Novel Technology for the Remote Monitoring of Animals

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Abstract

A new non-invasive array of micro-sensors worn as a collar that wirelessly transmits data via the internet has been developed to provide an always-on virtual 'connection' between animals and their veterinarian. The owner can also receive reports and animated views of what their animals are doing, even when the owner is absent. These recordings provide rich insights into the behavior and wellbeing that may be illustrated in text, graphics and photorealistic animations. The data is analysed continuously and the reports provide information to help veterinarians monitor response to clinical problems, as well as responses to therapy and surgery and the management of animal wellness programmes. This technology now provides information to veterinarians about what their patients are doing between consultations. This replaces the previous reliance on owner observations with evidence based information on which to base advice and treatment.

Introduction

All animals that move share one thing in common, they all change their movements when they become unwell or feel pain [6,7]. Different problems can affect their movement and behavioural patterns in different ways [1,7].

There is little formal scientific research addressing the use of changes in behaviour as an indicator of the early onset of disease. This almost certainly reflects the lack of suitable tools to code and record normal behaviour patterns that would then allow changes to be quantified and used as predictors.

Behaviour

The typical ethological approach to behaviour focuses on the Darwinian fitness and sensory capabilities supporting the observed behaviour, the changes in behaviour patterns with life stage and the evolutionary mechanisms giving rise to the observed behaviour patterns. The foundation of ethology has been based on direct observation in which observers go to great lengths to neutralise the effects of actually making the observations.

Behaviour refers to the organised patterns of activity making up an animal's life. Activity itself refers to the patterns of motion that are characterised by duration, frequency and intensity. Activity patterns vary diurnally and seasonally and have now been shown to be subject to short term modification by changes in the prevailing weather conditions. Patterns of activity are typical of a species and frequently characteristic of an individual. Without movement there is no behaviour to observe or measure. Modern technology now makes it possible to measure animal behaviour in their natural and undisturbed environment where experimental manipulation is impractical, undesirable or even unethical.

Relationship between animal behaviour and health

The development of behavioural indicators can be used to help identify and detect the early onset of ill health in animals. Moreover these tools can be used to assess an animal's response to treatment and the baseline used as a target to confirm that full health has been restored.

The lack of research in this field may reflect the belief that changes in behaviour are defects and nothing more than an inability to behave normally. It also reflects the lack of good data because measuring changes in behaviour has been laborious, time consuming, episodic and almost always lacks enough detail to be useful.

Behaviour as an indicator of health

Although behavioural signs are well established as a means of diagnosis there has been very little scientific research outlining the use of behaviour in the detection and management of disease. The use of behavioural signs are regarded as clinically subjective and based on empirical experience rather than the outcome of clinical trials. Such observational measures are difficult to repeat and are generally considered unreliable.

Behavioural signs that may increase in intensity and frequency include scratching, polydipsia and erratic movements of the body or head; alternatively the signs may decrease as in reduced hunger and thirst, lethargy and long term changes in mobility. In some cases the intensity and frequency of the behaviour may vary little but the diurnal patterns may change significantly as in photophobia. In some cases an animal may change their response to other individuals and their environment.

Sick animals usually eat and drink less and withdraw, spending more time inactive than normal. This response is not related to the debilitating effects of the disease but is a coordinated deep seated evolutionary response referred to as the sickness syndrome[3] that precedes the onset of signs. This response is thought to conserve energy for mounting an immune response and creating a fever. Many studies have shown the relationship between sickness syndrome and cytokines found in the cell walls of gram negative bacteria.

Animals are known to suppress the outward signs of sickness as they may draw attention to their weakened state. In situations where they are susceptible to predation, this may reduce their chances of survival. This stoicism creates a challenge for clinicians wanting to use behavioural signs in diagnosis. One way to overcome this is to use automated measures that can operate all the time and do not require the presence of an observer. These techniques are particularly useful as they record behaviours in periods when sick animals relax their guard and start to display behaviours they would not normally do when people are present.

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Modern devices make it possible to explore the onset of sickness behaviours and how these behaviours vary between conditions, giving rise to the potential for quantitative estimates of the level of sickness in an individual. Electronic systems monitoring feeding behaviour have been shown to identify animal morbidity 4 days earlier than direct observation.[4]

Methods of data capture

The advantages and disadvantages of methods of data capture are noted in Table 1. The traditional approach has been observation which was supplemented by recording images as technologies made that possible. More recently, there have been sensors developed that can give more detail and provide electronic records that can be calibrated with observations to allow for the interpretation of the information recorded and reported. The miniaturisation of these sensors has led to non-invasive monitoring and the use of sensors that do not influence an animal's behaviour.

Digitising behaviour

The Digital Event Loggers (DEL) are devices worn by animals that sense when and how they move and then store the data in memory. The devices house an array of sensors designed to sense a range of biologically important signs as well as to code and record motion in different axes relative to the wearer.

The records of coded movements create digital signatures that are characteristic of specific behaviour patterns. These signatures can be detected automatically with the appropriate algorithm thereby laying the foundation for an automated system that can quantify changes in animal behaviour over time. Wireless connectivity allows data to be captured and the results disseminated to health professionals in near real time over the internet.

The devices create a whole new method of assessing patients and reduce the reliance of health professionals on the care giver for feedback on how an animal is responding to treatment.

DEL and disease detection

The onset of illness in animals is usually indicated when they appear depressed, listless and off their food; the so called three 'A's of Attitude, Activity and Appetite.(2,5,7)

Changes in behaviour are amongst the first indicators that an animal is ailing. These changes can take on many forms including the loss of normal behaviour as well as the development of new and abnormal behaviours such as:

- Increased frequency of a normal behaviour: polydipsia in diabetics, scratching
- Decreased frequency of normal behaviour: hydrophobia in rabies
- Erratic behaviour: seizures in epilepsy and head throwing in salt toxicity
- Pattern changes : photophobia in facial eczema
- Avoidance: reluctance to jump in arthritis or perform strenuous activity in cardiac patients
- Abrupt changes in normal behaviour: sudden stopping in cardiac syncope

Table 1: Advantages and disadvantages of methods of data capture

Method	Advantages	Disadvantages
Observation	Observation is simple	Coding require for analysis
	Observe multiple animals	Coding behaviour consistently is difficult
	Can adapt recording method on the fly	Limited detail in coded recordings
	Night vision possible	No continuity – episodic recordings
	Only capture data on behaviour	Differences between recorders
		Presence may affect observed behaviour
		Can only observe one animal at a time
Imaging	Image recording for later observation	Animal must be in field of view
	Good at tracking	Images need coding for analysis
	Night vision possible	Automated image analysis limited
	Recordings can be re-examined	Recorded images still need coding
	Fixed array of cameras at locations	Episodic measurements very infrequent
		Large amounts unwanted background data
		Animals out of vision for long periods
Sensors	Environmental – cage movement sensed	Animals confined in cage
	Data automatically coded	Only measures changes in location
	Sensors on animal – no observer	Must decode and understand digital signal
	Animal not confined	Must be fixed for long periods to animal
	Continuous on-going data stream	Requires long battery life
	Long periods of uninterrupted recording	
	No need to be in line of site	
	Multiple sensors multiple measures	
	Consistent measurements between animals	
	Simultaneous recording multiple on animals	
	Sensors go where animal goes	
	Data coded automatically	

- Decreased activity: decreased movement of animals in pain

An important capability of DELs is to record behaviours in the absence of an observer thereby eliminating one of the biggest modifiers of normal behaviour patterns.

Case study

A 31kg 2 year old brindle Bull Terrier cross presented with itching and a rash. The dog was fitted with a Heyrex biosensor fitted to the collar that monitored scratching activity. The chart shown in Figure 1 clearly shows that scratching started around the 9th of January and apart from a single low level on 22nd January has continued.

Examination of the daily scratch patterns in Figure 2 shows that most of the scratching activity occurred between midnight and 06:00hrs. Scratching was severely disruptive to sleep during this period.

The veterinary examination revealed severe papular eruptions ventrally. There was severe interdigital erythema with palmar ulceration accompanied by muzzle erythema. There was also mild periocular erythema and moderate to severe purulent conjunctivitis, especially around the left eye. There was suspected Tradescantia flumeninsis ("Wandering Jew") hypersensitivity. Other hypersensitivity, with secondary infection was also certainly possible.

Cytology of a skin biopsy from the groin revealed no significant findings. Cytology from the feet revealed 2-4 yeasts per oil immersion field. A skin scraping was negative for Demodex. A Tradescantia test patch caused significant erythema and a marked increase in scratching as measured by the Heyrex digital event logger worn by the dog.

At the conclusion of the first veterinary consult the patient was given an injection of Dexamethasone. This improved the skin colour but had little effect on the scratching activity (Figure 3). The challenge with Tradescantia increased scratching activity to the highest level recorded in this dog (Figure 3). On the 11th February the client administered topical cream to the ventral surface which decreased scratching activity immediately.

Examination of the daily scratching activity patterns shows that the cream gave relief for around 8 hours following application last thing at night and before the care giver left the house in the morning (Figure 4). The scratching patterns over the day show that the dog started scratching late in the afternoon and would benefit from another application when the care giver got home from work. This change was instituted and the beneficial relief was clear (Figure 5).

Increase in scratching
Following exposure to Wandering Jew, the dog displayed a marked increase in scratching, easily identified in the long term scratching graph on HeyrexPro.

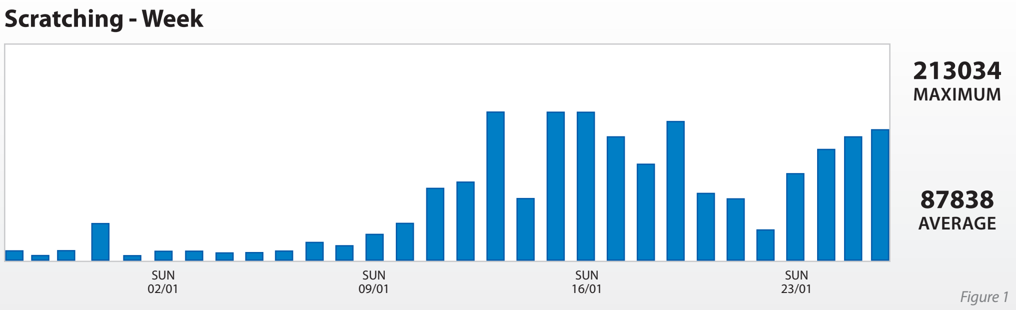

Figure 1

Nocturnal scratching profile
Reference to a single 24 hour period during this episode revealed that the majority of scratching occurred between the hours of midnight and 6am, making it difficult for owners to detect but again, easy to recognise using HeyrexPro.

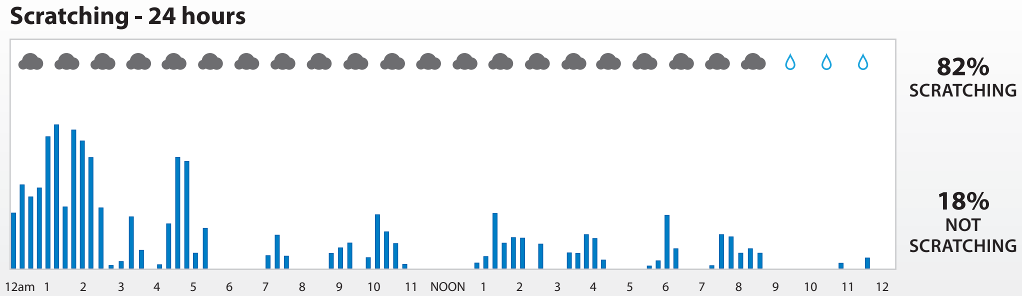

Figure 2

Treatment details
Histogram showing daily scratching behaviour over the 30 day period from 14th January to 12 February 2011. 'A' refers to the Dexamehasone injection; 'B' the challenge from tradescantia test patch; 'C' the application of topical cream.

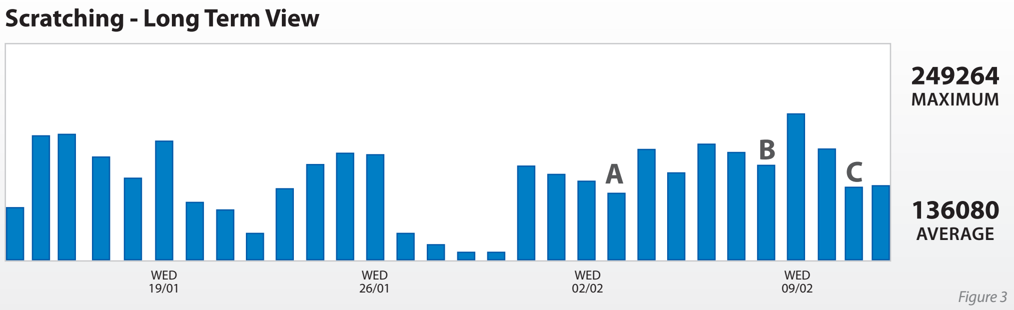

Figure 3

Treatment has insufficient duration
Treatment was instigated, consisting of applications of topical steroid cream to the affected areas. Treatment was monitored via HeyrexPro revealing that applications of cream were not providing total relief.

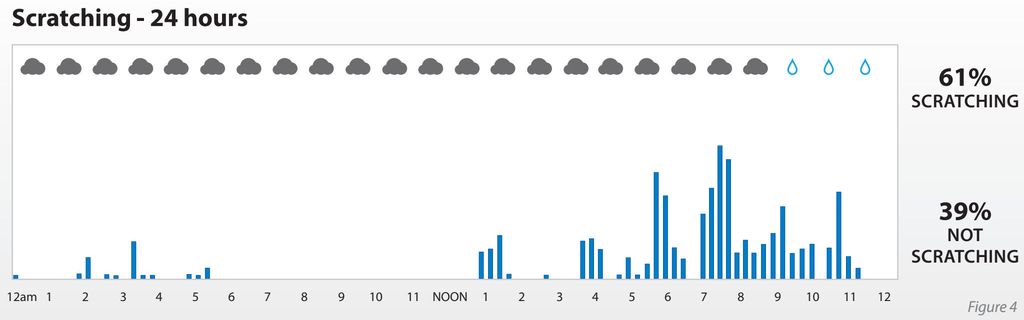

Figure 4

Treatment adjustment with Heyrex
Based on evidence from the HeyrexPro graphs, treatment was modified which provided 24 hour relief from symptoms.

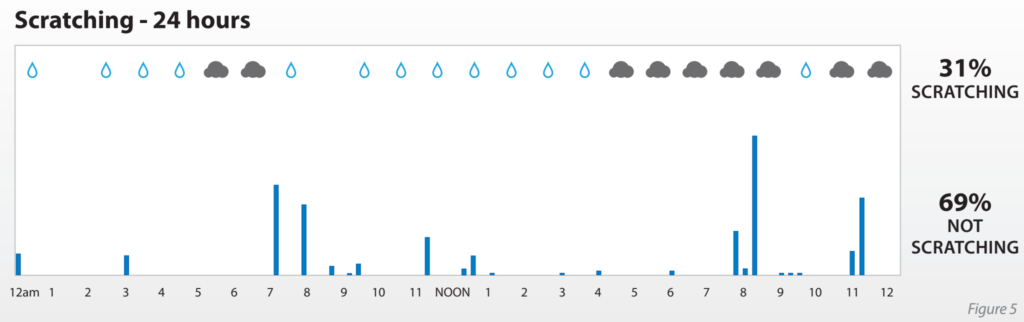

Figure 5

Discussion

New technology will now enable veterinarians to monitor the behaviour of canine patients remotely. This provides for an objective insight into a dog's behaviour between consultations. The data is interpreted to assist veterinarians reach clinical conclusions. They can now determine whether the therapy prescribed is effective and when intervention is required. Furthermore, the technology is now providing insights into behaviour that have not been reported previously.

Behaviour is an important indicator of the onset of disease and a vital means of assessing an animal's response to treatment. The ability to code, record and detect changes in behaviour patterns is providing the evidence required to improve animal wellbeing.

Once the characteristic daily behaviour profile of an animal has been established it is then possible to intervene with a clear objective, restoring the normal profile for that patient. The goal of any treatment plan should be to restore the normal behaviour patterns that are characteristic of the animal.

When a treatment programme has been recommended and agreed to, the patient's response to treatment can be monitored. If the desired response is not achieved then the patient can be recalled for a revision to the plan. The recall is based on clinical evidence rather than an arbitrary time frame allowing clinicians to implement individualised evidence based medicine.

The predicted improvement back to full health may become a valuable aid to provide a more objective gauge of treatment success for patients where their activity levels have been compromised by such degenerative changes as arthritis.

References and recommended reading

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