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EQUINE

Monitoring distances travelled by horses using GPS tracking collars

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Objective The aims of this work were to (1) develop a low-cost equine movement tracking collar based on readily available components, (2) conduct preliminary studies assessing the effects of both paddock size and internal fence design on the movements of domestic horses, with and without foals at foot, and (3) describe distances moved by mares and their foals. Additional monitoring of free-ranging feral horses was conducted to allow preliminary comparisons with the movement of confined domestic horses.

Procedures A lightweight global positioning system (GPS) data logger modified from a personal/vehicle tracker and mounted on a collar was used to monitor the movement of domestic horses in a range of paddock sizes and internal fence designs for 6.5-day periods.

Results In the paddocks used (0.8–16 ha), groups of domestic horses exhibited a logarithmic response in mean daily distance travelled as a function of increasing paddock size, tending asymptotically towards approximately 7.5 km/day. The distance moved by newborn foals was similar to their dams, with total distance travelled also dependent on paddock size. Without altering available paddock area, paddock design, with the exception of a spiral design, did not significantly affect mean daily distance travelled. Feral horses (17.9 km/day) travelled substantially greater mean daily distances than domestic horses (7.2 km/day in 16-ha paddock), even when allowing for larger paddock size.

Conclusions Horses kept in stables or small yards and paddocks are quite sedentary in comparison with their feral relatives. For a given paddock area, most designs did not significantly affect mean daily distance travelled.

Keywords behaviour; feral horses; foals; global positioning system (GPS); horses; paddock design

Abbreviation CI, confidence interval; GPS, global positioning system

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Extent of movement and distances travelled by domestic horses may affect their general health and hoof quality. It is believed that domestic horses have become more sedentary since the industrial revolution, with many now maintained in small paddocks and stables because the amount of land available for horse maintenance has decreased. The Thoroughbred racehorse, for example, is an athletic horse that is typically boxed in a stable for 23 hours/day and moved to the training track for a short gallop once daily.[1] The psychological, physiological and musculoskeletal consequences of this relatively sedentary lifestyle are not fully understood, but the low level of mobility from an early age may adversely affect the shape, structure and function of the foot. Domestication has also necessitated an altered diet,[1] and horses are routinely fed high-energy food twice daily. Confinement and altered feeding patterns parallel the modern human lifestyle that is thought to be a major contributor to current high prevalences of obesity, cardiovascular disease, arthritis and diabetes. For example, the prevalence of osteochondritis dissecans was 26% in 1000 yearling Thoroughbred horses surveyed radiographically, and diet and environment were cited as contributing factors.[2] Another radiographic study of 315 yearling Standardbred horses revealed bone and joint lesions in 58% of horses, 38% of which required surgical correction.[3] Hyperinsulinaemia has recently been associated with laminitis,[4] and both a diet high in non-structural carbohydrates and low levels of activity are associated with hyperinsulinaemia.[5]

It has been hypothesised that horses move more in large paddocks and that paddock design may also affect the distance moved; for example, it has been suggested that a 'racetrack' design is a useful strategy for increasing the distance moved by horses.[6] The effectiveness of this design has not been investigated. Understanding the relationships between both paddock size and internal fence design and distances moved would allow development of practical management strategies to increase horse movement.

The velocity of horse movement varies considerably, making locomotion studies in the field challenging. Global positioning systems (GPS) are now sufficiently lightweight and accurate to measure speed variation and to distinguish small movements of fast-moving animals, so accurate determination of horse movement profiles has become feasible. GPS have been used to measure locomotion variables in horses during cross-country riding[7] and in foals at pasture.[8]

Little is known about the movement patterns of domestic horses or the effects of the various forms of yard and paddock confinement on distance travelled. Also, to the authors' knowledge, there have been no reports of the distances travelled by free-ranging, non-domesticated horses. In studies of domestic cattle, those in a rangeland environment were observed to walk up to 27 km between visits to water,[9] whereas cattle in a more intensive grazing situation walked up to 5.5 km during a 24-h period that included grazing, watering and socialising.[10] Free-ranging cattle in Africa walk about 5000 km annually (an average of 14 km/day).[11] Equidae are generally more mobile than cattle and capable of covering greater distances between feeding and watering.[12] In one study, female zebra walked approximately 15 km over a 12-h period between water and their feeding region, remaining for 3 to 4 days before walking back to water.[13]

The aims of this work were to (1) develop a low-cost equine movement tracking collar based on readily available components, (2) conduct

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preliminary studies of the effects of both paddock size and internal fence design on the movements of domestic horses and (3) describe distances moved by mares and their foals. Additional monitoring of free-ranging feral horses was conducted to allow preliminary comparisons with the movement of confined domestic horses.

Materials and methods

GPS data logger

The University of Queensland Equine GPS data logger was constructed from a Wintec G-Rays GPS unit (G-Rays 2 WBT-201 data logger, Wintec Wireless Electronics, Taiwan). The store-on-board GPS unit was modified by the addition of a circuit board to control the power input from an additional three AA-battery pack. The total weight of the GPS, battery and collar for domestic horse tracking was 450 g. With the addition of a very high frequency location beacon for feral horse tracking, the collars weighed 700 g. The GPS unit was mounted on a neck collar with a full sky view, counterweighted by the battery pack, which hung under the horse's neck. The 130,000 position storage capacity of the unit and the life of a single battery power source (6.5 days) allowed data logging at the rate of a position every 5 s.

Data defining both the horizontal and vertical positions were downloaded via Google Earth Plus (Google Earth Plus-google.com). The Wintec software was used to perform distance calculations from the raw GPS positional data. The pattern of travel was superimposed on Google Earth satellite photographs and checked for plausibility and data error.

Horse movement assessments

Four preliminary studies were conducted to explore the effects of paddock design and size on distance travelled. In each study, the average daily distance moved for each horse was calculated, based on the total distance moved for the 6-day observation period. Descriptive statistics were calculated using Microsoft Excel and other statistical analyses were performed using Stata (version 10, StataCorp, College Station, TX, USA).

The project was approved by the University of Queensland Animal Ethics Committee.

Effect of paddock size. Data loggers were fitted to each of four mature-age (mean ± SD, 6.75 ± 2.2 years), pregnant (approximately 310 days of gestation) domestic Quarterhorse × Australian Stockhorse mares due to foal within 2 weeks of each other. These horses were grazed together for three consecutive 6-day periods in each of three different paddocks, sized in sequential order 0.8, 4 and 16 ha. All paddocks were on the same farm and the study mares were familiar with all paddocks. Mares were placed in each paddock at the same time. They were not hand-fed and all paddocks had sufficient pasture mass to ensure adequate feed intake over the confinement intervals.

A further seven domestic Quarterhorses (3 geldings, 4 mares; age 3–4 years) were each simultaneously tracked for 6 days on a commercial horse-training property. These horses were housed in familiar yards measuring 6 m^2 and were hand-fed twice daily throughout the study.

The relationship between paddock size and average distance moved for the group (calculated as the average of each horse's average distance moved daily) was described as a function of the natural logarithm of paddock size using data from the groups of domestic horses.

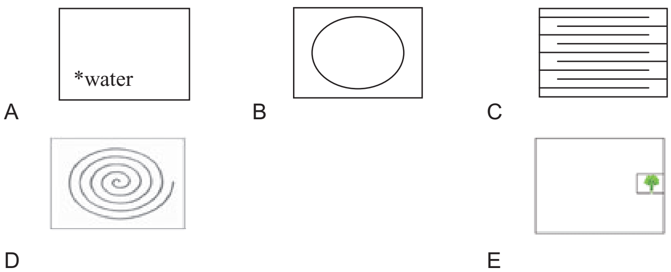

Figure 1. Internal fence designs compared in a study assessing the effects on distance travelled by horses: (A) open, B) racetrack, (C) maze, (D) spiral, (E) open and no tree. *Location of the waterpoint.

Effect of internal fence design. A 5-period cross-over design was used to assess the effect of various internal fence designs on distance travelled. Five horses (4 mares, 1 gelding; age 3–9 years) were each sequentially grazed separately in the five designs. The same rectangular paddock (100 × 50 m) was used throughout the study. There was one tree in the paddock, which provided the only area of shade for the horses, and a stationary trough was the only water point. The internal fence design of the paddock was varied using electric fencing. All horses were accustomed to electric fencing. The five internal fence designs are shown in Figure 1.

Open: The paddock perimeter was fenced with electric fencing (Figure 1A).
Racetrack: The open design with an additional internal oval ring of fencing to create an 8-m wide racetrack around the perimeter of the paddock (Figure 1B). Horses were confined to the racetrack strip and excluded from the centre of the paddock.
Maze: The open paddock was divided into 10 strips, 10 × 50 m long, with gaps at alternate ends to make all strips accessible (Figure 1C). Horses were required to move through each of the 10 strips to travel from one end of the paddock to the other, effectively travelling at least 500 m when moving from one end of the 100-m paddock to the other.
Spiral: The internal fencing had a spiral configuration so that the horses had to travel in circles of diminishing radius to move into and away from the centre of the paddock (Figure 1D).
Open and no tree: Because the horses spent a disproportionate amount of time standing under the shade tree in the open paddock, the open design was used with the tree fenced off to prevent this (Figure 1E).

The maze and spiral designs were not expected to have practical applications in horse management, but were included in the study to determine the effect of complex designs on movement. Each of the five horses were assessed separately in each paddock design, but always in the company of a subordinate yearling gelding to provide company and minimise the likelihood of separation anxiety, which may have affected the movements of the dominant horse. Each horse spent 6 consecutive days in each design, with no delay or 'washout period' between designs. The first horse was rotated through the five designs in an ad hoc order, then each of the remaining four horses was allocated to first receive one of the designs using a random draw, followed by each other design in the same order as the first horse. The paddock was spelled for 2 weeks between each horse and pasture cover was maintained to ensure grazing without supplementary feeding during each experiment. Mean distance travelled daily was calculated for each horse for each design and log-transformed. Mean distances travelled were compared between designs using linear regression with horse fitted as a fixed effect.

Mare and foal comparison. Three days after each mare's foaling, the same four mares used in study 1 (paddock size) were grazed with their foals in the 4-ha paddock for a 6-day period. To avoid interference with development of the mare–foal bond, GPS collars were applied to each mare and foal when the foal was 3 days of age. Each mare and foal was again monitored simultaneously when the foals were aged 3 to 5 weeks while in a different paddock (5 ha) on the same farm to determine if there was a difference in activity between newborn foals (a period when they are often stabled) and more mature foals. Effects of class (mare or foal) and foal age (3–9 days vs 3–5 weeks) on average distances moved daily were analysed using linear regression with pair (mare–foal combination) fitted as a fixed effect. Effects of pregnancy/lactation were analysed using linear regression with data only from mares with mare fitted as a fixed effect. Correlation coefficients were estimated for the association between the distances moved daily by mares and foals; separate estimates were made for 6-day periods commencing when foals were aged 3 days and then at 3 to 5 weeks. The 95% confidence interval (CI) for the correlation coefficients was calculated using Fisher's transformation.

Feral horse monitoring. Three mature feral horses from different family bands (1 mare, 2 stallions) and living wild in a 4000-ha paddock were tracked for 6 consecutive days. In order to apply the collars, horses were darted with 0.7 mL etorphine hydrochloride (Imobilon, Novartis SA Pty Ltd) when they approached water. When the horse went into lateral recumbency, the collar was placed and the immobilising agent reversed using diprenorphine hydrochloride (Revivon, Novartis SA Pty Ltd, IV). Horses returned to their family band within 15 min of darting and appeared both unaware of the initial human contact and unaffected by their collars. After a minimum of 6 days, the same feral horses were relocated using the very high frequency beacon on their collar and again immobilised by darting, the collars were removed, the immobilising agent reversed and the horses released.

Results

GPS collar performance

The data logger device logged positional data at 5-s intervals for 6.5 days. The unit ran continuously and did not record either the usual gaps in data or the error often associated with reconfiguring position in relation to satellites; it was 100% reliable over 384 data logging days.

Horse movement assessments

Paddock size study. Average distances moved for the groups were greater in larger paddocks (Figure 2A). The average for the group was: 4.7 km/day (range 4.2–5.2 km/day) for the 0.4-ha paddock; 6.1 km/day (range 5.8–6.5 km/day) for the 4-ha paddock; 7.2 km/day (range 6.7–7.6 km/day) for the 16-ha paddock. The average for the feral horses in the 4000-ha paddock was 17.9 km/day (range 12.52–5.9 km/day). The average for horses kept in the 6 × 6 m yard was 1.1 km/day (range 0.2–1.9 km/day).

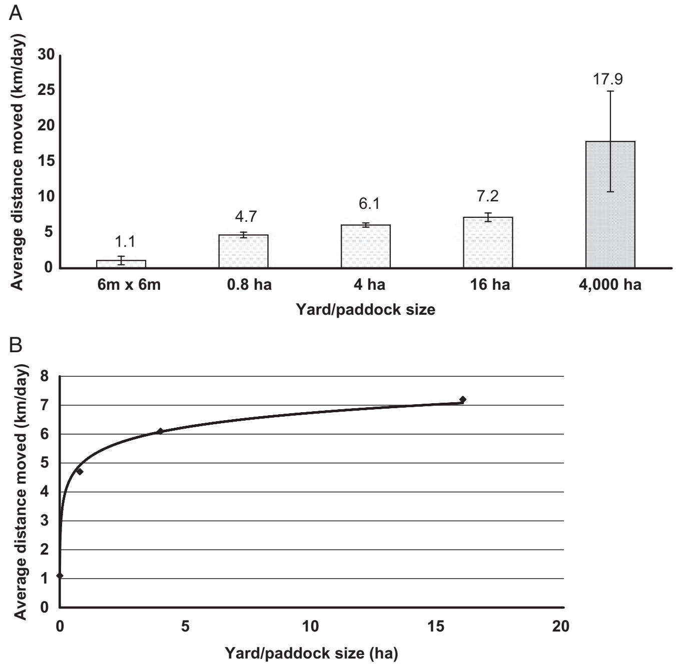

Figure 2. (A) Average distances (km/day) moved by groups of horses (± SD of each horse's distance) over 6 days in various sized yards and paddocks. Light shade indicates domestic horses; dark shade indicates feral horses. (B) Scattergraph of average distances moved by groups of domestic horses against yard/paddock area and logathithmic line of best fit of average distance moved by group as a function of yard/paddock area.

The average distances moved by the groups of domestic horses could be described as a logarithmic function of paddock area: Average distance moved/day = 0.72 (SE 0.029)**ln*(paddock size in ha) + 5.08 (SE 0.094)(R^2 = 0.997) (Figure 2B).

Internal fence design study. Mean distances travelled daily by the five horses for each of the internal fence designs are summarised in Table 1. The average of the distances travelled by each horse was greatest for the open paddock design and smallest for the spiral design (ratio of geometric means 0.72, 95% CI 0.55–0.96, $P = 0.03$). There were no significant differences ($P > 0.35$) in the distances travelled by horses between the 'open' paddock and either the 'maze' or 'open and no tree' paddock designs. There was also no significant difference between the 'open' and 'racetrack' paddock design (ratio of geometric means 0.94, 95% CI 0.71–1.24, $P = 0.63$).

Mare and foal comparison study. Prior to foaling, the average distance travelled for the group of mares (derived from study 1) was 6.1 km/day (range between mares 5.8–6.5 km/day). During the 6-day periods from 3 to 9 days and 3 to 5 weeks after foaling, the average distances moved by mares were 7.2 km/day (range 6.9–7.4 km/day) and 7.7 km/day (range 5.9–10.7 km/day), respectively (Figure 3). Daily distances moved by foals were 7.3 km/day (range 4.5–9.5 km/day) and 7.3 km/day (range 4.5–9.3 km), respectively. After account-

Table 1. Distances moved by five horses in paddocks with various internal fence designs

Internal fence design	Distance moved (km/day)			Ratio of geometric means (95% CI)	P value
	Range between horses[1]	Arithmetic mean[2]	Geometric mean[2]		
Open	2.8–5.3	4.1	4.0	Reference group	
Racetrack	2.7–6.0	3.9	3.7	0.94 (0.71–1.24)	0.63
Maze	2.5–6.8	3.8	3.5	0.88 (0.67–1.17)	0.36
Spiral	2.1–5.8	3.1	2.9	0.72 (0.55–0.96)	0.03
Open and no tree	2.8–4.9	3.9	3.8	0.96 (0.73–1.28)	0.78

[1]Average of distances moved by horse daily on 6 consecutive days. [2]Means of daily average for each horse. CI, confidence interval.

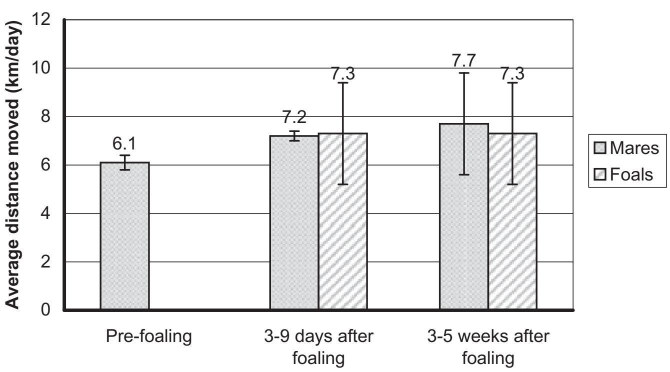

Figure 3. Mean (±SD) distances walked by mares before foaling, and by mares and their foals 3 to 9 days and 3 to 5 weeks after foaling.

ing for mare–foal pair and class (mare or foal), the difference in mean distance walked between 3 to 9 days and 3 to 5 weeks after foaling was not statistically diffferent (difference between means 0.2; 95% CI −1.8–2.2; P = 0.83). The observed correlation coefficient suggested that distances moved were quite closely correlated between mares and their foals during the first tracking period (3–9 days after foaling), but the estimate was imprecise (r = 0.81; 95% CI −0.68–1.00; P = 0.19). During the second study period (3–5 weeks after foaling), the correlation coefficient was 0.47 (95% CI −0.90–0.99; P = 0.53).

Feral horse monitoring. The average distance travelled over 6 days by the three feral horses in the 4000-ha paddock was 17.9 km/day (range between horses 12.5–25.9 km/day) (Figure 2A).

Discussion

GPS collar performance

The weight of the GPS collar with the location beacon attached was approximately 0.15% of total body mass, which was substantially less than in a previous report monitoring zebra in which a collar weight of 0.4% of body mass was found to interfere less with the rate of travel during grazing than a heavier collar weighing 0.6% of body mass.[13] The effects of the collars used in the current study on distance moved could not be assessed but were assumed to be minimal. The collars did not appear to disturb the movement of the horses as neither skin abrasions nor damage to the collars was evident after horses had worn them for 6.5 days.

Horse movement assessments

Paddock size study. Results from this study should be interpreted with caution. Because the horses were run together in each paddock and because they tended to move together, the group, rather than the individual horse, should be viewed as the unit of analysis and the results reflect effects of paddock size on average distance travelled for groups, not for individual horses. (The broodmares used in the study were normally housed together and their owner did not allow the mares to be separated, fearing that this may stress the mares in this important late stage of pregnancy.) In addition, under this study design, confounding may have occurred because of differences between paddocks, other than size, and horse-level factors related to the use of different horses in yards and paddocks. External validity of this study may be low because the relationship between paddock size and distance moved may depend on feed and water availability, terrain and horse characteristics. Distance travelled by heavily pregnant mares may vary from other classes of horses. Finally, groups of horses moved through the different sized paddocks in a non-random order. If carryover effects occur, they may have confounded the results.

Despite these limitations, the substantially lower average distances moved by the study horses in small enclosures as compared with the groups in open paddocks quantifies the relative inactivity of these horses outside of scheduled training sessions. Many athletic performance horses, such as Thoroughbred racehorses, Standardbred trotters and pacers, elite dressage horses, eventers and even long-distance endurance horses, spend the majority of time inside small box stalls or yards. Arena-trained horses, such as working Quarterhorses and dressage horses, may only cover between 1 and 2.4 km in a hard 30- to 40-min training session,[14] so total distance travelled daily during both training and confinement is still substantially lower than the daily movement of the group of unworked horses in the 4-ha paddock in the present study. Similarly, many racing Thoroughbred horses cover only 2 to 3 km in each training session and progress to their first start only 68 days following the start of training preparation.[15] If movement in the box or yard is 1.1 km/day, as observed in the current study, the total distance moved would be only 3 to 4 km/day, which is less than the average daily distance moved by the group of unworked horses in the 0.8-ha study paddock, is approximately 75% of that travelled by the group of unworked horses in the 16-ha study paddock and is approximately 25% of the average of the daily distances covered by the feral horses in this study. The ideal exercise regimen for racehorses has not been defined, although a total distance of between 5 and 9 km/day over a 10-week period has been proposed.[16] It is possible that athletic horses should move over greater distances daily for optimal health.

Distances moved by horses for the purpose of fitness conditioning may have different effects from the same daily distance travelled during sedentary activity, because of the differences in speed between these circumstances. Although the measured values of distance travelled serve to indicate relative movement activity, further processing of GPS positional logs into descriptors of speed, as well as the amount of movement, will add to the interpretative power of the recorded data. The low-cost, off-the-shelf GPS technology used in the present study potentially could be used for that purpose.

These results suggest that the distances travelled daily by groups of domestic horses may reach a maximum of approximately 7.5 km for paddock sizes exceeding the maximum used in this study (i.e. 16 ha). If confirmed with replicated studies in a range of environments, this would indicate that horses in paddock sizes exceeding 16 ha can be considered to be 'unconfined' for the purposes of gauging the effect on daily travel behaviour. However, the minimum paddock size that constitutes 'unconfined' is likely to depend on available feed, water resources and the number of horses in the group.

Internal fence design study. A 'trail' paddock design based on observations of feral horses, and simulated in the present study by the racetrack design (Figure 1B), has been proposed to promote natural movement of horses.[6] Interestingly, in the present study the average mean daily distance travelled was highest for the open paddock design. The study horses appeared to move less at night when exposed to complex internal fencing, possibly because of the greater risk of contacting the fences. Although the results of our study did not demonstrate that distance moved differed between the open paddock and racetrack designs, the racetrack design offers management benefits. The large central area of the paddock can be used for other activities, such as pasture rehabilitation, hay making or as an arena.

Mare and foal comparison study. The study results demonstrate that domestic newborn foals are as active as their mothers and capable of moving 5 to 10 km/day when aged 3 to 9 days. Early mobility is essential for feral horses because the mare and newborn foal must move with the family band soon after parturition; foals that do not stand and walk promptly may perish. However, conventional management practice for domesticated horses is to leave foals in box stalls or small yards until the feet and legs are 'hardened' enough to be able to withstand the rigours of outdoor mobility. In this situation, based on findings from the paddock size study reported here, foals would be unlikely to move more than 1 km/day in the first few weeks of life (compared with 7.3 km) and, because of the confined area, would be unlikely to reach speeds faster than walking. The musculoskeletal and neuromotor systems of the foal, as with most biological tissues, require mechanical stimulation to optimise growth and development. Although the effects of exercise in early foalhood are unknown, lack of early stimulation and tissue adaptation may compromise optimum development. Given adequate space, foals spend a substantial amount of their locomotion time at the trot or canter and high workloads during early development might be important in conditioning the musculoskeletal system. Researchers recently concluded that a 30% increase in foal workload did not adversely affect the musculoskeletal health of performance horses[17] and in a subsequent study there were no adverse effects of foal workload on the racing careers of these horses.[18] In a cohort study of 401 foals, the authors concluded that foals should be allowed to exercise regularly as a preventative measure for developmental orthopaedic disease and osteochondrosis, and that limiting paddock size may also help prevent cartilage damage.[19] However, it is not known whether the increased risk of cartilage damage in foals grazed in larger paddocks was because of increased exercise or because of access to a larger selection of pasture. This highlights the need to objectively measure exercise levels in horses in various environments.

Feral horse monitoring. Distances travelled by the feral horses were far greater than those observed for domestic horses and indicate that there are important behavioural differences between unworked domestic horses and feral horses, which is not surprising given the difference in resource availability (feed and water) between domestic and feral horses.

Conclusions

A lightweight GPS data logger, modified from a personal/vehicle tracker and mounted on a collar, was a practical and reliable method for measuring horse movement over extended periods. Horses kept in small paddocks are quite sedentary compared with their feral relatives and stabled horses and horses kept in small yards perform very little physical activity. Newborn domestic foals move as much as their mothers. Horse movement is limited to an extent by paddock size. Several popular paddock designs had no significant effect on distance travelled by unworked domestic horses.

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OBITUARY

John Allan Macfarlane

1945–2009

At the end of 1968 Mac was called in by Prof. Marsh Edwards for a viva in veterinary medicine. Marsh said, “Well, Mac, do you know why you are here?’

‘To see if I pass or fail!’

‘No, no Mac, to see if you get a credit or a pass,’ Marsh pointed out.

On hearing this, Mac stood up and muttered, ‘ Credit!! Never had one in my life, don’t intend to start now!’, and walked out.

In many ways, this typified John Allan Macfarlane – ‘do the job, do it well and walk away when it’s finished’.

John Mac died in a Brisbane hospital in May 2009 after a battle with leukemia. He was optimistic to the last, hoping for a cure.

He was born in Sydney in May 1945 and educated at Tudor House, Bowral, then The King’s School, from where he gained entry to the University of Sydney to study veterinary science.

After graduation John headed to Narrabri, working for the Rural Land’s Protection Board (RLPB), and there he developed a love for sheep and the sheep industry to which he devoted most of his life. In December 1986 he began work as the District Veterinarian in the Armidale RLPB and he was there till he retired in July 2007.

The control and eradication of virulent footrot, and management and advice to sheep farmers on controlling anthelmintic resistant intestinal parasites took up much of John’s time, but somehow he gained a Masters Degree in Rural Science and in Natural Resources, and passed his examination in Sheep Medicine for the Australian College of Veterinary Scientists.

It was following the discovery of ovine Johne’s disease (OJD) in the Central Tablelands in the 1980s, that John’s veterinary prowess came to the fore. The Regional Veterinary Laboratory in Armidale where many sheep in poor condition were being autopsied was not finding OJD as the cause. It appeared that the prevalence of OJD varied around the State. That RVL was closed in 1997, but John Mac continued his surveillance of the disease. Over 400 thin sheep presented for slaughter at the local pet food abattoir were autopsied, till the RVLs at Orange and Camden asked him to stop sending samples. All samples from those sheep proved to be negative. The RLPB chose 100 flocks at random for footrot surveillance and the rangers were permitted to collect faecal samples from 100 older ewes for pooled faecal culture. These all proved negative too.

At the urging of some sheep veterinarians, leaders of the industry in New England and senior veterinary personnel in the NSW Department of Agriculture, John oversaw the formation of the NE OJD Coordinating Committee, which sought to warn sheep farmers in NE and elsewhere of the dangers of bringing OJD into the district. Through an education program, John and the Board highlighted the epidemiology of OJD so that farmers moved from an ‘awareness’ to an ‘understanding’ of this insidious disease. It is testament to his work that there are still no known infected flocks in New England.

John was not an ‘upfront’ person. He did not like ‘leading the charge’, but nevertheless he was a good leader of a team, always ready to backup a spokesman with technical details. He was adept at delegating authority to others. Whether it be at a Senate Inquiry into OJD or deliberations with the Minister for Agriculture (or his senior staff), John would provide the information and let others do the talking. It was this self-effacing feature that was one of the most appealing parts of his character.

When in 2004 the Minister for Agriculture gazetted New England and other large parts of NSW as an OJD Exclusion Area, John did not slow down, but kept up the pressure through the RLPB system to maintain vigilance lest OJD ‘creep in’. The sheep industry in NE and NSW should salute him.

The veterinary profession has lost one of its great members, a good friend and quiet achiever who loved his wife and family, sailing and a good red wine. To Sally and their children Angus, Sam, Katherine and Jane, we extend our love and deepest sympathy.

D Moen

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