Vigilance and group size in California sea lions

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Abstract A relationship between group size and vigilance (visual scanning of the environment) has been found in many animal species. Decreased individual vigilance is expected to occur in larger groups because animals can rely on their group-mates to detect predators. However, many recent studies do not show a group-size effect, which indicates that more research is needed to determine the functional significance of vigilance and grouping behavior. This study used scan samples and 3-min focal animal samples to determine the effect of group size on individual and group vigilance in groups of California sea lions (*Zalophus californicus*) hauled out at Point Reyes, California. Increasing group size did not have a significant effect on individual vigilance, although group vigilance did increase significantly with group size. These results indicate that individual vigilance among California sea lions may be influenced by factors other than group size, such as body size and orientation.

Introduction

Vigilance, or visual scanning of the environment, is a behavior that has been studied extensively in many animal species. Various functions of vigilance have been proposed, including watching for predators, searching for food, and looking for mates (Renouf & Lawson 1986; Quenette 1990). A possible cost associated with vigilance is that time spent being vigilant decreases the time that an animal can spend in activities such as feeding, resting, and grooming (Elgar and Catterall 1981; Mooring and Hart 1995; Treves 2000).

A decrease in individual vigilance as group size increases has been reported in many species across different taxa (Da Silva and Terhune 1988; Quenette 1990; Roberts 1996; Treves 2000), including harbour seals (Da Silva and Terhune 1988), Thomsons' gazelles (Fitzgibbon 1989), Capuchin monkeys (Schaik van et al, 1988), and California ground squirrels (Loughry and McDonough 1988). There are two hypotheses to explain this so-called group-size effect. First, Pulliam (1973) proposed the many-eyes hypothesis, which states that animals in groups can rely on the vigilance of their group-mates to increase the probability of detecting predators and so avoid predation (Quenette 1990; Roberts 1996; Robinette and Ha 2001). Thus animals in groups tend to allocate less time to vigilance behavior and more time to other activities such as foraging (Roberts 1996). Second, the individual risk hypothesis suggests that group size reduces the risk of predation to an individual through dilution and confusion effects. Therefore individual vigilance will decrease with increasing group size if there is less risk of predation to the individual within the group (Roberts 1996; Robinette and Ha 2001). These hypotheses need not be mutually exclusive and may operate simultaneously.

Da Silva and Terhune (1988) tested the hypothesis that animals in larger groups have a greater probability of detecting predators. In canoes and on foot, the researchers actively stalked harbour seals (*Phoca vitulina)* that were hauled out of the water onto beaches. They found that while all groups eventually detected their approaches, harbour seals in larger groups detected the approaches at greater distances. This provides support for the hypothesis that animals in larger groups are less at risk of predation.

Despite the frequency with which the group-size effect is reported, recently there have been many studies that have not found evidence of the group-size effect. Some species even show an increase in individual vigilance as group size increases (Renouf & Lawson 1986; Beauchamp 2001; Robinette and Ha 2001). Renouf and Lawson (1986) found that individual vigilance increased as group size increased among male harbour seals during breeding season, indicating that the primary function of vigilance was watching for mates, not predators. The practice of scrounging to exploit the food discoveries of group-mates has also been found to increase individual vigilance as group size increases. For example, Robinette and Ha (2001) found that vigilance in northwestern crows was affected not by group size, but by factors such as the tide, which exposed more food sources when low, and the availability of opportunities to steal food from neighbors. Other factors that can contribute to increased vigilance with increased group size may be food density and quality, competition within group, sex, age, social status, distance from cover, time of day, and presence of predators (Quenette 1990; Robinette and Ha 2001). These potentially confounding factors are often not measured or controlled for in vigilance studies (Robinette and Ha 2001). These results, which contradict the predictions of the many-eyes hypothesis and the individual risk hypothesis, suggest that the relationship between group size and vigilance may vary among species or under different ecological circumstances.

Some studies have shown that in addition to ecological factors, within-group factors can play a role in vigilance levels. Position within the group has been shown to affect the vigilance of harbour seals, with peripheral members scanning more than central members (Terhune and Brillant 1996). Harbour seals newly arrived at a haul-out site also scan more than harbour seals that have been hauled out for awhile (Terhune and Brillant 1996). These factors may increase or decrease individual vigilance regardless of group size.

One species that has not been studied in relation to vigilance is the California sea lion (*Zalophus californicus*). Groups of California sea lions haul out, or pull out of the water onto rocks and beaches, at many sites around the San Francisco Bay Area, including Point Reyes National Seashore and Pier 39 in San Francisco. The California sea lions that haul out in the San Francisco Bay Area are primarily males and juveniles; females remain at the breeding grounds in the Channel Islands for most of the year (Marine Mammal Center, elec. comm.). Although little is known of the behavior of California sea lions in the wild, it is hypothesized that they haul out in order to rest, as do harbour seals (Krieber and Barrette 1984). Predators of California sea lions include sharks, orcas, and humans (Marine Mammal Center, elec. comm.). Surface predation may have been an important selection pressure during the evolution of the California sea lion, resulting in the need for vigilance. California sea lions are also highly social (Marine Mammal

Center, elec. comm.), so it is possible that they are vigilant to observe and interact with group mates.

The objective of this study is to answer the following questions:

1. How do varying group sizes affect both individual and group vigilance in California sea lions?
2. How do within-group factors such as position of California sea lions affect individual vigilance?
3. How do environmental factors such as tide, ambient temperature, and time of day affect individual vigilance?

Because of the varying results of previous studies, I do not have a prediction about the effects of group size, within-group factors, or environmental factors on individual and group vigilance among California sea lions.

Methods

Data was collected at Sea Lion Overlook at Point Reyes National Seashore, California. Observations were made on sea lions that haul out on two separate sites below the clifftop observation area. One site, the beach, consists of a long, narrow stretch of rocky beach. The other site, the rock, is adjacent to the beach but separated by water, and consists of four large rocks adjacent to each other. California sea lions regularly haul out at both sites. Sea lions were observed using a spotting scope (Bushnell "Trophy" Waterproof 20-50x50MM) on a tripod from the clifftop observation area.

Groups were defined as a single sea lion or a cluster of sea lions hauled out on either the beach site or the rock site. A sea lion was defined as single if it was at least 5 m away from any other sea lions. Upon arriving at the site, I sketched a map of the location of the sea lions, using site landmarks such as rocks to facilitate discrimination of sea lions. Then I assigned a number to each sea lion, for use in both the scan sampling and focal animal sampling described below.

Observations were made on 6 days in the year 2002: January 11, February 9, 18, and 25, and March 3 and 25**.** For each day spent in the field, I conducted as many observation periods as possible. Observation periods were conducted approximately every 8 minutes throughout the time spent at the site. At the beginning of each observation period, I measured the following environmental factors to determine what effect, if any, they have on vigilance:

1. Ambient temperature – measured with a thermometer, in degrees Celsius
2. Weather – *sunny, cloudy, foggy, rainy*
3. Time of day

Then I took a scan sample (Altmann 1974) to measure group vigilance, which I defined as the number of California sea lions in one group scanning during one sample. Scan samples lasted 15 sec to 90 sec, depending on group size. A scan sample consisted of noting the behavior of each sea lion in the group as I counted the group size. I divided behavior into four categories:

1. Scan: sea lion has head off substrate and is moving it from side to side.
2. Lie: sea lion is lying motionless on substrate
3. Head Up: sea lion has nose pointed up and is motionless
4. Move: sea lion is moving in any way other than scanning, including scratching, walking, and interacting with other sea lions

I observed each sea lion for 2-8 seconds to determine the behavior type. I correlated the behavior type with the pre-assigned number of the sea lion to assess whether certain sea lions spent more time engaging in certain behavior types.

Then I used focal-animal sampling (Altmann 1974) to measure individual vigilance, which I defined as the total number of seconds the focal sea lion spent scanning. I randomly selected one sea lion from the group that I had just scan-sampled and observed it for 3 minutes through the spotting scope. Although the sea lions were randomly selected, no sea lion was intentionally observed more than once. Using stopwatches, I measured the amount of time the animal engaged in the behavior types defined above. I also noted a number of other features of the focal animal:

1. Position – *central* (in center of group) or *peripheral* (near edge of group)
2. Orientation – *facing ocean, facing shore, facing center of rock*
3. Body size – *small, medium, large*

Regression analyses were performed on (1) group size and individual vigilance (time spent scanning), (2) group size and group vigilance (average number of individuals scanning), (3) ambient temperature and individual vigilance, (4) time of day and individual vigilance, and (5) individual vigilance and time spent moving in each individual. For the regression analysis of group size and group vigilance, I averaged the number of individuals scanning within each group using all group scanning measurements made for each group during the period the group was observed. Two-sample t-tests with unequal variance were performed on (1) position within group and individual vigilance and (2) weather and individual vigilance. Single factor ANOVA tests were performed on (1) body size and individual vigilance and (2) orientation and individual vigilance .

Results

On average, California sea lions spent 5.1% of their time scanning, 83.0% lying, 7.7% moving, and 4.2% with head up (Table 1).

Behavior	**Mean (s)**	**SE (s)**
Scanning	9.1	1.7
Moving	13.9	4.1
Lying	149.4	7.1
Head up	7.6	3.7

Table 1. Mean of times spent in behavior types during 180-s time period.

There was no significant relationship between individual vigilance and group size (Fig. 1). Although some data points in Fig. 1 came from the same group, no more than five points came from one group.

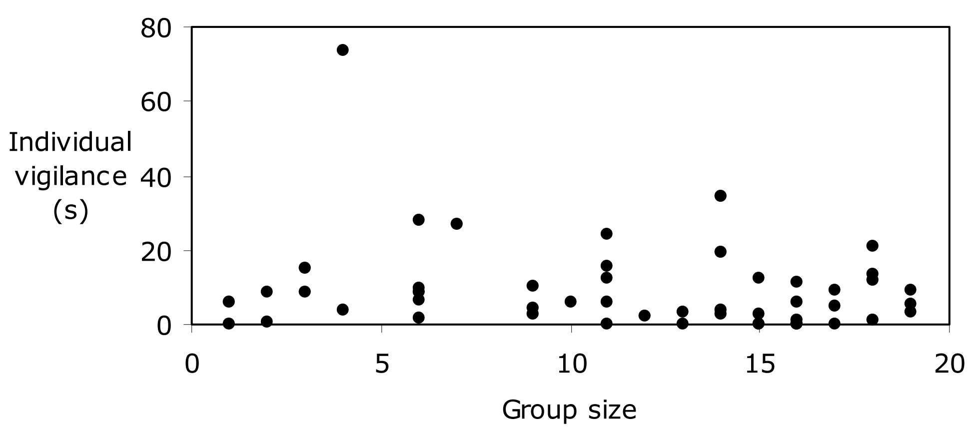

Figure 1. Individual vigilance during 180-s time period relative to group size. n=50, r^2=0.04, p>0.17.

The group vigilance increased significantly with group size (Fig. 2). There was also a significant positive relationship between time spent moving and time spent scanning among individuals; that is, California sea lions that scanned more also moved more (Fig. 3). This relationship was still significant when the 3 data points indicated by squares were omitted.

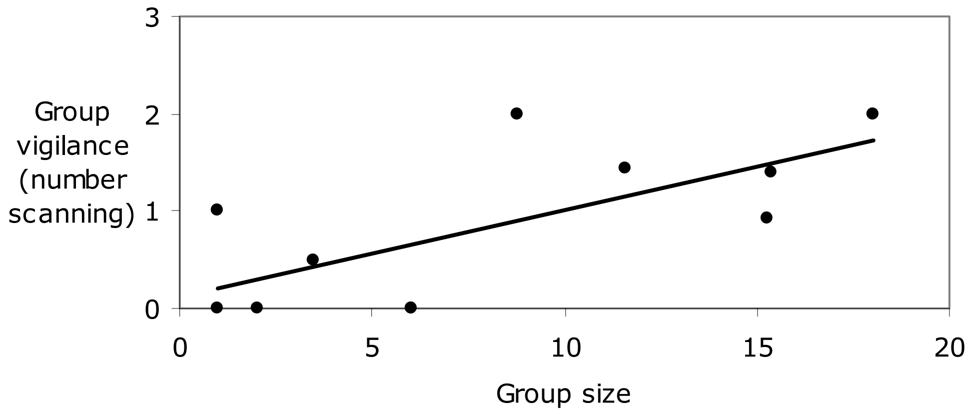

Figure 2. Group vigilance as a function of group size. Group vigilance = (group size × 0.09) + 0.13. n=11, r^2=0.48, p<0.02.

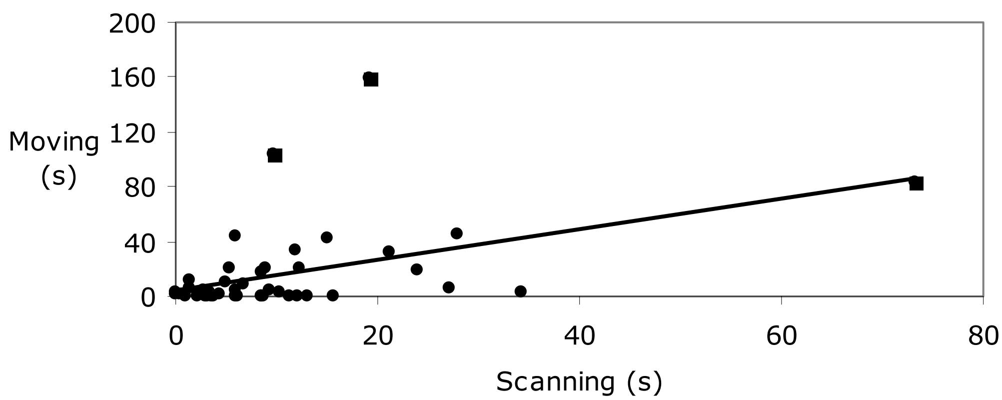

Figure 3. Amount of time individuals spent scanning and moving during 180-s time period. Time spent moving = (time spent scanning × 1.10) + 4.46. n=50, r^2=0.20, p<0.01. With the 3 points indicated by squares omitted, time spent moving = (time spent scanning × 0.61) + 3.50. n=41, r^2=0.14, p<0.02.

Environmental factors were not significantly related to individual vigilance. When tested against individual vigilance, the following were not significant: ambient temperature (n=50, r^2<0.02, p>0.4), time of day (n=50, r^2<0.06, p>0.09), and weather (Table 2).

	p-value	t-stat	n	Mean Scanning Times (s)	SE (s)
Weather	>0.47	0.72			
Sunny			27	7.9	1.5
Cloudy			24	10.5	3.2
Position	>0.52	0.66			
Central			18	11.3	4.0
Peripheral			30	8.4	1.6

Table 2. Mean scanning times during 180-s time period for California sea lions in different positions within the group and during periods of varying weather.

The size of the California sea lion was significantly related to individual vigilance; smaller individuals scanned more than larger individuals (Fig. 4).

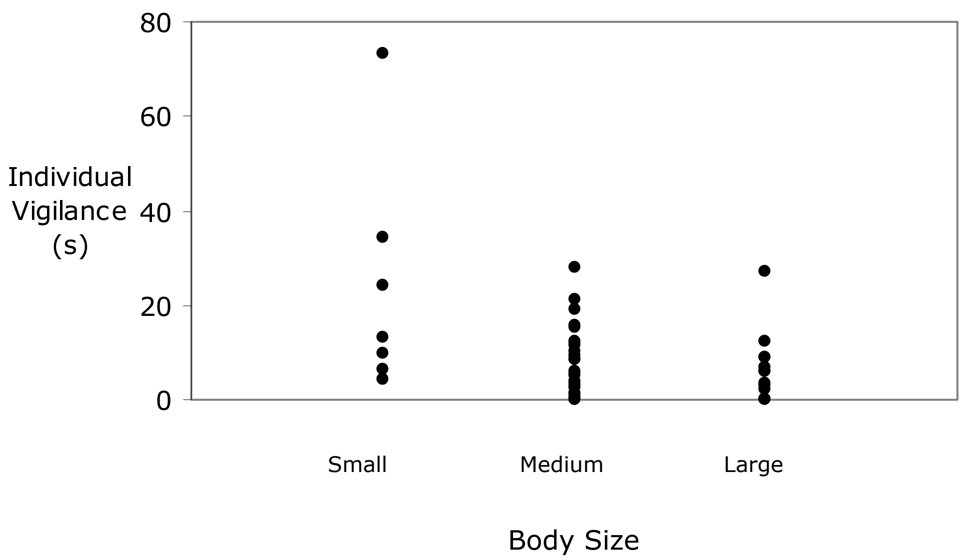

Figure 4. Individual vigilance during 180-s time period relative to sea lion body size. Including outliers: *large* n=14, mean ± SE=6.03 ± 1.92 s; *medium* n=30, mean ± SE=7.16 ± 1.30 s; *small* n=7, mean ± SE=23.57 ± 9.21 s; p<0.01. With outlier of 73.31 s in *small* category omitted: *small* n=6, mean ± SE=15.28 ± 4.75 s; p<0.05.

Position within the group, either central or peripheral, did not have an effect on individual vigilance (Table 2). California sea lions that faced the ocean scanned less than those that faced the shore or were parallel to the ocean, although this relationship was not significant (Table 3).

Orientation	**p-value**	**n**	**Mean scanning time (s)**	**SE**
	>0.057			
Facing ocean		22	5.39	1.73
Not facing ocean		29	11.92	2.61

Table 3. Mean scanning times during 180-s time period for California sea lions at different orientations.

Discussion

As predicted by the many-eyes hypothesis, group vigilance increased as group size increased (Fig. 2). This seems intuitively correct, as there would be more California sea lions scanning at any given time if there are more California sea lions grouped together. However, individuals in larger groups did not scan less than those in smaller groups (Fig. 1). These results indicate that the many eyes and individual risk hypotheses do not apply to California sea lions. There are a number of reasons why protection from predation may not be an important function of grouping together for California sea lions. It is possible that California sea lions do not rely on group members to alert them to predators. Another possibility is that California sea lions are simply not concerned about predation while hauled out. The generally low levels of individual vigilance support this possibility.

During focal-animal sampling, I noted a high number of incidences in which the primary purpose of scanning was to observe group members. With larger group sizes, there may be more potential for social interactions. However, individual vigilance did not increase significantly with increasing group size. These results suggest that California sea lions were not being vigilant solely for social purposes.

While taking scan samples to measure group vigilance, I noticed that some individuals scanned more often than others, while other individuals tended to lie motionless. The significant positive relationship between time spent scanning and time spent moving in each individual (Fig.

3) also indicates that individuals have a characteristic level of activity. However, the limits of this study made it difficult to fully test this hypothesis. Because I only observed individuals over a period of hours, it was impossible to determine whether a high level of activity, which generally leads to increased levels of vigilance, is a fixed characteristic of the individual, or whether the high level of activity is a temporary state based on comfort, hunger, hormones, or responsiveness to a mate or rival. To fully determine whether some individuals are characteristically more active than others, individuals should be marked and observed over a long period, perhaps months or even years.

The size of the individual was significantly correlated with scanning time. Small California sea lions scanned more than medium and large California sea lions (Fig. 4). Why size should matter is unclear. It is possible that smaller California sea lions were scanning to avoid confrontations with group members. I noted one instance in which a small, highly vigilant individual left the site when two of its group members began to engage in an aggressive interaction. Perhaps there is a hierarchy of power depending on size among California sea lions. It is also possible that smaller California sea lions are more vulnerable to predators, and therefore scan more to avoid predation.

Position within the group had no effect on the individual vigilance of California sea lions (Table 2). It is possible that I defined groups incorrectly, and this resulted in an apparent lack of significance of position. Additionally, some individuals remained out of sight during observation periods, which could lead to both an underestimation of group size and an incorrect characterization of group position. Another possibility is that if California sea lions do have a characteristic level of activity, some individuals may scan regardless of position within the group.

On average, California sea lions spend only 5% of their time scanning, while harbour seals spend 41.3% of their time scanning (da Silva and Terhune 1988). Why do California sea lions show little vigilance on land and no group-size effect, while their close pinniped relatives, harbour seals, show a definite group-size effect and are decidedly vigilant while hauled out? The answer could lie in anatomy. California sea lions have tail flippers that can bend under them, allowing them greater terrestrial mobility, while harbour seals have limited mobility on land because of their tail flippers (Marine Mammal Center, elec. comm.). It is possible that this anatomical distinction accounts for the greater vigilance of harbour seals – California sea lions can escape more easily while hauled out. The difference may also result from differing evolutionary selective pressures.

While this study did find that increasing group size leads to increased group vigilance, California sea lions did not exhibit a decrease in individual vigilance with increasing group size. These results indicate that the many-eyes and individual risk hypotheses do not apply to California sea lions. Vigilance among California sea lions may be influenced by factors other than group size. In particular, body size appears to play an important role in determining levels of individual vigilance.

Acknowledgements

John Latto, Matt Orr, Justin Remais, and Manish Desai provided valuable suggestions and encouragement during this study. I would also like to thank Christian Koenig, Janet Fortuna, and Latika Sharma for their assistance in taking measurements.

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