm 0.01 \text{ mm}, \text{and} 29.8 \pm 1.2 \text{ papillae per linear cm, respectively})\). Similarly, rumen papillae size did not vary by bolus administration in either experiment \((P > 0.05)\), being \(0.27 \pm 0.01 \text{ mm}\) on average. This value was similar to those reported in milk fed lambs by Lane et al. (2000) who also observed that the number of ruminal papillae decreased, whereas papillae length and width did not change with age in the lambs fed a milk replacer in absence of solid feed. Nevertheless, a significant effect was found for rumen papillae per linear cm in Exp. 1, where the value was greater in B1 than in the control kids \((P < 0.05; \text{Table 3})\). No difference was found for B2 mini-boluses \((P > 0.05)\) in Exp. 2.

Finally, B1 and B2 mini-boluses did not negatively affect the development of the stomach complex and histological characteristics of the reticulorumen papillae and crest. Similar results were obtained in lambs by Garín et al. (2003), who also detected small positive but nonsignificant effects from the use of mini-boluses in young lambs.

**Conclusions**

The use of mini-boluses was safe and fully adequate for the short-term electronic ID of milk-fed kids, and despite the kids not having a completely developed and functional reticulorumen, the stomach complex was able to efficiently retain the mini-boluses during the rearing period. Goat kid ID by electronic mini-boluses was possible at wk 2 to 5 of age (approximately 5 to 6 kg of BW), depending on bolus dimensions (recommended o.d. < 10 mm) and supported the theory that

### Table 2. Stomach features of milk-fed kids identified with 2 types of electronic mini-boluses (values are least squares means)

<table>
<thead>
<tr>
<th>Item</th>
<th>Exp. 1</th>
<th>Exp. 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Control</td>
<td>B1(^1)</td>
</tr>
<tr>
<td>Full weight, g</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stomach complex</td>
<td>612</td>
<td>715</td>
</tr>
<tr>
<td>Reticulorumen</td>
<td>426</td>
<td>495</td>
</tr>
<tr>
<td>Omasum-abomasum</td>
<td>168</td>
<td>211</td>
</tr>
<tr>
<td>Empty weight, g</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stomach complex</td>
<td>185</td>
<td>191</td>
</tr>
<tr>
<td>Reticulorumen</td>
<td>94</td>
<td>90</td>
</tr>
<tr>
<td>Omasum-abomasum</td>
<td>91</td>
<td>101</td>
</tr>
<tr>
<td>Content, g</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stomach complex</td>
<td>444</td>
<td>524</td>
</tr>
<tr>
<td>Reticulorumen</td>
<td>330</td>
<td>408</td>
</tr>
<tr>
<td>Omasum-abomasum</td>
<td>79</td>
<td>108</td>
</tr>
</tbody>
</table>

\(^1\)Mini-bolus of 9.0 g and 38.5 \times 9.5 mm containing a 32.5 \times 3.8-mm half-duplex passive transponder (Rumitag, Esplugues de Llobregat, Barcelona, Spain).

\(^2\)Mini-bolus of 16.3 g and 42.2 \times 12.2 mm containing a 32.5 \times 3.8-mm half-duplex passive transponder (Rumitag).

\(^3\)Including mini-bolus weight.

### Table 3. Development of reticulorumen walls of milk-fed kids identified with 2 types of electronic mini-boluses (values are least squares means)

<table>
<thead>
<tr>
<th>Item</th>
<th>Exp. 1</th>
<th>Exp. 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Control</td>
<td>B1(^1)</td>
</tr>
<tr>
<td>Reticulum</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary crest size, mm</td>
<td>0.61</td>
<td>0.63</td>
</tr>
<tr>
<td>Secondary crest size, mm</td>
<td>0.17</td>
<td>0.16</td>
</tr>
<tr>
<td>Papillae per linear cm</td>
<td>28.6</td>
<td>29.6</td>
</tr>
<tr>
<td>Rumen</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Papillae size, mm</td>
<td>0.26</td>
<td>0.25</td>
</tr>
<tr>
<td>Papillae per linear cm</td>
<td>18.9</td>
<td>22.4</td>
</tr>
</tbody>
</table>

\(^1\)Mini-bolus of 9.0 g and 38.5 \times 9.5 mm containing a 32.5 \times 3.8-mm half-duplex passive transponder (Rumitag, Esplugues de Llobregat, Barcelona, Spain).

\(^2\)Mini-bolus of 16.3 g and 42.2 \times 12.2 mm containing a 32.5 \times 3.8-mm half-duplex passive transponder (Rumitag).
Goats can be bolused at lighter BW than sheep. Oral administration of properly designed mini-boluses by trained operators was easy and safe and did not produce negative effects on growth performances or development of the reticulorumen of young milk-fed goat kids. These results support the use of properly designed boluses, characterized by a small outside diameter and a great specific gravity, as a unique device during the entire lifespan of goats.

LITERATURE CITED


