returned to the bay at low tide and there was still about 3 feet of water at the entrance to (15) and (16) but only a foot in the entrance to (17). We were only prevented from entering by a 10 feet drop to the entrance on the south side. This would be simple with a rope, but we were unable to return this year.

(18) This cave has two parallel off-shoots; the northern one is about 60 feet long and 15 feet high and the other is about 120 feet long and 15-20 feet high. Both are about 10 feet wide.

It would be useful if these caves could be properly mapped and indeed the west coast closely looked at, as we are sure that there are several more unknown caves quite possibly even larger than those on the east side. We would be grateful if in future the caves were not entered from August to November as our second visit to Puffin Gully disturbed the Seals greatly and this could have a detrimental effect on any pups present in the caves. Two dead pups found floating around the North-west point after the first September storm almost certainly came from Virgin Springs or Caves (2) or (3).

SOME ASPECTS OF THE SOCIAL BEHAVIOUR OF LUNDY GOATS

(Abstracts from '*The Social Behaviour of Lundy Goats*' by KEITH ALLEN, Dept of Psychology, University of Exeter, 1972)

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Introduction

The goats of Lundy are 'feral', that is, their ancestors were, at one time, in private ownership. However, as their owners found employment off the island with the decline of the quarries, the goats were left to fend for themselves.

The coat colours of Lundy goats indicate a complete mixture of the Alpine breeds Saaren and Toggenberg, and the Nubian goat of the Middle East. This mixture is generally known as the 'English' goat, *Capra hircus hircus*.

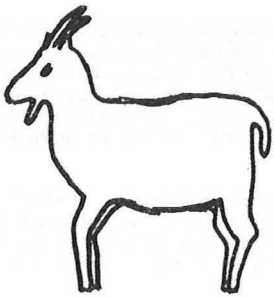
There were, in 1971/1972, approximately 60 goats on the island, roughly divided into 4 equal groups, with 'home ranges' approximating to the North-East, South-East, South-West and North-West, cliff faces.

I visited Lundy first in the early Spring of 1971 as part of my university course in 'Animal Behaviour'. I returned in the Spring of 1972 on a Lundy Field Society grant to continue my studies of communication and hierarchy in the goats.

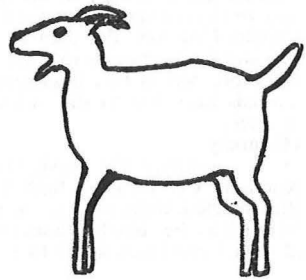
Startle

I orlginally set out to study the phenomenon of 'Startle'. On a previous visit to the island, my tutor had been interested in the communication of danger among the goats. On that occasion he heard a total of three 'baa's', all apparently from one animal, before a group began to move off. He suspected that a summation of warning signals was necessery to cause the flock to move off.

I found that there are two types of danger signal. The 'baa' for approaching danger, and the snort for imminent danger. The 'baa' involves the vocal cords, while the snort is the expulsion of air quickly via the nose. I witnessed several animals snorting, at close quarters, and saw that there is a one or two second delay while air is drawn in, before the snort can occur. This air may be drawn in as the animal 'sniffs' the air to smell the possible intrusion, or just very quickly. As the animal begins to draw in air, however, whether it is sniffing or not, it 'attends', i.e. it adopts the 'startle stance' of straight legs, straight neck, head erect—almost horizontal in fact, while nose, ears, and eyes are brought to play on the danger. Also, the tail may go up. How far it goes up, if at all, varies between animals. Sometimes it rises to the vertical, other times only to the horizontal, perhaps rising farther with subsequent snorts. The animals also 'attend', adopting the startle stance, when the warning signal is given as a 'baa' or even without any sound at all.



Normal stance.



Startle stance.

The attend/snort or startle reaction is usually given, as I have said, to mminent danger, the imminent danger, however, has to be invisible, or only slightly visible, to the attending goat, for a startle to be elicited. If the danger was more obvious, all the animals would just run off in silence. In such cases I believe the danger is passed by the speed with which the attending goat runs off, and the fact that its tail is up—undoubtedly a distress or danger signal. Surprise also produces no snort, just an instant and total retreat. A good stimulus for elic'ting the snort was found to be a head appearing round a rock, or over a ridge in the heather, for no more than a second. This apparently left the goat that noticed it alert, but uncertain. It is this *uncertainty* that I believe is the key. The startle reaction is only given when the animal is *uncertain* as to whether there is danger.

The expulsion of air suddenly, and the raising of the tail, were probably originally autonomic nervous effects, like raising the hair in humans. They functioned as a form of communication of emotion, and thus evolved as signals (Barnett 1957). Greig (1970) said that the goats gave a 'warning snort' with *certainty* of danger, 'with force and a convulsive shudder'. I must disagree about the certainty, and I would say that the 'shudder' is just a jerk associated with the force of the snort. It certainly carried a fair distance. Darling (1937) reported that Red Deer up to half a mile away would respond to the snort of a goat and run.

I carried out a long series of startles, and analysed six responses to an uncertain stimulus:

(1) Goat looks.
(2) Goat 'attends'—head up, neck and legs straight.
(3) Goat snorts, with or without tail up.
(4) Goat takes 1-5 steps *towards* stimulus—'investigating'.
(5) Goat moves off.
(6) Goat recruits others to move off.

Thus it can be seen that a goat may look unconcernedly, or it may attend, or even snort, while it is uncertain of danger. Occasionally, goats 'investigated', taking a few steps towards the uncertain stimulus. Tegner (1962) also recorded this 'investigating' behaviour, though Greig (1970) saw no examples of it.

Often the goats would move off after snorting, or just attending. Usually other animals responded to the one that originally responded to the stimulus.

Communication

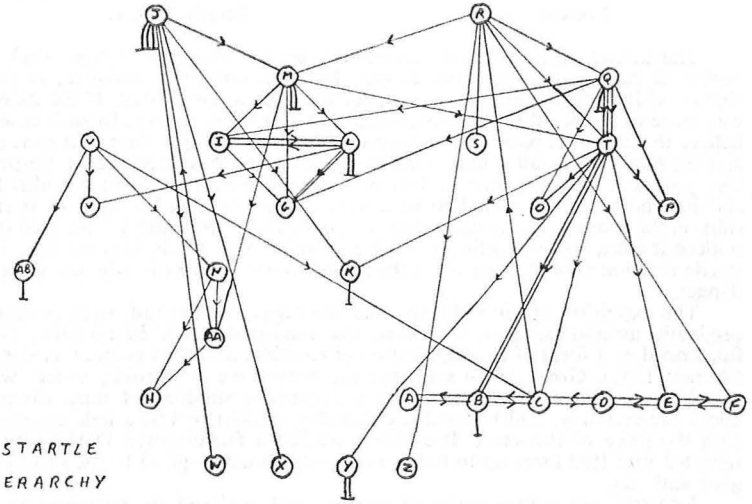
The fact that other animals are recruited by the startled animal indicates that the moving off, the snort, and even the 'attend' stance, are forms of communication. It is only when the original animal snorts, or moves off, that any other animals begin to move off, and then not necessarily.

Once, when I startled one particular female, she snorted a total of thirteen times without moving off, or causing any of the other members of the group to move off. It required snorts from two other animals before the group retreated.

This indicated to me that the idea of summation of warning signals being necessary to cause a startle, needed revision to a summation of *animals* giving warning signals. However, the data from my experimental startles indicates that often one snort was enough to cause the group to move off, while on other occasions, the snorts would be completely ignored. I was unable to try the summation of animals idea due to the difficulties of startling a specific number of animals at once.

Hierarchy

I considered the possibility that there might well be a hierarchy of startle reactions. Certain goats high in the hierarchy would immediately be followed if they snorted, while others, low in the hierarchy, particularly the kids, could snort as much as they liked without anyone paying any attention. From my experimental data I constructed this hierarchy:



The letters refer to individual goats.
→— indicates one goat recruits another to startle.
AA, AB, W-Z are kids.
A - F are males, and the rest are females.
Those at the top of the hierarchy are always recruiting, those at the bottom are always recruited, with very few exceptions.

This hierarchy includes two groups of goats, the 'South-West' and 'North-West' groups, which joined up during some bad weather at the time of my second visit. Separating out the 'South-West' group, basically the animals on the left of the hierarchy diagram, I was left with this hierarchy:

J
M
I L
G
K N
H
W X Y Z (the 4 kids of 1972)

Comparison of Hierarchies

With the assistance of Paul Munton (who was on the island studying the maternal behaviour of the goats for a Ph.D. thesis) and the memories of various islanders, I constructed a family tree for the same 'South-West' group, thus deducing an age hierarchy.

I observed the travelling behaviour of the goats, both when scared, and when naturally travelling from one feeding area to another, on the precipitous cliff faces of Lundy. From these observations I constructed leadership hierarchies.

Careful noting of occasions when one goat butted another out of the way, or when one jumped out of the way of another, produced yet another hierarchy, dominance.

(For further information on the construction of these hierarchies please consult the original paper, the LFS has a copy).

I compared all possible pairs of these hierarchies. The only significant correlation found was between age and dominance, this with a probability of error of less than 5 in 100.

Stewart and Scott (1947) are among the papers that disagree with this finding. However, I have taken from their data the rank order of age, and the rank order of 'dominance score' they gave each goat in their study. Applying the same statistical test (Spearman's Correlation Coefficient (r)) to their data, as I did to mine, the correlation of age and dominance is rather better than that from my data (probability of error less than 1 in 1000).

I therefore conclude that age and 'dominance are correlated in *Capra hircus hircus.*

References

Barnett, S. A. (1957). The Expression of Emotions. *New Biol.*, **22**, 73-90.

Darling, F. F. (1937). *A Herd of Red Deer, a Study in Animal Behaviour.* London: O.U.P.

Greig, J. C. (1970). The Ecology of Feral Goats in Scotland. M.Sc. Thesis, University of Edinburgh.

Stewart, J. C. and Scott, J. P. (1947). Lack of Correlation between Leadership and Dominance Relationships in a Herd of Goats. *J. comp, physiol. Psychol.*, **40**, 255-264.

Tegner, H. Where did our Wild Goats come from? *The Times* 30/8/62 London.

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My thanks are due first, to Paul Munton, of the Dept. of Psychology, University of Bristol. I am indebted to him for assistance in identifying and classifying the goats, for the family tree, and for disagreeing with me over the hierarchical communication of startle. Thanks also to Denver Daniels of the Dept. of Psychology, University of Exeter, my tutor, who supervised and encouraged me throughout.

Further, I would like to express my gratitude to the Lundy Field Society who gave me a small grant to go back in 1972 to continue my investigations of communication and hierarchy.

SOME NOTES ON THE PLEISTOCENE GEOMORPHOLOGY OF LUNDY

By C. G. TAYLOR

1. Introduction

To date the only paper published concerning the Pleistocene Geology of Lundy is that by G. F. Mitchell of Trinity College, Dublin. It is entitled 'Glacial Gravel on Lundy' and was published as a transaction of The Royal Geological Society of Cornwall, volume XX, part I, 1965-66. The extract deals principally with the gravels and roche moutonees that Mitchell found on the island during a brief visit.

I made several visits to Lundy between 1965 and 1970, and between 1970 and 1973 I was resident on the island. Although the observations I have made