Dog-Livestock Interactions: Influences on the behavioural responses of sheep to working dogs in the herding environment

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A B S T R A C T

Animal herding requires an understanding of species-specific behaviours and the interactions between livestock, handlers and dogs. The significant knowledge gap on the behavioural responses of sheep to working dogs in the herding environment has stimulated investigation into this field. The primary objective of this work was to investigate links between the frequency of undesirable sheep behaviours (i.e. foot stamping, splitting, stopping and escape) and the herding style and skill level (indicated by trial score) of working dogs. Identifying the specific behavioural displays that elicit sheep defense behaviours will facilitate the selection of ideal herding dogs based on temperament and skill set. The *Observer*™ 10.0 program was used to code sheep and dog behaviours. Fifty video recordings from the 2013 NSW West Wyalong Yard trials were observed and analyzed. A total of 46 dogs were used in the study. All were of the Kelpie breed, with the exception of one Border Collie. The frequency of sheep behaviours (per minute) was compared across multiple factors: competition level (Improver or Open), trial score, trial duration and sex. The NSW Yard Dog Association allocates trial scores based on herding performance. Dogs must begin in the Novice level and progress into the Improver (intermediate), then Open (higher) division. Statistical analysis revealed a significant interaction between all factors (competition level, trial score, duration and sex) and the frequency of sheep behaviours (escape, foot stamping, splitting, start/stop) ($P=0.007$). Specifically, trial score was strongly associated with the frequency of escape attempts in sheep ($P<0.001$). Dogs with a high trial score triggered less escape attempts throughout the trial than dogs with a low score. Further, dogs from the Open level had fewer incidences of splitting, escape and foot stamping by sheep than Improver dogs. This was expected, given that more experienced dogs would be more capable and confident than novices. Foot stamping showed a moderate positive correlation with single escape attempts by sheep (0.560), which may be a useful predictor of sheep flight responses. 'Not moving' in dogs also showed a strong positive correlation with escape (single) (0.865). Investigation of dog behaviours revealed a strong correlation between escape attempts with crouching and stalking (0.715 and 0.880 respectively). As prey species, it is reasonable that sheep perceive these two postures to be averse or threatening, which may elicit flight responses. Comparison between sexes revealed that females showed more frequent crouching and stalking than males, suggesting that sex may influence herding behaviour. Based on the study findings, experienced herding dogs that limit escape and defense behaviours in sheep achieve higher scores in yard trials.

1. Introduction

Working dogs are a traditional component of farming practice and offer an invaluable service to humans. The estimated median value of the work performed by herding dogs is currently $40,000 per annum, which provides dog owners with a 5.2 fold return on investment (Arnott *et al*., 2014). In 2009, the population of herding dogs in Australia was estimated at 94,592 (Australian Companion Animal Council, 2009), yet trends toward increased dog use has current figures standing between 270,000 and 300,000 (Arnott *et al*., 2014). More recently, their involvement in animal management has become controversial and is subject to external scrutiny, particularly by livestock industry bodies and animal welfare organizations. This has been brought to light by reports of injury to livestock (ASPCA, 2013), which has prompted concerns over their welfare. Inexperienced or incompetent dogs have a tendency to show objectionable herding techniques such as wool pulling, limb nipping and body biting, which exacerbates the distress experienced by sheep. It has been demonstrated that animal handling techniques influence aspects of both behaviour and physiology (Hemsworth *et al*., 2011). Altering the way in which sheep are handled and the practice of low stress techniques will achieve greater livestock cooperation and in turn, improve production. Adopting an approach centered on a sound understanding of sheep behaviour will allow stockpersons to manipulate some, if not all, aspects of herding, to reduce stress and facilitate sheep movement.

Kilgour and De Langen (1970) were among the first to measure physiological changes in cortisol concentration in sheep as a direct consequence of various handling procedures. Results indicated that dogs chasing livestock elicited the greatest rise in cortisol, which, when chronic, has been associated with decreased wool production and poor meat quality (Apple *et al*., 1995; Ruiz-de-la-Torre *et al*., 2001). This finding was later validated by

Hemsworth *et al* (2011), in his study involving working dogs positioned >2m, <2m and in 'close' contact with sheep. The highest cortisol concentrations were recorded in the situation involving the closest proximity, where dogs were directly positioned beside the flock.

Observed changes in the expression of normal behaviours in different contexts (such as in herding), particularly in the presence of dogs, have been well documented (Frid and Dill, 2002 and Beausoleil *et al*., 2005). Beausoleil (2005) observed changes in ovine behaviour in the presence of numerous stimuli, reporting an increased frequency of vigilance behaviour, foot stamping and urination in the presence of a wolverine figurine that was positioned in a predatory, stalking posture. Such outcomes validate concerns over the welfare of sheep. In the natural environment, animal conflicts arise between competing motivations in many situations. In the presence of a predator or perceived threat (such as a human or dog), there is shift in motivational state to survive, initiating a 'fight or flight' response. In this instance, both active and passive strategies may be observed, including active defense (charging, foot stamping and facing), active avoidance (escape or hiding) or passive avoidance (immobility) (Erhard & Mendl, 1999). The objectives of the study were twofold: firstly, to identify the interactions between sheep and dogs in the herding environment (Figure 1) and secondly, to determine whether factors such as herding competition level, trial score, sex and trial duration significantly influenced the frequency (per minute) of sheep behaviours.

Both the body language (ie posture; arched back, eye contact) and herding style of a working dog are paramount for its success. Investigating the relationship between working dogs and sheep during herding through behavioural analysis will ultimately allow for a better selection of dogs based on both temperament and skill set. Potentially, this may lead to a reduction in stress experienced by sheep, through more efficient herding. This may be interpreted as movement of

livestock to the desired destination with a low frequency of escape attempts, retaliation (foot stamping), stopping and splitting (separation of the flock). To achieve this, it is essential the dog maintain an appropriate balance between speed and pressure. The dog must apply pressure to the sheep in order to move them to the required destination, yet show composure and calm when necessary to maintain the flock in a low stress environment. (ADDED)

It was hypothesized that working dogs with a high trial score will move livestock more efficiently than dogs with a low trial score. The NSW Yard Dog Championship classified dogs into competition levels of varying difficulty, which is in part determined by their previous trial scores and herding ability (ADDED). In this study, dogs from the lower "Improver" division and the progressively higher "Open" division were compared. Dogs in the Improver level were expected to trigger more undesirable displays in sheep, such as escape and splitting, than Open level dogs. Identifying the specific behaviours in dogs that trigger undesirable displays in sheep will allow handlers to be better informed in their selection of working dogs for herding. This may lead to improvements in herding efficiency and animal welfare, through a reduction in stress experienced by sheep.

2. Methodology

(changed order as suggested)

2.1 Materials and Procedure

The West Wyalong Yard championships are held annually, involving the assessment of working dogs based on their ability to herd sheep in a controlled environment (ADDED. A total of 50 videos from the 2013 trials were collected, which included 16 from the improver division and 34 from the open division. Prior to analysis, information was collection regarding the dog owner's

name, age and sex of dog, breed, competition level (Open or Improver), number of sheep herded and trial score. Yard dog trialing is a sport which has classes of competition from Beginner/Novice through to Improver and Championship (NSW Yard dog championship, 2014) (ADDED). Each dog is allocated a trial score based on herding performance. In the study, dogs from the Improver division and the progressively higher Open division were compared. In these trials, dogs are required to move sheep through a series of obstacles and lead them into a drafting pen. All dogs from the Improver level are eligible to enter into the higher Open level. However, any dog that has achieved an Open title may not compete in the lower level (NSW Yard Dog Association, 2013). A total of 46 dogs were used in the study (14 females and 32 males). All dogs were purebred kelpie breeds (45), with the exception of one border collie. In some instances, dogs appeared in both Improver and Open yard trials (refer to appendix). Similarly, some dogs ran multiple trials and therefore appear in more than one observation. Trial scores, indicative of herding ability, are allocated based on performance by two selected Judges. Scores ranged from 49-90 out of a 100. Incorrect or inappropriate responses from dogs incur a penalty. Scores are determined through a deduction system, whereby each fault demonstrated during the trial is equivalent to one point. At the end of the trial, the total number of faults is calculated and subtracted from the initial perfect score (100). Trial scores are used to determine whether a dog may progress into a higher competition level. Dogs that fail to complete the trial are classified as 'retired' (NSW yard dog association, 2013). In the data, these appeared as 'R'. Two major faults commonly demonstrated throughout trials are escape by sheep and splitting of the flock. Other faults include overworking or underworking sheep, sheep not brought in a straight line to the obstacle or interference by the handler. Therefore, this work will serve to test the validity and robustness of the NSW trial scoring system by determining whether a high trial score is a true reflection of a dog's ability of dog's to move livestock with enhanced efficiency. Ethical approval was granted prior to the commencement of this research (NOO/1-2013/3/5902).

2.2 Software

Analysis was performed using the observational software *Observer XT 10.0* (Noldus IT 206/354 Eastern Valley Way, Chatswood). This software has several advantages over previous paper and pencil methods, as it allows behaviours to be coded accurately and quantitatively (Yalowitz and Bronnenkant, 2009). Video data can be used live or imported following recording. In the study, off-site video footage from the 2013 West Wyalong Yard Trials was imported into the system. The statistical analysis module allowed data to be filtered to identify correlations between sheep and dog behaviours.

A coding criterion was designed in the Observer XT to classify the primary sheep and dog behaviours of interest. Each behaviour was assigned to a key/consonant to record its frequency in the Observer program (e.g. escape single = f). The frequency of sheep behaviours were documented in a group context. The responses of individual sheep were not recorded, as they were not the focus of this study. The sheep behaviours recognized included: 1) *start* 2) *stop* 3) *foot stamping* 4) *escape single* 5) *escape group* and 6) *splitting*. Dog behaviours included 1) *moving* 2) *not moving* 3) *stalking* 4) *crouching* 5) *chase* 6) *bark* 7) *licking* (Table 1). For consistency, two distinct time points defined the beginning and end of each observation: in essence, these points were the moment when the dog initiated its first movement towards the sheep, to the time when all sheep have entered the drafting pen (Figure 1). The duration and frequency of sheep and dog behaviours was recorded using the software. Statistical analysis of the data was undertaken in Genstat™ 16th edition (VSN International Ltd, Waterhouse Street, Hemel Hempstead, UK). Log-linear models and simple correlations were used to determine the relationships between factors (i.e. trial score, level, sex and trial duration) and sheep behaviour.

Relationships between behaviours and factors were indicated by significant P values (>/<0.05).

2.3 Repeatability

Intra-rater reliability allows researchers to determine the degree of accuracy when an observation is repeated under identical conditions by the same observer. The usual method of calculating the intra-rater reliability is to use the Kappa statistic (Cohen, 1960) (Table 2). To ascertain this, a random subsample of 5 herding videos was selected and replayed in the Observer program. The reliability or repeatability was determined using the event frequency method. This involves comparing the frequency or number of sheep and dog behaviours documented in both the original and recoded observation. A Kappa statistic of 0.87 was achieved.

3. Results

Regression analysis revealed a significant interaction between trial score, competition level, duration and sex with the frequency (per minute) of all sheep behaviours (P=0.007). Specifically, trial score had a significant interaction with the frequency of escape attempts (single and group). In general, the number of escape attempts per minute was greater in lower scoring dogs compared to dogs with a high trial score. Similarly, the interaction between both competition level and trial score with escape frequency (single and group) per minute was highly significant (P<0.001) (Figure 2). The frequency of splitting in the mob was also greater in lower scoring dogs, suggesting that more experienced dogs may be capable of stopping a split before it occurs. Trial duration also showed a significant interaction with the frequency of all sheep behaviours (P<0.001). Investigation of dog behaviours revealed a significant relationship between both stalking and crouching with escape attempts in sheep (P<0.005). Both crouching and stalking

behaviour showed a strong correlation with single escape attempts (0.715 and 0.880 respectively). Improver dogs displayed more frequent stalking and crouching during the trial than Open dogs (Figure 3).

Comparison between dog sexes revealed that females (14) displayed more frequent crouching and stalking behaviour than males (32) (Figure 4.) Sex had a significant interaction with the frequency of sheep escape behaviour (single and group) ($P<0.01$). Correlation analysis revealed that foot stamping was positively associated with escape attempts (0.560). A strong positive correlation was also established between single escape attempts and not moving in dogs (0.885).

4. Discussion

Based on the subjectivity of behavioural observations, it is imperative that the degree of agreement across observers is determined. In the absence of clearly established technical characteristics, researchers cannot be assured that the variables of interest are being consistently measured, nor are they being accurately represented. The intra-rater reliability was used to calculate the degree of concordance using a single observer. The kappa statistic achieved in the study (0.87) is comparable with previous reports studying cognitive processes in humans (Chung *et al*, 2010). According to Cohen (1960), an intra-class correlation coefficient (ICC) or Kappa statistic 0.70 is considered acceptable.

Due to the limited research in this field of animal behaviour, cross comparative analysis was difficult. To the author's knowledge, this is the first known study investigating the specific

movements and interactions of sheep and dogs during herding. The results of the study provide a reasonable indication of the chief predictors of undesirable ovine responses, which may be used to facilitate better selection of dogs based on temperament and skill set. The study results supported our initial expectations. The hypothesis that working dogs with a higher trial score would be able to move sheep more efficiently than dogs with less ability was supported. Higher scoring dogs were able to complete the trial with fewer escape attempts by sheep and less splitting than lower scoring dogs.

The assumption that less experienced, Improver dogs would be more likely to elicit undesirable sheep behavioural displays such as foot stamping and escape attempts (single and group) was also confirmed. Data analysis revealed a higher incidence of escape attempts (single and group) in the Improver level compared with the Open level. As expected, dogs with a lower trial score elicited more escapes by sheep (single and group) during the trial than higher scoring dogs. A dog described as 'weak', while comfortable around light or cooperative sheep, will generally stop and stare or turn away from the sheep when faced with a difficult situation. Anecdotal observations suggest that sheep can interpret this weakness relatively well and respond by taking advantage of the opportunity by attempting to escape. This may serve as a possible explanation as to why dogs with a lower trial score elicited more sheep flight behaviour. It is apparent that the level of experience in dogs is also an important factor for dog selection. It is assumed that a higher competition level coincides with more experience in herding. The significant interaction between trial duration and the frequency of sheep responses is also important, as working dog handlers may select more experienced dogs to move livestock swiftly and fluently to the required destination. The premise behind this is that moving livestock swiftly will provide less opportunity to display undesirable behaviours such as escape, stopping and splitting.

The positive correlations between dog crouching and stalking with single escape attempts (0.715 and 0.880 respectively) were expected based on the predator/prey relationship of the two species. Stalking is an innate predatory posture and is a common behaviour of wolves, often displayed during hunting. In the predatory sequence, stalk is preceded by eyeing out the prey and is followed by chase (Coppinger *et al*, 1987). This series of events leads to a grab-bite and eventual dissection and consumption of their prey (Coppinger *et al*, 1987). It is therefore reasonable to presume that a dog displaying frequent stalking and low, crouching behaviour will be considered threatening to sheep and thus elicit or prompt flight responses.

Comparisons between sexes revealed that female dogs demonstrated more frequent crouching and stalking behaviour than males. Sex had a significant interaction with escape frequency (single and group), with females eliciting more flight responses in sheep than males. Based on this finding, identifying sex-related behavioural differences in herding dogs may assist working dog handlers in their selection of dogs for specific roles on farm. The differences between females and males in crouching and stalking frequency suggest that there may be a sex related influence on herding behaviour. Further investigation using a larger sample size across multiple working environments may serve to explain this finding. Based on the association between crouching and stalking with escape responses in sheep, the frequency of these displays in dogs during herding may serve to reduce both the stress experienced by livestock and facilitate more efficient herding. This can be achieved through appropriate training of working dogs that places less emphasis on these behaviours and greater emphasis on alternate herding techniques.

The moderate positive correlation between foot stamping and single escape attempts highlights the potential for a new method of assessing working dogs to improve sheep welfare. This is

consistent with results from previous studies by Torres-Herdandez and Honenboken (1979), reporting an increase in foot stamping by 32% in the presence of dogs. Foot stamping is an important behavioural display, as it has been shown to be used by sheep to successfully defend themselves against coyotes and shows an intention to butt (Connolly *et al,* 1976). In the context of livestock herding, this is significant in that working dog handlers may be able to potentially avoid undesirable flight responses by the flock by using foot stamping as a predictor. Handlers may issue vocal commands to the dog to add or remove pressure on the flock when foot stamping is displayed, to circumvent an attempt to escape. However, because this study only examined sheep behaviours in a group context and did not assess the behaviour of individuals, further assessment needs to be conducted to evaluate the strength of the relationship between foot stamping and escape attempts during herding. Whether an individual sheep carried out multiple foot stamps during a trial was not determined in this study.

4.1 Conclusions

The swift, yet calm movement of sheep to the required destination with minimal start/stop movements is considered an ideal herding style, as sheep are provided with less opportunities to escape. The strong positive correlation between single escape frequency and 'not moving' in dogs supports this. When a dog ceases moving, sheep most commonly respond in a similar way and fixate on the stimulus. It is at this point where individuals are required to make a decision as to how to react and may be either passive (avoidance/escape) or defensive (foot stamping, escape). Previous studies have shown that gregarious creatures tend to form tighter flocks when threatened (Hamilton, 1971). Thus, sheep will aim to remain within the centre of the flock, often at the expense of others. This is a classic example of Hamilton's 'selfish herd theory', which postulates that aggregations are the consequence of individual efforts to reduce their own predation risk (Hamilton, 1971). It is reasonable to suggest that the ability of a working dog to

keep the flock together and moving is bound to reduce the level of stress experienced by sheep and consequently, improve particular aspects of welfare and production.

4.2 Recommendations

It is recommended that handlers be more careful in their selection of dogs based on their temperament and develop thorough training programs with these dogs to ensure they reach their full potential. Based on the study results, yard trial score may serve as a useful means of verifying a dog's efficiency in herding. However, trial score is among multiple other factors (such as experience and sex) that should be considered when determining the suitability of a dog for herding. A dog with a very high trial score, that demonstrates frequent stopping or stalking/crouching may not necessarily be the most appropriate based on the associations between these behaviours and flight responses in sheep. It is critical that working dogs possess a keenness to work yet possess the ability to relax (The Working Kelpie Council, Australia 2013). Achieving the correct balance between speed and pressure is important, as moving to livestock to the required destination is likely to be more effective if it is done in a way that exerts low stress. Further research into the flight zone of sheep during herding trials should also be conducted to facilitate working dog training and improve herding technique (ADDED).

4.2 Limitations

This study is limited by its predominant focus on the Kelpie breed during herding, with the inclusion of only one border collie. Future research in this field should include a broader range of

working dogs for comparison of natural herding style and herding ability among different breeds. Further, only selected herding techniques were included in the coding scheme. Behaviours such as 'Eye' and 'Bite', while not included in the study, frequently occur in the herding environment and should be further investigated. Finally, in some trials, responses of sheep to the dog and the stockperson may have been compounded when the drafting gate was opened outward to allow the dog to move sheep through. While no direct human interference occurred throughout the trials, the effects of background noise such as human vocalization/commands and dogs barking may have influenced sheep responses. Because herding trials are conducted in a controlled and relatively small environment, the responses by sheep in a natural setting, such as a farming property, would be expected to be more variable and unpredictable.

There is scope for future research to determine the inter-rater reliability or the degree of concordance of results among multiple raters. This would be useful in assessing the merit of behavioural observations as a subjective measurement of animal welfare. Validation of the behavioural responses against physiological parameters that imply reduced welfare such as cortisol levels is also warranted.

5. Acknowledgements

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Tables & Figures

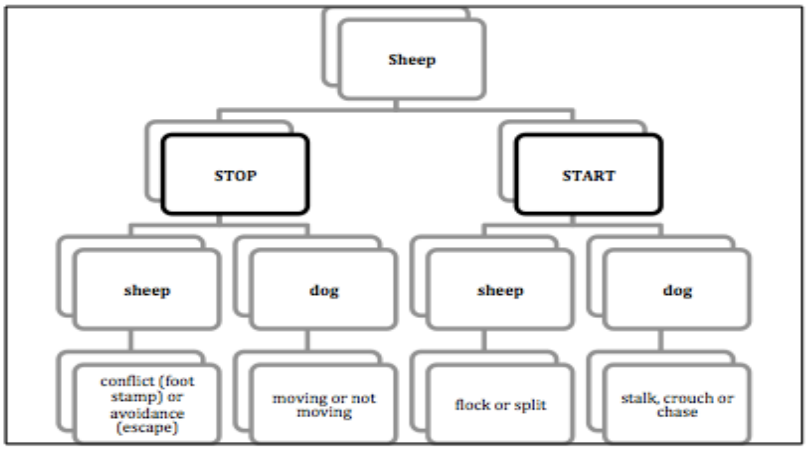


Figure 1. Behavioural ethogram on the possible interactions between sheep and dogs in the herding environment. The specific dog movements that influence the flock's decision to stop or initiate movement are of primary interest.

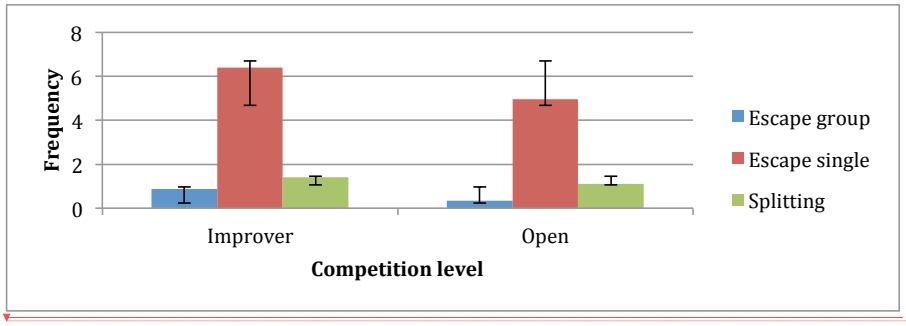
Behaviour (Dogs)	*Description*	*Behaviour type*
STALKING	The dog approaches the sheep at the walk, with back arched	State event
CROUCHING	The dog is crouching on the ground without advancing	State event
MOVING	All movement where the dog is making progress in any direction, but not stalking or chasing	State event
NOT MOVING	When the dog is stationary, but not crouching	State event
BARK	Vocalization directed toward sheep	Point event
CHASE	Running action toward sheep, generally following an escape attempt by one or more sheep from the flock	State event
LICK	Tongue moves across lips or muzzle	Point event

Behaviour (Sheep)	*Description*	*Behaviour Type*
START	Sheep advance in any direction	State event
STOP	Sheep are stationary OR flocking in a circular motion without advancing	State event
ESCAPE SINGLE	An individual sheep makes an attempt to escape and separates from the flock	Point event
ESCAPE GROUP	The entire flock attempts to escape, usually following the attempt of one individual sheep	Point event
SPLITTING	Division of the flock with individuals or groups moving in different directions	Point event
FOOT STAMPING	Foot is lifted and placed on ground forcefully during head on interaction with the herding dog	Point event

Table 1. Coding criterion of sheep and dog behaviours to be observed and recorded in the Observer program. A state event is defined as an event where the duration of the behaviour is relevant. A point event is one where the duration of the behaviour is irrelevant or not directly measureable.

Observation (owner_dog)	**Percentage of agreement (%)**	**Kappa**
White_White	84.36	0.83
Taylor_Ice	82.00	0.82
Cox_Cherokee	85.19	0.84
Thompson_Aker	96.15	0.85
Luff_Fob	86.21	0.96
Average		**0.87**

Table 2. The inter-rate reliability calculated from a random subsample of 5 observations. The average degree of agreement between observations using a single observer was 0.87 (Kappa).



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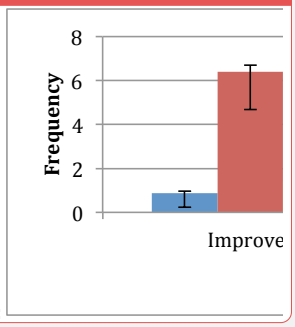

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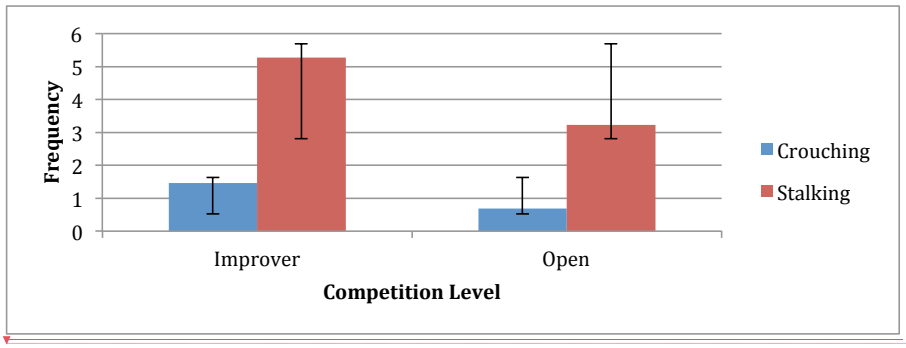
Figure 2. The average frequency (per minute) of sheep single escape attempts, group escape attempts and splitting in Improver and Open level trials. Error bars have been fitted and are equivalent to 1 standard deviation.



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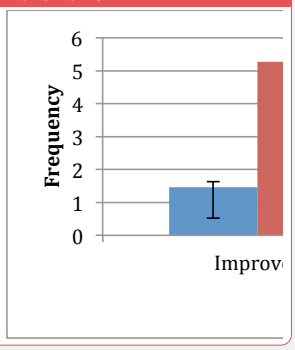

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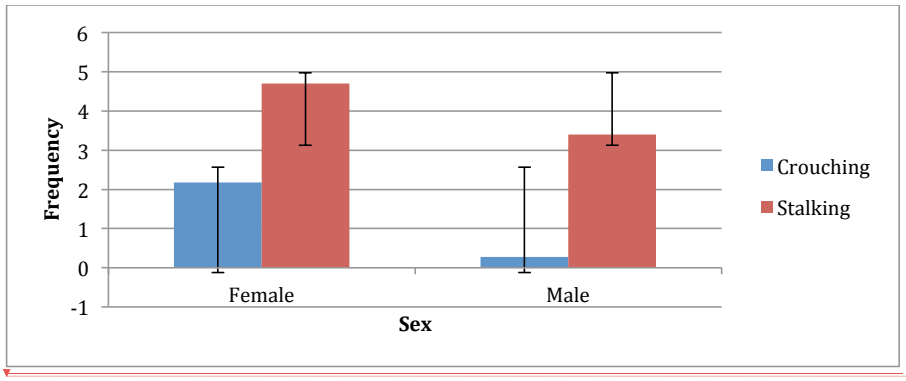
Figure 3. The average frequency (per minute) of crouching and stalking behaviours in the Improver and Open level. Improver dogs demonstrated more frequent stalking and crouching behaviour during the trials than Open dogs. Error bars have been fitted and are equivalent to 1 standard deviation.



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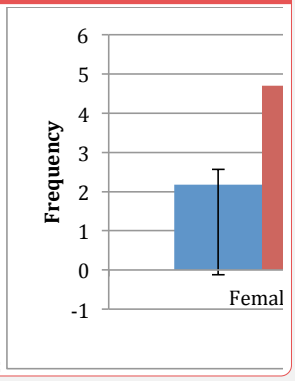

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Figure 4. Average frequency (per minute) of stalking and crouching behaviour in male and female dogs. Comparison of sex revealed that females demonstrated more

crouching and stalking behaviour than males. Error bars have been fitted and are equivalent to 1 standard deviation.

APPENDIX

WEST WYALONG YARD SCORES

Improver level

Owner (surname)	Dog	Trial Score
COX	Bonnie	74
HANSON	Busy	R**
HOCKING	Tom	78
LUFF	Whoppa	85
LYNCH	Lil*	90
COX	Mayah	86.5
M.KIER	Zena	R**
PATTERSON	Tash	47
PATTERSON	Foster	64
RUTTER	Jess	58
SHERWOOD	Glen	67
TAYLOR	Ice	66
TAYLOR	Box	86
THOMPSON	Tess	72

*** Dog appeared in more than one trial/observation**

Open level

Owner (surname)	Dog	Trial Score
COX	Cherokee	78.25
COX	Chief	91.5
DARMONDY	Swig	87.5
DARMONDY	Butch	76
DAWSON	Boof	80.5
DUFFY	Trip	77
HAZEL	Nelson	77
HOCKING	Rubina	77
HOCKING	Gumby	78.5
HOCKING	Tom*	81
JOHNSTON	Boss*	77.5
JOHNSTON	Jimmy	86
LAMBERT	Ring	84.5
LAMBERT	Queen	86

LAMBERT	Toby	86.5
LUFF	Coop	87.5
LUFF	Fob	71.5
LUFF	Wonder	90
LUFF	Tar	80
LYNCH	Lil*	70.5
MORTIMER	Becky	87.5
MORTIMER	Dixie	93.5
PATTERSON	Nugget	85
RUTTER	Earl	92
RUTTER	Rick	75.5
RUTTER	Tom	80.5
RUTTER	Hammer	91
RUTTER	Chloe	79
RYAN	Reef	72.5
THOMPSON	Aker	39
THOMPSON	Cougar	85
WHITE	Fella	64
WHITE	Oz	55.5

****R = *Retired* (dog has left the course without completing it)**

BEHAVIOUR	SPECIES	IMAGE
Stalking	*Dog*	
Crouching	*Dog*	
Not moving	*Dog*	
Chase	*Dog*	

Visual Coding Scheme

BEHAVIOUR	SPECIES	IMAGE
Stop	*Sheep*	
Splitting	*Sheep*