Development of the Bovine Syndromic Surveillance System (BOSSS)

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The Bovine Syndromic Surveillance System (BOSSS) is an electronic system for reporting of syndrome data from diseased cattle. BOSSS was developed for use by a wide range of observers of cattle including veterinarians, stock inspectors, farmers and stock workers.

BOSSS uses a combination of artificial intelligence and an intuitive interface to capture the data of cattle observers. The artificial intelligence component is the cattle computer diagnostic program BOVID© (Larcombe, 1994). BOVID© is a naïve Bayes classifier that contains data on around 1,000 diseases of cattle (endemic and exotic), around 1,500 individual signs and the conditional probabilities for individual signs for each disease. The program uses Bayes theorem to update probabilities for individual diseases when information on likely disease prevalences and the observed clinical signs are provided.

Lay observers can provide detailed information on disease events occurring within the animals in their care when provided with a vocabulary and system for reporting their observations. This requires only basic training when combined with a flexible and logical vocabulary and a method for extracting specific extra detail from a case depending on the details of the case. The existing disease observational and reporting skills of observers was examined in a pilot study involving cattle workers from extensive cattle stations in the lower gulf region of Queensland. Participants used a form containing 31 individual syndromes grouped into nine classes (eg nervous system, gut and mouth) to describe disease events they observed. Basic training in disease syndromes was provided via a booklet with common examples within each sign and group category. Disease observations were lodged using a check-box form that listed all 31 signs and observers were encouraged to also provide a free text description of the case.

The syndromes that were selected by the producer as present were considered appropriate based upon their free text description of the case for most reports received in the pilot study. The average number of signs reported per case was 2.7 (range 1 to 10). Only signs that were present were reported (positive signs). Typically the free text description included information about signs that were not present (negative signs) but these were not formally recorded. Also, extra information on most cases could be obtained by interviewing the observer and this process was most valuable for collecting negative sign information (ie signs that were definitively not present in the case) and for characterising the event (ie class of stock, number affected).

The pilot study demonstrated that providing lay observers with a suitable and flexible vocabulary and a system for extracting extra detail on cases (especially negative signs) would allow them to provide syndrome reports to a quality resembling those from veterinarians.

BOSSS was developed to facilitate reporting by lay observers. The BOVID© clinical sign hierarchy was re-organised from a clinical examination based process to an organ-system based process. Within the hierarchy, the sign groupings branch and progress from the general to the more specific. The hierarchy was modified to allow a sign to be selected at any level of the hierarchy. This was essential to allow an observer to use a general description of a sign if they were unable to determine or describe the specific sign. For example, it is essential that a user can select a general sign such as

'abnormal breathing' instead of forcing them to choose between more specific options such as 'increased respiratory rate' or 'increased respiratory noise'.

For each disease, the conditional probability for each sign that occurs higher in the hierarchy (a parent node) was calculated using the conditional probabilities for the signs that occur immediately below it in the hierarchy (child nodes). This process assumes independence between all child nodes and begins at the lowest level of the hierarchy moving progressively higher until all nodes are assigned a probability. The formula for calculating conditional probability of a parent node is:

$$P(S|D)_{Parent} = 1 - \prod_{1}^{n}(1 - P(S|D)_{Child\,n}),$$ where n = number of child nodes

This adjustment enables both a skilled observer to provide detailed and specific sign information and a less skilled observer to provide a more general description using the same system.

The need to navigate a list of signs was avoided through the development of a graphical user interface for entering basic signs. A hyperlinked image of a cow was created with links between organs systems and body structures to relevant general level signs. A lay observer can quickly enter a description of the most obvious signs using the interface. This development makes basic data entry intuitive for non veterinarians.

Veterinarians combine clinical examination skills with an extensive knowledge of cattle disease to investigate cases. The veterinarian uses various techniques to gather extra information to rule in or rule out individual diseases. Most lay observers do not have sufficient knowledge of diseases and causation to use basic presenting signs to guide the further investigation of a case (or to further describe a case). This is the key skill of the clinician. The interrogation module of BOVID provides an avenue for the system to guide further description and investigation of cases. This facility was employed within BOSSS to enhance the capture of negative and positive signs by lay observers.

A selective list of questions are provided for the observer grouped into two basic categories – signs that can be observed from a distance and signs that require hands-on contact with the animal (eg observation of cattle restrained within in a crush). The questions are selected using a probabilistic model that estimates the potential information gain from each currently unrecorded sign in the case from the current probability estimates for disease with individual sign conditional probabilities. The most discriminating signs have highest information gain and questions pertaining to their presence or absence are presented to the user. This process does not require the user to have detailed knowledge of disease, causation or the sign hierarchy and is therefore an efficient and user friendly way to extract extra information from lay observers.

Because BOSSS has been designed to process information in real time the user is able to access interpreted information from the system. BOSSS has been developed to provide the user with the system's interpretation of their case, useful links to information on disease and to experts as a reward to the user for providing data. The artificial intelligence system provides a differential diagnosis disease list with links to information on epidemiology, treatment, disease control and further investigative steps that may be taken. This information is confidential to the user. The disease differentiating process allows filtered information on methods for control and investigation to be provided. BOSSS has a List Server that links users with a network of volunteer experts. These experts can access case data and provide personal advice to the user. Other rewards for contributors will include capacity to benchmark disease within their herd against region averages, access to syndrome and disease trends, and mapping of likely individual pressures. This information will be obtained from summarising all reports provided and will be available to all users.

BOSSS was developed as an on-line system and was constructed using the open source server-side scripting language php. Data is processed and stored on a central server using the open-source database mySQL. Baseline disease prevalences were obtained from a survey of veterinarians. The provision of data requires the user to access a computer. Cases of disease are observed in the field; therefore systems are being investigated to enable the BOSSS reporting system to be accessed in the field. The development of hand-held BOSSS systems is proceeding, and palm computers and programmable mobile phones are being examined as potential hardware. Significant problems to address include software and hardware limitations on these small devices, interface and data entry issues, battery life and remote telecommunication access. If successful, the capacity to use the system in real time whilst the animal is being observed is likely to improve the quality of information provided, speed investigation of cases and make the system more appealing to potential users.

The BOSSS system can be viewed at www.ausvet.com.au/bosss.

References

Larcombe, M. T., Brightling, P., Blood, D. C. and Kennedy, P. C. (1994) In *Bovine Information & Diagnosis (BOVID)* Animal Information Management, Melbourne.