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Electronic Boluses & Sheep Identification

Report for ScotEID

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ELECTRONIC BOLUSES & SHEEP IDENTIFICATION

INTRODUCTION

1. EU regulations on the individual identification of sheep permit the use of an electronic rumen bolus plus a (black) conventional ear tag as an alternative to the pairing of an electronic and a conventional ear tag.

2. This note reports the findings of a short desk-study of research and market preferences relating to electronic rumen boluses in sheep, in the context of possible pressure from the European Commission to increase bolus usage in Scotland.

3. The study comprised a literature review, e-mail contact with a number of international researchers and government traceability bodies, plus telephone conversations with several UK abattoirs and some farmers currently using boluses in Scotland.

BOLUS USAGE

4. The European Commission (EC) does not hold data on the relative usage of tags and boluses across the EU (pers. comms. DG SANCO, EuroStat, JRC). Nevertheless, it is possible to discern usage to some degree from on-line documentation and information provided directly by some Member States (see Appendix 1).

5. Although permitted under EU regulations, many Member States have either explicitly not approved boluses for usage or do not list them as approved identification devices. In such cases, usage is either confirmed as zero or may be inferred to be very low (pers. comm. relevant Ministries of Agriculture). This mirrors the position for sheep identification in Australia, Canada and the USA (pers. comm. DPI, CFIA, USDA).

6. Although approved for usage in Germany, Ireland, the Netherlands and the UK, the voluntary uptake of boluses for sheep identification is very low (<2%) in these countries (pers. comms. relevant Ministries of Agriculture).

7. By contrast, although precise figures are unavailable, rates of bolus usage are apparently relatively high in Bulgaria, Cyprus, Greece, Italy, Portugal and Spain (pers. comm. relevant Ministries of Agriculture; JRC). Typically, tags are used for slaughter lambs with boluses reserved for breeding stock. However, even in these countries it is not certain that boluses

are used for all breeding stock. For example, following active promotion by the Government, Spain has perhaps 6m bolused sheep (pers. comm. Prof. Caja), yet this is out of a national breeding flock of over 11m (JRC, 2009).[1]

8. High bolus usage is seemingly associated with perceived advantages of better retention rates in terms of lifetime costs, ear-related animal welfare and lower susceptibility to fraud (pers. comms. various Ministries of Agriculture, JRC).

9. By contrast, for countries where boluses are approved but little used, boluses are seemingly perceived as imposing higher costs on farmers, marts and meat processors. This also applies in countries where boluses are not approved, but in such cases the over-riding concern appears to be one of potential food-chain contamination risk due to the possibility of less than 100% recovery of boluses at abattoirs (pers. comms. various Ministries of Agriculture).

10. The evidence for these somewhat divergent positions is summarised below in light of positive and negative points gleaned from published research and interviewees.

MAIN REVIEW FINDINGS

Positives

11. The use of rumen boluses for electronic identification of sheep has been studied in a number of research projects – including a large trial in England (ADAS, 2005) - over the past 20 years or so (see Appendix 2 for more details). The results of these suggest that appropriately designed[2] boluses are suitable for both young lambs and adult sheep and can offer some technical advantages over tags.

12. First, boluses can have higher (>99%) rates of retention than tags which are subject to various snagging hazards. This means that using boluses can avoid some re-identification tasks and possible ear-related welfare issues associated with tag loss and re-tagging. Mortality losses attributable to boluses are very low (c.0.03%).

13. Second, although not immune to fraudulent use, (internal) boluses are less prone to tampering than (external) tags. This

[1] Although this may reflect delays in identifying the historic flock rather than usage of tags.
[2] Bolus designs with larger volumes and diameters and/or lighter and less dense materials are prone to poor retention rates. However, a small volume and diameter but with a specific gravity of at least 3 and a weight of at least 20g is suggested as suitable for young lambs and for subsequent high retention through adulthood (Ghirardi et al., 2006).

means that they offer some degree of greater security, which may be a consideration for high-value animals.

14. Scottish farmers currently using boluses cited both of the above reasons for doing so (see Appendix 3).

15. Third, although there can be difficulties with using handheld readers, boluses can have consistently high (>99%) read rates.

Negatives

16. However, published research also reveals some potential problems with bolus usage and these are supported by more anecdotal evidence from some interviewees.

17. First, although a 100% rate of recovery of boluses post-slaughter was reported for some studies, others reported much lower (76% - 97%) rates. This justifies concerns about risks of foodstuff contamination plus potential damage to meat-processing equipment and/or the operational cost of achieving 100% recovery.

18. Indeed, as noted above, some countries have not approved boluses due to such processing-sector concerns. UK processors' views of ceramic boluses were generally negative due to safety concerns and the need to avoid potential problems by using a costly systematic preventative approach in line with HACCP principles (see Appendix 4). Such a system would be required if all sheep were bolused, but would become both more necessary and more complex if a mixed-identification system was used whereby some sheep were bolused and some were not.

19. Hence one key issue identified was the need to develop abattoir systems to record and communicate the presence and numbers of livestock containing ceramic boluses linked to a system to record, capture and verify that the boluses had been recovered. Assuming this was achievable, there remained concerns over the practicality of implementing a recording and recovery system due to the challenges associated with communicating information between different processing areas in an abattoir and the abilities of staff to adopt and operate new working practices.

20. Second, the regulatory obligation to also use a conventional (black) tag means that tagging and tag loss remain issues for bolused sheep. This, together with the higher initial cost of a bolus relative to an electronic tag and additional re-identification effort, means that higher retention rates do not readily translate into farm-level cost savings under plausible assumptions (see

Appendix 5) nor necessarily into the anticipated welfare improvements.[3]

21. Specifically, unless very high rates of tag loss and high unit costs for tag re-identification are assumed, even much superior rates of retention for boluses are insufficient to offset the higher cost of boluses and replacement black tags relative to EID tags. Beyond the higher cost of a bolus, the obligation to use a black tag is also instrumental here in that it exposes a sheep to tag loss risks (and any associated welfare issues)[4] plus imposes additional higher re-identification effort and costs in the event of tag loss.

22. Third, bolus usage will involve additional administrative effort for re-identification on-farm or exception management at Critical Control Points. That is, although bolus retention rates may be very high, losses of boluses and/or black tags will occur - yet determining the nature of incomplete/missing identification will be more involved than for tag-only identification.

23. For example, <u>any</u> untagged sheep will need to be scanned to check for a bolus. If a bolus is present, the matching black tag then needs to be re-ordered and inserted once the replacement tag arrives – which will either involve keeping the animal separate for a while or finding it again amongst the flock or batch. Similarly, whereas visually spotting incorrectly identified animals amongst a batch of EID-tag-only sheep, doing so amongst a batch of mixed-identification sheep will be more difficult.

24. In both cases, the additional administrative burden may be individually small but cumulatively significant.[5] Perhaps more significantly, the need to cater for black tag and bolus loss will necessarily incur on-farm capital expenditure on reading equipment. In aggregate, this would negate the significant cost-savings offered by recourse to Critical Control Points (CCPs) and further weaken the cost-benefit results for electronic identification (see Moxey, 2010; also JRC, 2007 & 2009; Defra, 2009).

[3] That is, although offering an improvement over double-tagging, the obligation to use a black tag still exposes a sheep to ear-related welfare issues. Moreover, given the apparent variation in ear-related welfare issues across different farms, it is possible that welfare issues would also arise from failure to adhere universally to best practice in bolus application.

[4] Single rather than double tagging will reduce but not eliminate ear-related welfare issues; as such, bolusing would not offer any welfare advantage on slaughter lambs.

[5] This echoes previous debates about mixed identification systems for breeding and slaughter-only sheep in Scotland, which was resolved in favour of a degree of commonality.

25. Fourth, as with tagging, the process of inserting boluses has to be done correctly. Incorrect application can result in boluses being regurgitated or livestock being injured. Anecdotally, diets may influence "coughing up" in both lambs and adult sheep, suggesting that retention rates may not always be as high as reported in the literature. Hence, as with tagging, appropriate training would be required to promote best practice in insertion but also subsequent management.

26. In addition, there is some evidence that whilst some farmers with experience of boluses opt to continue with them, others revert to tags. This is likely to reflect cost considerations but also perceived greater ease of tagging relative to initial bolus application and any re-identification application.

DISCUSSION

27. Although much of the international research into boluses has not involved breeds or management systems directly analogous to Scottish sheep, results appears to be relatively robust and are considered transferable (pers. comms. Caja & Pinna). More importantly, trials in England (ADAS, 2005) of different identification methods included over eleven thousand bolused sheep. As such, the technical performance of boluses is already well documented.

28. However, even if boluses do offer some technical advantages over tags in terms of retention and read rates, the associated on-farm costs appear to be excessive and other additional costs also arise further along the supply-chain.

29. Hence it is perhaps unsurprising that the clear domestic market preference is for EID tags rather than boluses. That is, Scottish Government policy remains neutral regarding the choice between EID tags and boluses and existing ScotEID information systems and infrastructure are capable of reading both, but farmers' overwhelming voluntary choice is for EID tags.

30. Opting for boluses over tags would imply attaching significant importance to combating fraud, to possible welfare gains from reduced tag usage, or to achieving higher read rates. Whilst individual farmers' personal circumstances may support such rationales, their basis at the industry-level appears questionable.

31. For example, despite persistent anecdotal concerns (e.g. Moxey, 2011), objective evidence on the extent of welfare issues arising from tagging is still absent, making it difficult to quantify the problem. Moreover, if there is a genuine welfare

issue to address, the use of boluses is not the only response available and other options may be cheaper. For example, greater adherence to best practice in tagging, improved tag design/quality or single tagging.[6]

32. Similarly, since traceability is not linearly-related to average read rates (Kiss et al., 2006; Catterhall & Galseby, 2009), even if boluses were to offer consistently higher read-rates than could be achieved by other means (which may not be the case), it seems unlikely that any marginal improvement in overall traceability would justify the higher costs across the supply-chain given the already weak cost-benefit status of electronic identification in Scotland (Moxey, 2010).

CONCLUSION

33. In combination, the absence of any clear evidence-based rationale for greater national usage of boluses, the clear domestic market preference for tags and the variation in uptake and policy stances across the EU all make it seem unlikely that the European Commission would exert pressure on Scotland to unilaterally increase its usage of boluses. Attention would be better directed at improvements to the current tag-based system.

[6] Any ear-related welfare gains from using boluses are not to do with the bolus per se but rather to do with the use of a single rather than a double tag. Importantly, this means that boluses & black tags offer no ear-related welfare gains over the use of single slaughter tags for lambs.

APPENDIX 1: BOLUS USAGE ACROSS THE EU

Table 1: Member States ordered by approximate size of national sheep flock

Member State	Bolus status	Bolus usage
UK	Approved	Minimal
Spain	Approved	Significant
Greece	Approved	Significant
France	Not approved	None
Romania	Not listed	
Italy	Approved	Significant
Ireland	Approved	Minimal
Portugal	Approved	Significant
Germany	Approved	Minimal*
Netherlands	Approved	Minimal
Bulgaria	Approved	Significant
Hungary	Not listed	
Cyprus	Approved	Significant
Sweden	Not approved	None
Poland	Not approved	None
Austria		
Slovakia		
Czech Republic	Not listed	
Belgium	Not approved	None
Denmark	Not listed	
Slovenia	Not approved	None
Finland	Not approved	
Latvia		
Estonia	Not approved	None
Lithuania	Not listed	
Malta		
Luxembourg		

"Approved" or "Not approved" confirmed by relevant Ministry of Agriculture; "Listed" or "Not listed" taken from official documentation.[7] Blank cells indicate a lack of official documentation and no response from relevant Ministry of Agriculture.
Usage confirmed by relevant Ministry of Agriculture or JRC, but "Not listed" could reasonably be taken to imply no usage.
*In Germany, no official data are held but official arrangements for device distribution imply that tags are likely to be far more common than boluses.

[7] See http://ec.europa.eu/food/animal/identification/ovine/ovine_tags_en.htm, although not all links are "live"

APPENDIX 2: OVERVIEW OF RESEARCH & EXPERIENCE

Introduction

1. The use of a bolus within the rumen as a means of providing slow-release drugs or nutritional supplements was first attempted in the 1970s, with work on extending the idea to electronic monitoring developing apace in the 1990s (Caja et al., 1999).

2. Typically, the same type of transponder used in an electronic ear tag is encased in a ceramic material to form a small pellet. This is administered either by (a chainmail gloved) hand or a balling gun and rests in the second fore-stomach (reticulum) from where it can be read by the same type of reading devices used for ear tags but offering less vulnerability to accidental or deliberate loss (Stanford et al., 2001).

3. The use of rumen boluses has been considered in a number of research studies, some specific to sheep (e.g. Ghirardi et al. 2007), to cattle (e.g. Fallon, 2001) or to goats (Carne et al., 2011).

Main EU studies

4. The EU has funded three main studies of electronic identification during the 1990s, two focusing primarily on testing alternative technologies under controlled conditions followed by a much larger project testing preferred technologies under field conditions.

5. The first two projects ("FEOGA" & "AIR2304") ran from 1993 to 1995 and 1995 to 1998 and each involved around 5k sheep. The results indicated that ear tags and rumen boluses were both suitable for electronic identification purposes, but boluses were shown to have a higher retention rate and to potentially pose less welfare problems (Ribo et al., 2001; JRC, 2002).

6. As a result, the EU funded the much larger "IDEA: IDentification Electronique des Animaux" project (Ribo et al., 2001; JRC, 2002) that ran from 1998 to 2001 with over 400k sheep bolused in five countries (France, Italy, the Netherlands, Portugal and Spain) plus a further 92k electronically tagged in one (France). The greater emphasis on boluses presumably reflected the positive endorsement of boluses by the previous studies.

7. Again, results were positive for boluses with casualty losses due to incorrect bolus application of only 0.03% and reported

retention and read rates[8] in excess of 99% plus a recovery rate of boluses at abattoirs of 97% to 100%. Similar times of 1-3 minutes were reported to double tag or to single tag and bolus,

8. However, it should be noted that the effective sample size reduced over time to around 150k at 14 months and 89k at 21 months with only 3089 being slaughtered within the project's timeframe. More importantly, the majority of sheep were bolused at 12 months of age or older - meaning that most were heavier than 25kg.

9. Farming systems studied within IDEA were mostly described as intensive or semi-intensive, often for milk rather than meat production, with Merinos the only breed described explicitly as extensive meat production. Nevertheless, the retention and read rate results should – with appropriate training & adherence to best practice - be transferable across breeds and systems (pers. comms: Prof Caja @ Universitat Autonoma de Barcelona; Prof Thomas @ University of Wisconsin-Madison; Prof Pinna @ Università di Sassari).

Other EU Studies

10. Although the IDEA results were positive, the size of bolus used (75g) was inappropriate for younger lambs. In response, a number of studies were undertaken (mostly by researchers from the IDEA project) to develop smaller boluses that would be more suitable. As before, attention was focused on retention, read and recovery rates but also on possible impacts on lamb growth and development (Caja et al., 2005; Garin et al., 2005; Ghirardi et al., 2007)

11. Timeframes, sample sizes and bolus specifications vary across the different studies (and are all much less than under IDEA), but Ghirardi et al. (2006) summarise the results statistically and provide recommendations on bolus design. Specifically, their own experiments confirm others' findings that very light boluses suffer from poor retention and read rates - leading to recommendations for a minimum weight of 20g and a specific gravity of at least 3. No adverse welfare effects were observed and retention and read rates comparable to those for larger boluses were achieved.

12. Importantly, this recommended bolus design is suitable for young lambs (4 weeks, 10kg) and thus permits compliance with traceability requirements for early identification, yet will also be retained through adulthood (>2 years).

[8] These may not be directly comparable to ScotEID read rates for tags since the latter include missing and malfunctioning tags whereas some of the bolus studies exclude such exceptions. Correcting for this difference would narrow (but not eliminate) the apparent performance gap.

13. Saa et al. (2005) illustrate cost savings offered by electronic bolus vs. conventional tag identification. Sensitivity to assumed retention rates and costs of re-identification is acknowledged. Oddly, the possibility of double-tagging with conventional tags and bolusing is mentioned as a possible remedy to the risk of losing the single black tag.

14. JRC (2007 & 2009) consider EID costs under different configurations. Interestingly, the role of market preferences is acknowledged in that tags are not considered in the scenarios for Cyprus and Portugal whilst boluses are not included in the UK scenarios. Both tags and boluses are considered for the Netherlands, although only results for tags are presented – presumably reflecting a higher cost for boluses. Velthuis et al. (2009) do not consider boluses for the Netherlands.

Other Studies

15. The majority of published studies are generally positive about the use of boluses for electronic identification in sheep. By contrast, less favourable results are reported for a small study in Croatia where difficulties were encountered with using handheld readers on a commercial flock of over 600 dairy ewes, leading to read rates closer to 90% than 100% (Štoković et al., 2009).

16. In England, ADAS (2005) included around 11k bolused sheep (amongst around 120k sheep in total) in field trials, confirming high (>99%) retention rates and similar times for applying a bolus and tag or double tags. However, they also observed some difficulties with handheld readers and difficulties bolusing a few sheep due to size or anatomical problems plus lower (95%) read rates and higher labour requirements for handling batches of sheep with mixed identification devices. More notably, lower rates of bolus recovery at abattoirs - from only 76% for small (20g) boluses to 92% for larger (60g) boluses – are also reported.

17. The ADAS study also included a survey of farmers' preferences for boluses before and after the trial. Interestingly, a smaller proportion (22% for ewes; 12% for lambs) preferred boluses after the trial to before (29%; 18%), perhaps suggesting poor experiences with bolus application and/or performance for some participants. Stebbings (2009) alludes to a similar effect in that whereas some participants in the first Welsh EID trial opted for boluses, none did so in the second trial.

18. Defra (2008) include the ADAS and Welsh trials alongside some other less accessible reports in their summary of UK evidence on EID, echoing concerns about possible issues with bolus recovery at abattoirs and read rates using handheld readers.

The GB National Scrapie Plan

19. The GB National Scrapie Plan (NSP) predated compulsory electronic identification but used boluses in relation to identification and recording of sheep with varying degrees of resistance to scrapie. Boluses were preferred to tags due to the perceived greater security against fraud that they offered,[9] but were provided free to participating farmers (pers comm. AH, Worcester).

20. However, although several thousand sheep were bolused under the NSP, it was not intended or designed as a formal trial of bolus performance and funding was not available for on-going monitoring. Indeed, many boluses were read only once at the point of insertion as "fit & forget" devices. Consequently, there are no statistical records or analysis of retention or read rates, nor of mortality rates and any welfare issues (pers comm. AH, Worcester).

21. Nevertheless, anecdotal recollections of staff involved in the NSP suggest that retention rates were generally reasonable and mortality rates were low. However, retention rates were notably poorer at the outset of the scheme when 15g rather than 20g boluses were used and retention rates for 20g boluses also seemed to be affected by diet, particularly at the time and shortly after insertion. Specifically, feedstuffs such as turnips or silage were liable to induce higher "coughing-up" losses."

22. Since the advent of compulsory electronic identification, the current incarnation of the NSP no longer uses boluses since most farmers have already opted for tags (pers. comm. AH, Worcester).

[9] That is, NSP certification attracted a premium for rams, particularly pedigree breeds, and this created some incentive for fraudulent misidentification – but boluses were more likely to prevent this than tags were.

APPENDIX 3: VIEWS OF SCOTTISH FARMERS CURRENTLY USING BOLUSES

Six farmers out of eight known to be currently using boluses for electronic identification purposes in Scotland were contacted. The findings of the research are summarised below.

Reasons motivating use of boluses

- A perception that boluses provided a more humane method of animal identification by comparison to ear tags which had problems associated with ear tag loss and subsequent ear damage
- A perception that boluses provided a more secure method of animal identification with lower losses and subsequent costs when compared to electronic ear tags (the extent to which black ear tags that might be lost and therefore need to be replaced with identical tags could not be quantified by the respondents)
- No respondent was able to quantify the comparative loss rates and thus the scale of the benefits that might be obtained
- Flock security measure which had reduced/stopped the theft of livestock where holdings were not adjacent to the farmers dwelling
- To facilitate the process of record keeping to assist with flock recording systems and to comply with legislative movement requirements (in the same way that electronic ear tags allow)
- Greater reliability of the flock record keeping and movement systems due to improved retention rates of the bolus versus electronic ear tags

Good points

- The process of inserting a bolus is straight forward
- Boluses provide a secure form of identification. Keepers who own livestock and keep them away from their place of residences appear to value this feature highly. Examples included keepers with more than one holding or keepers who sent livestock away to another holding to overwinter
- Overwintered livestock in are possibly more likely to be exposed to conditions where they may lose ear tags (less familiar surroundings) and thus boluses were preferred by those interviewed in the survey

Negative points

- Inserting a bolus has to be done properly or some of the boluses can be regurgitated (particularly so if the stomach is full)
- A black tag has to be inserted in the ear of an animal if it is bolused negating some of the perceived welfare benefits that might be gained if only had to be bolused
- A black tag has to be inserted in the ear of an animal if it is bolused and if the tag is lost a new tag has to be ordered with a number that corresponds to the bolus number. This adds cost
- If a black tag falls out you can't be sure an animal is bolused unless you can read the electronic bolus
- A hand held reader is less suitable for reading boluses, and thus may require farmers to buy additional reading equipment

Other findings

- Bolus use was restricted to breeding sheep, livestock that it was envisaged would be kept for around five years
- Flocks using boluses were selling livestock both for slaughter and for the store market (these animals were tagged)
- Most of the farmers interviewed in the survey had been using boluses for between one and two years and their feedback was based on the experience and knowledge gained during this timeframe.

APPENDIX 4: VIEWS OF UK ABATTOIRS

Processor interviews

One business that slaughtered ewes on a consistent basis in Scotland was interviewed. A further interview was undertaken with a representative working for a rendering business which was also likely to be affected due to the need to process both fallen stock and abattoir by-products. The remainder of the Scottish processors interviewed processed lambs - which although perhaps less likely than ewes to contain boluses could still do so. Hence lamb processors' views were sought as important industry stakeholders.

A key reason preventing greater engagement with processors who process ewes is that this sector of the industry is dominated by firms located in Northern England. These businesses purchase the livestock they process from Scotland through various livestock markets located throughout the country. Indirectly (via the Food Standards Agency), feedback was also received from two Halal approved plants based in Northern England that slaughtered ewes on a regular basis

The feedback from the sector is summarised as follows:

- Initial reactions by processors to the use of ceramic boluses was negative due to food safety concerns and need to avoid potential problems using a systematic preventive approach in line with HACCP principles
- On further reflection during the interview process, some of the participants considered that systems could be put in place (at some cost) to manage the recording and recovery of ceramic boluses used for identification purposes, but that the need to cater for both tags and boluses in a mixed-identification system would necessarily complicate matters.
- Some operators had experience of processing cattle with bolus implants, most commonly used for worming, but these were made up or a 'cardboard' type of material and had not caused any problems in processing
- Due to the complete lack of experience of this kind of operation, many thought it would be advisable to carry out trials to investigate the practicalities of establishing the necessary systems and controls
- Notwithstanding the potential to develop new systems, if given a choice, it was the preference of many not to have to accommodate ceramic boluses

Key practical issues were identified as follows:

- A desire that the equipment currently used to read ear tags should also be capable for reading boluses

- The need to develop systems to record and communicate the presence and numbers of livestock containing ceramic boluses linked to a system to capture, record and verify that the boluses had been recovered.
- Concerns over the practicality of implementing a recording and recovery system due to the challenges associated with communicating information between different processing areas in an abattoir and the abilities of staff to adopt and operate new working practices
- The installation of appropriate screens in abattoir gut rooms to sift the stomach contents in order to recover and remove the boluses
- The installation of appropriate screens in the rendering process to capture boluses and minimise the numbers entering the crushers
- A need to test the ability and resilience of the current equipment used in abattoirs to cope with ceramic boluses and identify what if any investment may be required.

APPENDIX 5: EXPECTED IDENTIFICATION COSTS

1. The expected costs of electronic identification for an individual sheep depend on the price paid for initial identification devices, the likelihood of having to replace a device, the price paid for a replacement device and time spent on administering initial and replacement devices.

2. In addition, in the case of boluses, capital expenditure on reading equipment will be inescapable since visual inspection alone will be inadequate. Although not considered further here, previous analysis demonstrated the burden of on-farm reading equipment and supported the development of CCPs to avoid around £2m of cost at the Scotland level (Moxey, 2010). Wide-spread bolus usage would negate this capital saving.

3. Current prices for a bolus and black tag are around £2.61 and £0.19, giving £2.80. The current price for an EID tag plus a conventional tag is around £0.81. The current price for an EID slaughter tag is £0.67. Labour is assumed to cost £10/hour.

4. If a bolus is present and working but a black tag is missing, a farmer has to replace the black tag with a black tag with the same number. It is not possible to switch to double-tagging instead since only one active EID device is permitted per animal. An individual replacement black tag matched to a previous number is £0.28, plus £1.50 for postage.

5. If a black tag is present but a bolus is absent, a replacement bolus with a number matched to the black tag is (with postage) significantly more expensive than the original price. However, if surplus devices were ordered in anticipation of some losses, a farmer could simply apply a new bolus and black tag and note the re-identification in the flock register (for £2.80).

6. If either the EID or conventional tag is missing, the missing tag could be replaced with a tag matched to the other's number. However, since the price of such replacement tags (with postage) is higher than for original tags, most farmers will insert two new tags from their stock of tags and note the re-identification in the flock register (for £0.81).

7. The time taken to administer a bolus and black tag or an EID and conventional tag are reported as similar in some studies, although the actual time varies from 1 to 3 minutes. Other studies and anecdotal evidence suggest that bolusing can be more time-consuming, more so in the case of re-identification due to the need to use a reader to scan for boluses and the additional effort required to order a replacement black tag and to keep track of an animal until its replacement black tag arrived.

8. Bolus loss rates are consistently reported as low, but estimates of tag loss vary greatly from around 2.5% to over 10% per year – equivalent to around 10% to 40% over a four year period. This may reflect differences in tag design and adherence to best practice in tagging plus variation in exposure to snagging hazards. Black tag loss rates are assumed to be the same as for other conventional, non-EID tags.

9. Table 2 below illustrates how different assumed rates of bolus loss and tag loss (for both conventional and EID tags) plus different assumptions about labour effort involved affect the expected cost of identifying and re-identifying an individual breeding sheep over a four year period using a conventional tag with either a bolus or an EID tag.

10. For example, a bolus loss rate of 1% with a black tag loss rate of 5% and a labour effort of 1 minute for initial identification and any re-identification equates to an expected cost of £3.09/sheep, £3.45 if labour effort were 3 minutes. Double-tagging costs would only exceed this minimal bolus cost if labour effort were 3 minutes and tag loss rates were 50% or more.[10] The cost comparison becomes even less favourable to boluses if an animal is kept for less than four years whilst single-tagged slaughter lambs have by far the cheapest identification costs (and possibly less welfare issues than a bolus & black tag)

11. Hence, although the assumed unit costs can be varied, it is apparent that - even with some favourable assumptions - bolus usage is relatively expensive when compared to double-tagging under most plausible scenarios. That is, higher retention rates are more than offset by the higher cost of a bolus and the obligation to use an expensive-to-replace black tag that is subject to the same snagging hazards as other tags. With the capital expense of on-farm reading equipment, bolus usage could easily double identification costs for breeding sheep.

12. Consequently, the low rate of voluntary uptake of boluses in Scotland and the wider UK may well reflect farmers' individual decisions about the costs of complying with traceability regulations.

13. Uptake of boluses in some other countries appears to have been encouraged through a mixture of regulatory requirements – effectively obliging boluses to be used – and/or subsidies. For example, funding of around £1 per bolus is currently available in Portugal. However, Table 2 suggests that this level of subsidy would not necessarily make bolus usage costs comparable to those of double tagging for farmers in Scotland.

[10] Implying that each sheep was re-identified at least once. In practice, tag loss probabilities are unlikely to be independent and thus costs are slightly exaggerated here.

Table 2: Expected lifetime identification costs per breeding sheep using bolus + black tag vs. EID tag + conventional tag

Expected lifetime cost of bolus usage															
					Bolus loss/malfunction rate over four year period											
Assumptions	£				1.0%	2.5%	5.0%	10.0%	1.0%	2.5%	5.0%	10.0%	1.0%	2.5%	5.0%	10.0%
Bolus cost	2.61	Labour (min/sheep)			1	1	1	2	2	2	3	3	3	3	3	3
Black tag cost	0.19	Black	5.0%		3.09	3.14	3.21	3.55	3.27	3.32	3.58	3.74	3.45	3.50	3.58	3.74
Replacement bolus cost	2.80	tag	10.0%		3.19	3.24	3.31	3.66	3.38	3.42	3.69	3.86	3.56	3.61	3.69	3.86
Replacement black tag cost	1.78	loss	25.0%		3.48	3.53	3.60	3.98	3.69	3.74	4.04	4.20	3.90	3.95	4.04	4.20
Labour cost per hour	10.00	rate	50.0%		3.97	4.01	4.09	4.50	4.22	4.27	4.61	4.77	4.47	4.52	4.61	4.77
			100.0%		4.94	4.99	5.06	5.56	5.28	5.33	5.75	5.91	5.61	5.66	5.75	5.91
Expected lifetime cost of double tag usage																
					EID tag loss/malfunction rate over four year period											
Assumptions	£				10.0%	25.0%	50.0%	100.0%	10.0%	25.0%	50.0%	100.0%	10.0%	25.0%	50.0%	100.0%
Double tag cost	0.81	Labour (min/sheep)			1	1	1	1	2	2	2	2	3	3	3	3
Replacment EID tag cost	0.81	Non-EID	5.0%		1.12	1.27	1.51	2.00	1.31	1.49	1.77	2.34	1.51	1.70	2.03	2.69
Replacement non-EID tag	0.81	tag	10.0%		1.17	1.32	1.56	2.05	1.37	1.54	1.83	2.40	1.57	1.77	2.10	2.75
Labour cost per hour	10.00	loss	25.0%		1.32	1.47	1.71	2.20	1.54	1.72	2.00	2.57	1.77	1.97	2.29	2.95
		rate	50.0%		1.56	1.71	1.95	2.44	1.83	2.00	2.29	2.86	2.10	2.29	2.62	3.28
			100.0%		2.05	2.20	2.44	2.93	2.40	2.57	2.86	3.43	2.75	2.95	3.28	3.93

Expected cost calculated as:

(Cost of initial bolus & tag or double tags) + (Labour cost of initial identification)
+ (Probability of loss * cost of replacement, for each bolus or tag lost)
+ (Probability of loss * Labour cost of re-identification, for each bolus or tag lost)

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