PRACTICAL ANIMAL IDENTIFICATION AND INTERROGATION SYSTEMS

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SUMMARY
Current practices and recent initiatives on food chain animal identification for both disease and residue trace back and on-farm value adding management and quality assurance are reviewed, with the emphasis on cattle and to a lesser extent on sheep and other small stock. Performance criteria for various applications are identified. The availability and performance of identification device options are surveyed in terms of both method of attachment (tag, anklet, collar, bolus, implant) and means of reading the animal identification (by eye, bar codes, OCR, radio frequency transponders, programmable magnetic resonance, EEPROM contact devices). Future developments in reading options are assessed, including OCR, two dimensional bar codes and radio frequency transponders. Likely developments of mandatory whole of life food chain animal identification are indicated for Australia and the European Union.

Keywords: Animal identification, cattle, trace back, transponder, bar codes.

INTRODUCTION
Research has been funded over many years by the Meat Research Corporation (MRC), its predecessor agency and the Australian Meat & Livestock Corporation (AMLC) on the use of electronic animal identification (EID) to improve cattle management systems. In 1995 incidents of chemical residue contamination of meat involving insect growth regulating chemicals with much longer half lives than Dieldrin or DDT, such as chlorfluazuron (CFZ) in cotton trash and fluazuron (Acatak®) as a cattle dip generated the need to revisit permanent individual animal identification (ID) options as a means of improving trace forward and trace back of food chain animals either showing residue contamination or suspected of having been exposed to such chemicals. Permanent identification of companion animals is well established using subcutaneously implanted glass encapsulated radio frequency transponders.

In 1995, while the AMLC / MRC were continuing their EID projects, including Market Link, three initiatives were also undertaken by government regulators. The Agricultural and Resources Management Council of Australia and New Zealand (ARMCANZ) asked Agriculture Victoria to commission a consultant study (Karingal 1995) on permanent cattle identification. MRC funded work in Tasmania to explore permanent identification options for sheep (Jackson 1996)—Kondinin had earlier reported comparative performance of sheep tags (Kondinin 1990). The Animal Health Committee set up a working group on 'Minimum National Standards for Sheep and Cattle Identification'.

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As the outcome of these initiatives, the ARMCANZ Steering Group in October 1996 (Bailey 1996) endorsed Karingal Consultants recommendation for a dual tagging approach to animal identification based on the existing transaction tag, i.e. tail tag, and a new birth tag to remain on the animal for the whole of its life. The Karingal Consultants report (Karingal 1995) which is available from Agriculture Victoria at Bendigo contains a full review of Australian and overseas literature on animal identification and tracking systems. This present paper focuses on food chain animal identification, particularly cattle and sheep. A further study on animal identification options for dairy shed and test day automation has recently been carried out by Anderson Wright Associates.

**IDENTIFICATION AND TRACKING SYSTEM APPLICATIONS AND CRITERIA**

Individual cattle identification systems exist or will be needed in future in three main applications: regulatory disease and residue monitoring, value adding management systems in the beef herd (both pasture based and feedlots), test day and more general dairy shed automation. There will be similar needs for sheep and other food chain animals (Jackson 1996). In the European Union (EU), such systems are also critical in minimising animal subsidy fraud. The key performance criteria for these various applications developed in the work referred to earlier for cattle are set out in Table 1. They vary significantly between applications. No one identification device is likely to be able to satisfy all needs. Similar criteria will apply to sheep and other animals in the food chain.

**Animal Numbering Protocols:** Any animal identification system, whether it be a closed system, such as the Australian Dairy Herd Improvement Scheme (ADHIS), National Beef Recording System (NBRS) or Market Link, or a national trace back system has to start with an agreed animal numbering protocol. The relevant standard is ISO 11784. EID devices will generally have factory programmed random numbers. These will have to be computer matched to the number normally used on farm, whether it be a regulatory birth tag code, an NBRS or ADHIS number or a user assigned number. Devising and agreeing a national numbering protocol for a regulatory birth tag code that will be used in more than one State involves a different dimension. A national numbering protocol for birth tags was recommended in the Karingal report (loc. cit.) to consist of two parts: the first part to be a property identification code, based on the existing transaction “tail tag” code of seven alphanumeric characters with a check digit and the second part to be a serial number with the option of having as the first character the NBRS year of birth character or the ADHIS two year of birth digits. Zeros at the start of the numeric serial code would not be printed on ID devices. Animal management information software developers will need to include this birth tag code, a string of fourteen alphanumeric characters, as the Master animal number.
Table 1 Cattle Identification Systems Criteria

<table>
<thead>
<tr>
<th>Application</th>
<th>Purpose</th>
<th>Cost Target: Device $ per unit</th>
<th>Reading Device Location</th>
<th>% Retention/ Readability over Time</th>
<th>% Reading Error</th>
<th>Ability to Remove Device from Animal</th>
<th>Abattoir Recovery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regulatory trace back:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. transaction tag</td>
<td>Trace to last property of residence</td>
<td>$0.07-$1.00</td>
<td>Visual in race or pen. Machine at abattoir</td>
<td>99% after 1 month</td>
<td>1%</td>
<td>Must be removable</td>
<td>Yes from body</td>
</tr>
<tr>
<td>2. for whole of life: birth tag</td>
<td>Trace to property of birth</td>
<td>$0.20-0.30</td>
<td>Visual in crush. Machine at abattoir</td>
<td>99% after 3 years</td>
<td>1%</td>
<td>Tamper resistant preferred</td>
<td>Yes from body</td>
</tr>
<tr>
<td>3. subsidy fraud and theft prevention</td>
<td></td>
<td>$1-3, but possibly $8-10 in EU</td>
<td></td>
<td>99% after 3 years</td>
<td>1%</td>
<td>Must be tamper proof</td>
<td>Yes from body</td>
</tr>
<tr>
<td>Value added management (including QA)</td>
<td></td>
<td>$1-3</td>
<td>Visual/ machine in race. Machine at abattoir</td>
<td>5% per over management period</td>
<td>1%</td>
<td>Maybe, reusable if EID</td>
<td>From body if still attached</td>
</tr>
<tr>
<td>Dairy herd test day &amp; shed automation</td>
<td></td>
<td>$8-12(1)</td>
<td>Machine in dairy shed</td>
<td>99% over lactation life</td>
<td>0.05%</td>
<td>Yes, reusable if EID</td>
<td>From body if still attached</td>
</tr>
</tbody>
</table>

Notes: 1. Total system cost $14-18 per cow

TYPES OF AVAILABLE ANIMAL IDENTIFICATION SYSTEMS

We have earlier discussed performance criteria. Two categories of animal ID device attributes have to be considered: attachment methods and reading methods.

Attachment Options: Attachment options for short term transaction tags include tail tags, ear tags and possibly also patches stuck to an animal's hide, such as the American Back Slap Tag. These are used for trace back to the last property of residence, not for individual animal identification. Development issues with transaction tags relate to achieving machine readability at abattoirs to avoid transcription errors and to reduce recording time and between batch variation in adhesion and print fastness. These issues are both being addressed in the current animal identification field trial program described later. Preliminary laboratory tests have shown promise in identifying adhesive coated substrate batches likely to pose problems in the field (Jac Paper 1996).

For longer term applications, such as whole of life birth tags or ID devices for beef or dairy herd management, attachment options include ear tags of various sizes, rumen bolus, subcutaneous implants and, for dairy cattle in herring bone shed applications, anklets and possibly escutcheon tags. ID device costs range from $0.20-1.50 for ear tags to $7-12 each for EID devices. The only feasible and potentially reliable (ie difficult to remove) alternatives to branding, where this is required, are rumen bolus and possibly implants containing RFID transponders. The high transponder cost makes unlikely large scale replacement of branding with RFID, but it could still be attractive in value adding management systems to avoid loss of hide value due to branding.

Subcutaneous implants merit some special comment. Earlier research in Australia (Hasker et al. 1995) identified a number of problems with the devices then available: migration if implanted in the rump and hence abattoir recovery problems, technician level skills needed and high glass capsule breakage rates when inserted in the ear. More recent work in Barcelona, Spain, (Caja et al. 1994) and in Munich, Germany, suggests that these problems can be overcome with the more robust devices now available, particularly if they are sheathed in Teflon® plastic (Kern 1995). A very recent development has been the identification by USDA's Food Safety and Inspection Service (USDA 1996)—as permissible for food chain animal implantation—of “sites, all in inedible tissue, where it has been demonstrated there will be minimal or no migration of the implanted device”: for cattle, subcutaneous on the scutiform cartilage at the base of the ear and above the dewclaw of the foot. Implants above the dewclaw may be an alternative to anklets for dairy cattle RFID in herring bone sheds. The cost advantage will still rest with anklets because of the ability to recycle the RFID device on farm, ie. before slaughter. Interestingly, recent information from the Ministry of Agriculture and Fisheries (MAFF) in the UK suggests that the proposed large scale trials of EID in the EU will use rumen capsules rather than implants or ear tags.

The options for sheep are more limited including only ear tags and possibly implants (Jackson 1996). Horn brands are only effective on those with horns.
Reading Options: ID device reading options fall into three categories: readable by eye, machine readable and readable both by eye and by machine. Traditional plastic and metal ear and tail tags are examples of ID devices at present read by eye. There is however the possibility of standardising the fonts used, eg OCR B, to make such devices readable with optical character recognition (OCR) scanners. An OCR reader has been used for many years for sheep identification in New Zealand (Karingal loc. cit.). ID devices that are only machine readable include a rumen bolus or implant containing an R/F transponder. Some additional external ID device will generally be needed with such devices. Ear tags and anklets containing transponders and plastic tags carrying bar codes are examples of devices that are readable both by eye and by machine. Bar coded tags have been used very successfully to identify cattle entering feedlots through to slaughter and to a lesser extent on farm. They are also being used for identifying sheep. Available information suggests that retention of machine readability of some bar coded tags may be a problem when tags are exposed to chemicals such as cattle dips.

Visual coding techniques may be suitable for use on tags where the main need is to read the tags in the abattoir and machine reading of tags for on-property management purposes is not an issue. Bar coding for on-property management tags does not offer the full benefits of hands free reading as does RFID.

The AMLC/MRC EID project (AMLC 1995,1996a) chose the Texas Instruments Registration and Identification System (TIRIS®) as it offered both superior reading distances and compatibility with International Standards. Other suppliers as indicated later offer similar systems. Hand held and race mounted antennas were connected to computers on-farm and at abattoirs to combine the EID with other data such as live weights, treatments, genetic and carcase data. The major benefit in cases being hands free or even operator-less reading in dusty or wet environments.

Hand held systems that include a hand held computer and antenna in one unit are also available from organisations, such as Telxon and Husky, that specialise in hand held computers and bar code scanners. TIRIS® based stationary transceiver units have been repackaged with a number of styles of antennas by Allflex®, ALEIS® and AnimaLife®. Such configurations allow reading distances of around 600-1000 mm depending upon the brand and model and use of plate or hoop antennae to identify cattle walking in single file through a race. An important issue is the need for a user friendly interface on-farm. An opportunity exists to supply packages with easy to use touch screen computers to allow users to enter data with minimal or no keyboard or software training.

RELATIVE ADVANTAGES AND COSTS
Field performance data: Conventional large plastic ear tags (say 100mm by 70mm overall) with or without bar codes have a long record of successful applications as a management tool in beef and dairy cattle herds. The key issues are retention rate and machine readability. Australian hearsay (Karingal loc. cit.), eg. the BTEC Program experience, suggested about 85% retention over three years. Tag suppliers have claimed higher retention but to-date have not been able to produce independently validated field trial data to support these claims. The only Australian test data available (Evans et al. 1996) reported the strength of tags against that of an animal's ear. The
data are of limited value as the tests were done on new tags rather than after accelerated UV exposure and other studies and experience indicates that tag loss arises from ear failure (tag torn out) rather than tag failure. The only presently available independent study involving sound statistics (Moquin et al. 1993) suggests that retention rate is inversely correlated with tag size. For large plastic tags, 85% retention over three years confirmed the Australian experience. The only tags likely to meet the 99% retention target rate for whole of life birth tags were a small metal tag and smaller size plastic tag. There is however animal welfare and abattoir concern about the use of metal tags (Johnson & Edwards 1996).

A key Karingal recommendation was the need for large scale field trials with a variety of ID devices to confirm birth tag selection criteria and identify most suitable types of ID devices. These trials (AMLC 1996b), funded by MRC and coordinated by AMLC, have just started and will involve two herds in each State in three different environments: dairying, specialist semi-intensive beef and severe scrub/bush. ID device types being tested include small metal and small plastic tags, two types of medium size (60mm. by 60mm. overall) plastic tags, button ear tag and rumen bolus both containing encapsulated transponders. The trials will last three years.

FUTURE DEVELOPMENTS (next 2-3 years)
Reading Options with Bar codes and Related Systems: The ARMCANZ initiated field trials (AMLC 1996b) include investigations of OCR readability and newer types of bar codes, including two dimensional symbologies (2D). Small metal tags are being used as a starting point to test the application of coding systems, as they are expected to offer very high retention rates; it may be difficult to make such tags machine readable. To-date metal tags have been produced with OCR fonts and applied to feedlot cattle for short term trials and are also soon to be marked with a two dimensional code called ID matrix. The code will be formed using a number of pin prick dots punched into the metal with an indenting process. Both OCR and 2D rely on contrast to work. The machine readability of such tags after exposure is not at present known, even if they can be successfully marked.

Two dimensional bar codes allow good information compression and high redundancy. Data compression is important as the proposed birth tag code number is 14 alphanumeric characters long. Such a long number string would almost certainly not fit on normal bar coded tags, let alone small metal ear tags. Redundancy defines the ability of two dimensional codes to rebuild their data even if parts of the code are obscured, since the data are encoded or scattered in two directions across the symbol and not left to right and top to bottom as in a normal bar code. This hopefully can reduce loss of readability due to exposure, dust moisture and generally and loss of clean edge contrast.

Radio Frequency Transponders: Radio frequency transponders (colloquially called “chips”) used in animal identification (RFID) fall into two basic categories:

- **active**, where the transponder has its own enclosed power source battery
- **passive**, where the energy transmitted from the reader aerial energises the transponder response.
All transponders for animal applications need to operate at frequencies that comply with the low interference requirements of the Australian Spectrum Management Agency (Commonwealth of Australia Radio Communications Act 1992). The usable frequency bands are: low frequency 100-140 kHz, high frequency above 10MHz and microwave up to 2.45GHz.

Active transponders are typically more expensive (around $80 each) than passive transponders because of the costs associated with the enclosed battery, inadequate battery technology and more complex electronics. Their primary advantage is that they can be read at distances up to 20 metres, i.e. an animal in a paddock. Their cost has limited their use to neck collars on dairy cows with a pedometer that monitors cow activity for heat detection and animal health monitoring, marketed by Afikim and Wespalia as part of dairy herd management and milking systems. Because of their high cost, there are only one or two herds in Australia using these devices. Use is not likely to increase significantly unless there is a breakthrough in battery technology. Active devices are used extensively in transport applications (e.g. Amskan®).

Passive transponders available commercially at present and used for animal RFID operate in the frequency range 120-140kH. Available readers typically (depending on antenna performance) have a reading range of up to 500-1000mm. They can read an RFID device on an animal moving single file down a race or on a body on a moving abattoir chain (AMLC 1995,1996a) and hence could be used for automated cataloguing of cattle arriving at a sale yard. They cannot read a device on an animal in a paddock or read an ear tag with a reader held by a dairy framer standing behind the animal in a herring bone shed. The ISO international standard recently approved in Hawaii, ISO 11785, has adopted a frequency of 134.2 kHz. At present only two brands, TIRIS® and Datamars®, are known fully to conform fully with this standard. There are other brands operating at other frequencies in the 120-140kHz range that are covered by an Annexe A to the standard—from a systems integration point of view they are “backwards compatible”. Over the next few years, it is possible that manufacturers in this latter category (AEG Trovan®, Datamars®, De stron®, Nedap®) will release their own ISO fully compatible products. While this increased competition will undoubtedly reduce encapsulated passive transponder RFID prices from their present level in Australia of $6-12, the industry view (Transponder News 1996) suggests that this low frequency technology is close to its practical cost minimum and there are unlikely to be major further technology derived cost reductions, eg. down to the $1-3 considered economic for added value cattle management systems. We have followed up a number of claims about RFID devices costing a dollar or less, but such devices are not yet proven in the low frequency range. The only way in which these costs per animal will be achieved with available technology will be by recovery and recycling RFID devices, eg. by a commercial third party managing abattoir recovery and distribution of recycled devices. Three to four reuse cycles should be possible.

Available information suggests that the future technologies to produce much lower cost RFID devices will come in the MH and GH frequency ranges. The electronics is stated to be much more difficult and only a few prototypes are presently available (Jedi®, Tag Track®). A further advantage of these higher frequency devices is that they use a much narrower reading beam and hence might be able to discriminate between different animals in a mob. There are also claims of
significantly greater reading distances. Such devices are unlikely to be commercially available much before the year 2000.

**Other Electronic Devices**

Two other EID technologies are available. EEPROM based touch EID devices, where a wand is used to make contact with and interrogate the “button contact tag” device on an animal, have been developed by MacSema in the USA and by the Dairy Research Corporation in New Zealand as part of their milking machine development. Our analysis suggests that such devices may have dairy shed animal ID applications, but are likely to see greater use in other areas of test day automation such as milk sample flask identification. The other new technology has been the development in Denmark of the MagTag®, an ear tag using programmable magnetic resonance. The developers claim a lower cost than for RFID, but its use could only be as a lower cost alternative to bar coded or transponder containing ear tags with all their limitations.

**THE FUTURE OF REGULATORY FOOD CHAIN ANIMAL IDENTIFICATION**

As indicated ARMCANZ on the recommendation of its Steering Group chaired by Dr. Peter Bailey has foreshadowed implementation in some and possibly eventually all States of a two tag food chain animal identification system supported by vendor declarations. The tags will be the existing transaction tag, eg. tail tag, and a new birth tag to be attached at birth or before leaving property of birth and to be retained throughout the life of the animal. There is a further objective to make all such ID devices machine readable at the minimum on bodies after slaughter in an abattoir. A study is currently under way as part of the field trial program to examine the systems implication of mandatory whole of life animal ID (Jones 1996). The indications are that several States will implement such a system when the field trial data are available to identify types of ID devices with adequate retention and readability performance.

The Karingal study explored the possibilities of developing central databases of cattle movements as presently exist in Northern Ireland and Holland or animal passports or identity cards such as have been used in France for many years and have recently been introduced in Great Britain. The British conclusion was that data capture costs made such central databases excessively costly and hard to maintain without universal electronic identification. The conclusion was that for Australia, State agencies should promote and facilitate animal movement recording by farmers, but not make such recording compulsory, that is beyond the present waybill and vendor declaration systems. The European Union clearly has an ultimate central animal movement database objective.

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