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FORAGING BEHAVIOUR OF THE JAPANESE SIKA DEER ON LUNDY

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ABSTRACT

The objective of this study was to investigate foraging behaviour factors in Japanese Sika deer including vegetation, habitat, sex differences, weather conditions, diurnal variations and human disturbance. *Ad lib* and applied focal animal sampling were successfully conducted using advanced visual night sights to span a 24-hour period with foraging, vigilance and 'other' as behavioural categories. Vegetation sampling provided evidence of differences between gully and field observations according to sex. Weather conditions appeared to have little impact on behaviour. Sika deer showed reduced vigilance behaviour at night and human disturbance caused them to flee on 50% of the occasions.

Keywords: *deer, foraging behaviour, diurnal*

INTRODUCTION

The Sika deer (*Cervus nippon*), a native of eastern Asia (Horwood & Masters, 1981), was first introduced to the United Kingdom in 1860. Seven Japanese Sika deer (*Cervus nippon*) were released on the island of Lundy in 1927 (Whitehead, 1964). Boddington (1987) estimated that the population had increased to approximately ninety by 1960. Obviously, there is only a limited area available to the deer on Lundy. Bathe and Scriven (1975) stated that the foraging activity of these herbivores compromised the prosperity of the Lundy farm, by damaging crops and competing with the domestic sheep and cattle present on the Northern half of the Island. Culls conducted in 1961, 1962, 1973 and November 1999 repeatedly reduced the herd size, currently estimated to be approximately 60 deer (Yohan-Larson, 2000). Significant long-lasting effects on the behaviour of the remaining wild deer would be expected, for example, Eaton and Boddington (1987) observed that culling had resulted in the deer on Lundy being extremely wary of man (to the extent that visitors to the island could leave without a single sighting).

Cervus Nippon are considered to be one of the least social British species of deer, although in protected wildlife habitats some can become relatively tame (Putman, 1986). The female Sika deer will typically graze alone, or in hind and calf pairs. The stags adopt a solitary existence for most of the year except in the rutting season

when a harem of hinds is fought for. Boddington (1987) reported the largest herd observed on Lundy comprised six hinds and one fawn whilst the average group size was 2.12. The preferred habitat of feral herds of Sika deer is forested areas (Landesman, 1999). However, their environmental adaptability has enabled many herds to thrive in regions of heathland, freshwater marshes and grassland (Nowak, 1991). Variations in habitat are thought to result in variations in behaviour (Horwood & Masters, 1981). The Sika deer of Lundy were most frequently sighted in the cover of rhododendron thickets and gullies on the south-east of the island during daylight hours (Rodway-Dyer & Hartnell, 2001). Careful observers have also sighted stags, prickets (a buck in the second year of life, Merriam-Webster, 2001) and occasional females in the exposed fields in the centre of the island. Furthermore, after dark large numbers occupied the fields before returning to undercover locations at dawn (Rodway-Dyer & Hartnell, 2001). Nowak (1991) stated past research had specifically focused on deer activity patterns between dawn and dusk and found the Sika deer to be primarily nocturnal creatures. Past authors had excused this limitation on the assumption of there being "little behavioural difference between day and night" (Clutton-Brock *et al.*, 1982, as cited in Koga & Ono, 1994). However, using advanced visual aids Rodway-Dyer and Hartnell (2001) successfully made systematic observations of the diurnal behaviour of Sika deer.

The focal activity of grazing and browsing animals, such as Sika deer, is foraging. Several factors such as vegetation, sexual differences, weather conditions and human disturbance are known to affect foraging behaviour in ungulates. The diet of Sika deer is diverse and may include grasses, leaves, trees, ferns, forbs and shrubs (Feldhamer, 1980). Sika deer are highly adaptable to their environment and are able to browse or graze on the available vegetation in a given area. Sika deer frequently forage in areas of dense vegetation, such as low bush thickets, conifer plantations and heavy undergrowth in deciduous woodland during daylight hours (Horwood & Masters, 1970; Putman, 1986; Kiddie, 1962) and feed on open slopes from dusk to sunrise (Boddington, 1987). On Lundy Rhododendron bushes provide excellent cover on the steep slopes of the island with thin grass cover in-between. The plateau area has fields with rich grazing land. Grasses and heather (*Caluna vulgaris*) have been reported to constitute the deer's main dietary resource (Bathe & Scriven, 1975). The deer forage for alternative vegetation such as bulbs, shoots and the rhizome system of bracken (*Pteridium aquilinum*) in the winter season due to a shortage of grass.

Sika deer foraging behaviour and feeding ecology may relate to sex differences. Studies have investigated underlying nutritional values. Stags tended to feed on forbs-shrubs in spring, which correlated with their corresponding antler regrowth (Miura, 1984). Koga & Ono (1994) suggest that stags may select these nutritious plants to meet the calcium requirements for their growing antlers. Similar studies indicate that calories, protein and fibre represent the main nutritional factors affecting foraging behaviour (Beier, 1987; Clutton-Brock et al., 1987; Hofmann, 1989; Staines *et al.*, 1982, as cited in Koga & Ono, 1994).

It is thought that the greater the difference between male and female body size (sexual dimorphism) the greater the difference in foraging behaviours (Koga and

Ono, 1994). Sika deer are sexually dimorphic both in body size and foraging habitat (Horwood & Masters, 1981). Observations by Webley *et al.* (2000) on Lundy suggested males predominantly fed in the gullies, whilst the females foraged over wider ranges. Clutton-Brock *et al.* (1982) suggested that females exclude males from the "superior range" due to their lower metabolic requirements and reduce standing crops too low for males to graze economically. Males are then forced to forage in other areas containing higher crop growth but lower nutrition.

Foraging habitat offers significant cover and protection to the deer from their predator, man. The behaviour of the deer (including tossing of heads, hesitant steps and raised forefeet and bounding away) whilst foraging, indicates a high degree of vigilance towards man (Horwood & Masters, 1981). Eaton & Boddington (1987) recorded the intensity of grazing and availability of grass in population areas and demonstrated that for the south of the island, the availability of grass in the highly grazed areas (5.4%) was far less than that found in less grazed areas (41.2%). As the south was the area most visited by humans, areas of high grazing may be represented by the safest area to graze, although not the most nutritious vegetation.

The objective of this study was to investigate foraging behaviour in Japanese Sika deer considering factors such as vegetation, habitat, sex differences, diurnal variations and human disturbance. Since variations in habitat are thought to correlate with variations in behaviour this relationship was studied in terms of the deer's foraging ecology. To establish the significance of different foraging habitats samples of vegetation from the different feeding locations were recorded. This meant that foraging behaviour could be compared to vegetation type. As the study was conducted to cover the complete diurnal range it was proposed that Sika deer would forage on vegetation in camouflaged areas during daylight hours and in more exposed areas after daylight hours. Group sightings and identification of individuals were conducted throughout the study. Sika deer were expected to forage in sex-segregated groups during daylight hours and multi-sex groups after daylight hours. Foraging behaviour and locations of Sika Deer were expected to be related to the frequency (and presence) of human disturbance (Sika deer had no other predators on the island). Occurrence of vigilant behaviour was expected to relate to disturbance events, thus demonstrating the impact of man on deer foraging habitats.

METHODOLOGY

Pilot studies were conducted at Paignton Zoo, (South Devon) and Powderham Castle (East Devon) to establish coding practices, inter-observer reliability and familiarisation with the deer by the two researchers. The investigation on Lundy was undertaken between Saturday 8th April and Saturday 15th April 2000. A preliminary day long study involved *ad lib* sampling (Altman, 1974) to locate on a scaled map of the island as many deer as possible. The number present in the group and as many features as possible including sex, size, distinctive markings and features of the antlers (including the number of points) were recorded.

Focal animal sampling (Altman, 1974; Lehner, 1996) was then conducted over

two-hour observation periods to examine (the deers') foraging behaviour. These two hour observation periods spanned the complete diurnal range. The behavioural patterns were categorised into the three following 'state' groups: foraging (actual cropping, chewing and swallowing); vigilance (territorial behaviours coded as: alertness, caution, stamping, tails/ears, head raising, and specific interactions); and other (such as lying down, standing quietly, self-grooming, defecating, mating, drinking and walking). Foraging behaviour and the effects of man were the main considerations. General observations were also made noting the location, date, weather conditions, time of day (night time occurring between 2000 and 0600 hrs with the observers using advanced visual night sights), number of deer, groups present and distinguishing features. Records of disturbance by man were made in order to assess vigilance associated with the impact of humans. Vegetation analysis, employing quadrat sampling and line transects to record species richness, percentage cover and biodiversity index, were conducted in the prime foraging locations.

RESULTS

Chi-square tests were conducted to determine if there were significant differences between the observed and expected values. Deer foraging behaviour was successfully observed for a complete 24-hour period. A total of 46 sightings were recorded during the 8-day investigation. Female groups (n=33, 72%) formed the majority of sightings, followed by male sightings (n=7, 15%) and mixed group sightings (n=6, 13%). Group sizes of 7, 3 and 2 deer were frequently sighted (6-8 occurrences) whilst the largest sized group of 31 deer was only observed on one occasion.

The vegetation sampling indicated differences in species richness and percentage cover between the gullies and fields. Using the simple location classification of gully and field, a total of 30 (65%) sightings were recorded in gullies and 16 (35%) in the fields. Where detailed behavioural observations were made the locations were classified into 7 areas (Main Path, Quarter Wall Gully, Bottom Waterfall Gully, Top Waterfall Gully, Field, Top 2nd Main Gully and Barton Cottages Field). The vegetation analysis subsequently focused on these areas. Figure 1 illustrates the state recording and vegetation sites, in addition to locations where general observations were made.

Most days were sunny or had sunny periods although some rainfall showers occurred on two days within the study period. Winds varied from 16 to 40 km/hr, mainly from the east or north. Human disturbance occurred on 20 out of the 46 sightings. The disturbances were due to the deer noting tourists, the ferry horn, farm machinery, our presence and on one occasion a flare. The deer fled to cover in 10 (50%) of the disturbance incidents.

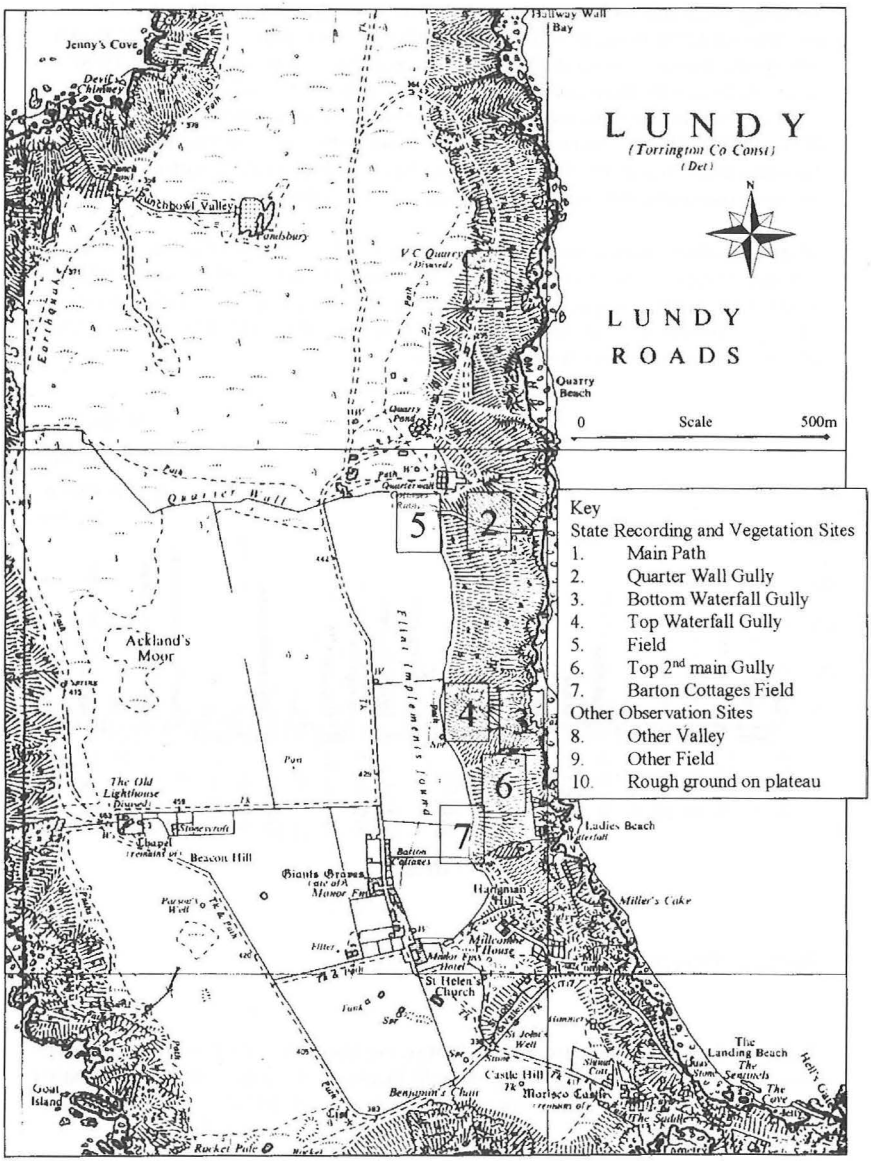

Figure 1: Study locations on Lundy

Figure 2. shows the behavioural observations recorded and categorised into foraging, vigilance and other behaviour, for the complete diurnal range. The dominant activity between 0100 and 1200 hours is foraging and vigilance is at a minimum. There is a later peak in foraging behaviour between 1800 and 1900 hours. Between the hours of 1200 to 1400, 1700 to 1800, and 2000 to 2200 vigilance occurs for more than 50% of the time. During the hours of 0000 to 0100; 0700 to 0800; 1600 to 1700 and 2200 to 2300 other behaviour dominated for more than 50% of the time. Foraging dominated the general pattern during the morning hours and vigilance dominated in the afternoon.

Male deer observations dominated the time period of 2000 to 0100 hours. Mixed sex and female group recordings only occurred for blocks of 3 hours (1000 to 1300; 1300 to 1600 respectively). The majority of observations in fields occurred during the hours of darkness. Between the hours of 2000 and 0900, one exception of gully locations occurred (0100 to 0200).

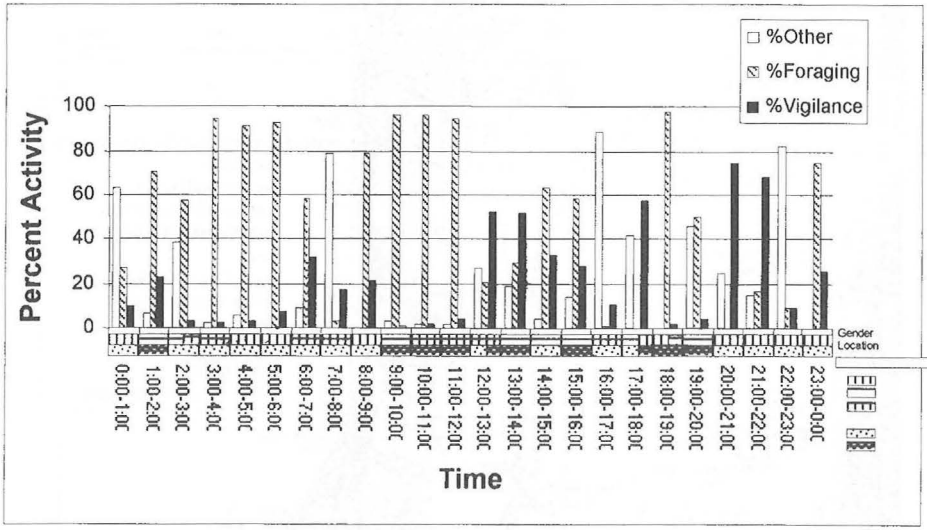

Figure 2: Diurnal behaviour of deer on Lundy

Figure 3 shows that of the total 46 sightings, the majority of male and mixed groups were observed in Waterfall Gully or field locations. Female sightings dominated the gully areas. Figure 4 shows that most sightings occurred during daylight hours. The night time sightings tended towards fields or the top of gullies.

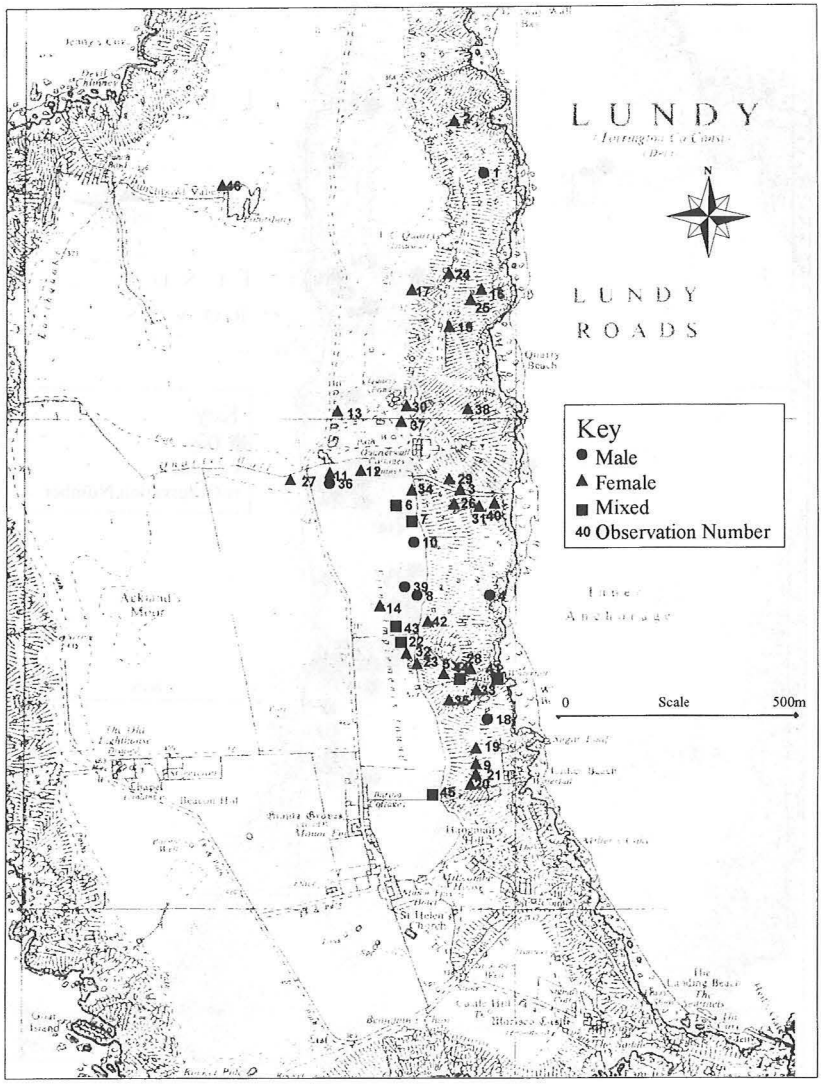

Figure 3: Observations – location and gender – and group composition

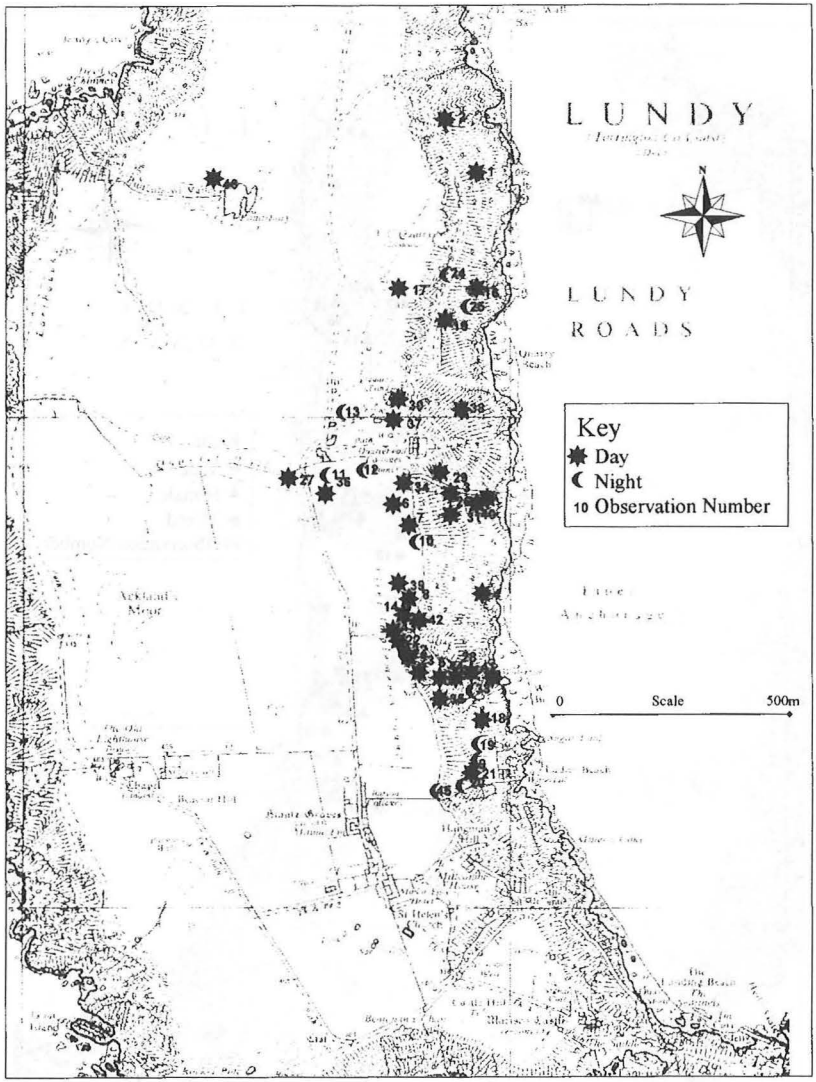

Figure 4: Location of day and night observations

Figure 5 shows behaviours were most frequently observed in location 5 (field). Waterfall Gully, including the top and bottom areas, was another popular location for the deer. Locations 1 and 6 both had less than 1 hour of behaviour observations.

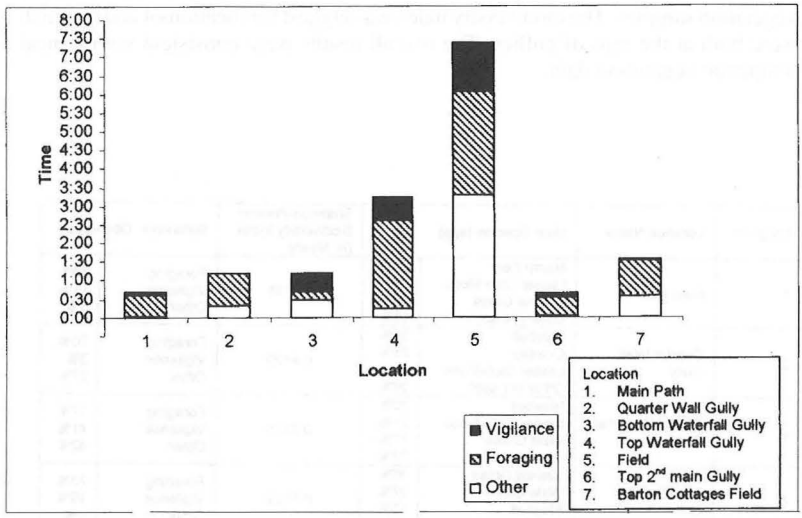

Figure 5: Total behaviour time observed according to location

The behaviour activities are compared with vegetation diversity within the locations on Figure 4 (Table 1.). All three behaviour activities occurred at all locations. As previously stated, the area was divided into seven locations. Location 1 (the area of the flat path near V.C Quarry) mainly consisted of narrow grass (*Poa nemoralis*), lesser club-moss (*Selaginella selaginoides*) and marsh fern (*Thelypteris palustris*). Foraging appeared to be the main activity during the observed time period. At location 2 (Quarterwall Gully) the predominant species were bluebell (*Endymion non-scriptus*), cowslip (*Primula veris*) and lesser club-moss. Foraging dominated approximately three-quarters of the time period observed in this area, the remainder being mostly 'other'. Location 3 (the bottom of Waterfall Gully) had an abundance of bluebell, wide grass and lesser club-moss. Vigilance and other were the dominating activity behaviours at this location. Location 4 (the top of Waterfall Gully) had narrow grass, wide grass and bluebell as the main species. Foraging was the dominant activity and approximately a third of the time was spent in vigilance. At location 5 (the field) the main species were narrow grass, wide grass (*Poa annua*) and lesser club-moss. 80% of the time was equally divided between foraging and other. Location 6 (the top of the Second Main Gully) had approximately three-quarters of the species represented by narrow grass, bluebell and lesser

celandine (*Rannunculus ficaria*). Deer foraged for most of the time period here or appeared vigilant. At location 7 (the field near to Barton Cottages) consisted mainly of narrow grass, wide grass and dry grass. The activity was predominantly foraging, followed by other. Figure 6 clearly shows that species richness was far greater in the gully locations than on the field sites. This was confirmed by calculating the Shannon-Weaver biodiversity index statistic (Shannon & Weaver, 1949) for the vegetation samples. The biodiversity index was highest for locations 4 and 6, which were both at the tops of gullies. The overall results were consistent with typical temperate vegetation data.

Location	Location Name	Main Species (spp)		Shannon-Weaver Biodiversity Index (H' Mean)	Behaviour Observed	
1	Main Path	Marsh Fern Lesser Club-Moss Narrow Grass Other (10 spp)	51% 19% 15% 15%	0.3745	Foraging Vigilance Other	84% 11% 5%
2	Quarter Wall Gully	Bluebell Cowslip Lesser Club-Moss Other (11 spp)	32% 23% 19% 26%	0.4420	Foraging Vigilance Other	70% 3% 27%
3	Bottom Waterfall Gully	Bluebell Lesser Club-Moss Wide Grass Other (11 spp)	30% 21% 17% 32%	0.3118	Foraging Vigilance Other	17% 41% 42%
4	Top Waterfall Gully	Narrow Grass Wide Grass Bluebell Other (6 spp)	36% 27% 15% 22%	0.5622	Foraging Vigilance Other	73% 19% 8%
5	Field	Narrow Grass Wide Grass Lesser Club-Moss Other (9 spp)	46% 36% 4% 14%	0.3221	Foraging Vigilance Other	38% 18% 44%
6	Top Second Main Gully	Bluebell Lesser Celandine Narrow Grass Other (10 spp)	28% 24% 22% 26%	0.6805	Foraging Vigilance Other	70% 23% 7%
7	Barton Cottages Field	Narrow Grass Wide Grass Dry Grass Other (5 spp)	49% 39% 8% 4%	0.4238	Foraging Vigilance Other	62% 2% 36%

Table 1. Percentage split of activity and vegetation diversity at each location

All Chi-square tests on the 46 sightings were non significant (i.e. $p>0.05$) between the observed and expected values. The variables were gender (i.e. male vs. female), single/mixed (i.e. single sex vs. male and female) sex groups, location (i.e. camouflaged vs. exposed) and time of day (i.e. day vs. night).

DISCUSSION AND CONCLUSIONS

Greater diversity of species were found in the gully areas. It is difficult to infer the extent to which this influenced the deer foraging behaviour as other factors such as disturbance by man and time of day could also have affected behaviour. The deer appeared to prefer to graze in the fields without being disturbed. Higher sugar concentration levels would exist in the grasses in the evening from accumulation of the day's photosynthesis. It is difficult to assess the impact of deer on sward heights due to other species, such as lagomorphs and rodents.

Some groups of deer were observed repeatedly. Mostly these were of the same sex and had clearly identifiable deer within them such as the stag group of 7, a pricket group of 7, an old hind with pricket, a young hind and baby, two solitary hinds and groups of 17 and 22 hinds. Chi-square results showed that there was no significant evidence of sex-segregated groups during daylight hours and multi-sex groups after daylight hours. The data may have been influenced by frequent daytime observations of a single hind accompanying a young pricket and the unusual repeated sightings of a stag group and stag/pricket group during daylight hours in the exposed fields. The many sightings of hinds made in the gullies, close to camouflaged areas, may have reflected a preference for camouflage. However, it was the very careful observation techniques that led to successful data collection in those locations. There were frequent sightings of two solitary hinds that appeared to have been ostracised by the herd. This finding corresponded with the local report (Yohan-Larson, 2000) of there being two unhealthy hinds. A potential pattern noted in the hind groups, was the presence of a sentry acting as the main form of vigilance for the group. This allowed the remaining deer to forage. Velveting activity was both seen and heard within the male deer groups around the rhododendron thickets. Stags were also observed performing aggressive gestures when approached by fellow prickets and occasional tussles between stags were seen. This contrasted to a young pricket, which was seen gently scratching a stag's neck using his pedicles and approaching it nose-to-nose.

The only indication that weather had any direct impact on the deer was the observation that during showers the deer tended to stop foraging and lie down until the rain passed. It will however, have had impacts on the vegetation types and growth rates. Micro-climatic effects were found to exist within the gully regions of Lundy, whereby the wind direction would change slightly. Some locations were more sheltered than others and may have influenced the deer's' choice of location

and behaviour. The distance that human scent carried may also have been influenced by weather conditions.

The night sights allowed invaluable, accurate observation of deer behaviour during the diurnal range for the first time ever on Lundy (Rodway-Dyer & Hartnell, 2001). Difficulties existed in identifying individual deer at a distance greater than 100 metres and observations of deer at a distance may well have been missed. The chi-square results showed no significant effect of day and night on foraging activity in exposed and camouflaged locations.

Human disturbance did have an impact on deer behaviour according to the descriptive statistics. Figure 2 clearly showed a decline in vigilance at night. A distinct increase in vigilance corresponded to the time at which people arrived by ferry to the Island and this was close to the gullies. However, many deer were sighted in daylight hours, which could be indicative of culls having had little effect on behaviour or even that the deer were aware of the time of year when such activities took place. The deer stayed in their location for 50% of the time following instances of human disturbance. Figure 6 however, does reveal a greater level of vigilance towards the south of the Island, nearest the human populated areas. A large number of sheep and lambs occupying the fields resulted in no sightings of any deer groups there for a 24 hour period. Prickets were seen to run away from both lambs and rabbits when disturbed by them.

In conclusion, this study provided a clear insight into Sika Deer behaviour on Lundy. A closer examination of the northern section of Lundy using night sights would be of interest. Continued systematic and wide scale observation is required to ascertain exact numbers of deer on the island, their foraging regime and the impact on the local ecology.

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