The ecology and behaviour of the feral goats of the College Valley, Cheviot Hills

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THE ECOLOGY AND BEHAVIOUR OF THE FERAL GOATS OF THE COLLEGE VALLEY, CHEVIOT HILLS.

BY

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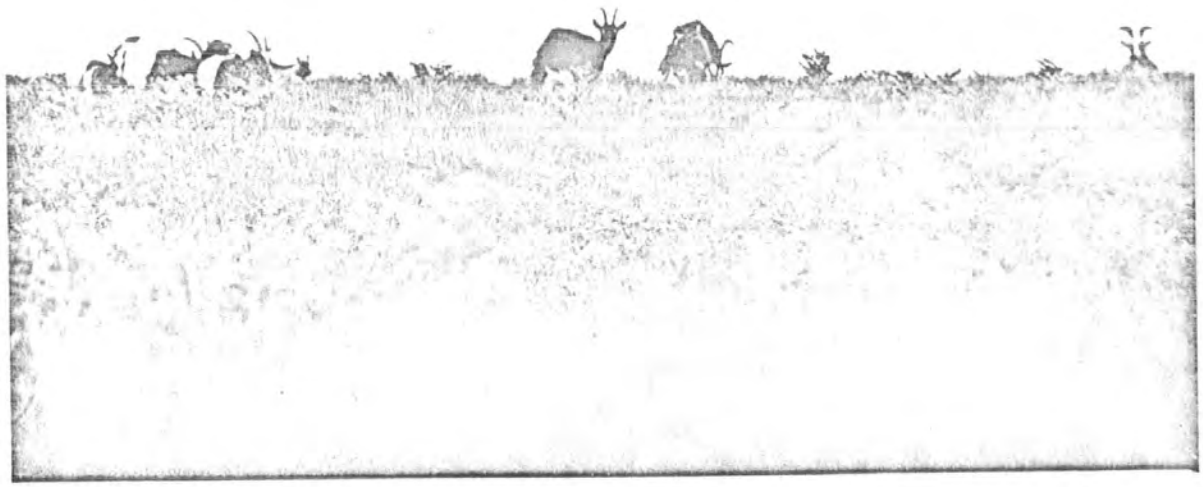
Submitted as part of the requirements for the degree of Master of Science (Ecology), University of Durham.

October 1977



ACKNOWLEDGEMENTS

My thanks are due to Dr. K.R. Ashby under whose supervision this study was made.

I also wish to express my thanks to Dr. J.H. Anstee, Mrs. S. Hetherington and Mr. J. Richardson for their technical assistance, and to Mr. and Mrs. G. Elliot, and Mr. and Mrs. P. Fergie of Hethpool, and to the Robb family of Whitehall for all their hospitalities.

My thanks are also due to Mrs. Bransden who typed the script.

This study was made possible by a grant from the Natural Environmental Research Council.

CONTENTS

INTRODUCTION

The goat appears to have been the first ruminant to have undergone domestication. Archaeological records indicate that the probable centre of domestication lay in South West Asia (Harris, 1962, Zenner, 1963) the earliest known remains coming from Neolithic Jericho, and dated to 6-7,000 BC.

The probable ancestor of the domestic goat, Capra hircus hircus L. 1758 was the Bezoar, or Pasang, C.L. aegagrus Erxleben 1777 (Zeuner, 1963) whose past range (Iran, Asia Minor, Greece and Lebanon) includes the sites of the discoveries of the earliest known remains of domestic goats.

That the Bezoar was an important ancestor of the domestic goat is indicated by the fact that the horns of the males have a sharp anterior keel which is a feature of most domestic breeds, the classification of capines being largely based upon horn morphology. The Ibex group of goats, which, like the Bezoar and most domestic goats, possess scimitar-shaped horns, differ from the latter in that it is the posterior keel of the horn that is sharp edged. The anterior edge is flat, and bears well marked cross-ridges, a feature not seen in any domestic goat.

It is unknown whether the evolution of the spiral horned conformation found in some domestic billies is a result of deliberate selective breeding by man, or the result of natural variations in the wild ancestral Bezoar stock, which although normally possessing Scimitar-shaped horns, sometimes show a tendency to curve inwards or outwards in the 'dorcas' conformation.

The Bezoar may probably not be the sole ancestor of the domestic goat as both C. hircus aegagrus from Asia Minor, and the Arabian Ibex C. ibex nubiana F. Cuvier 1825, will both hybridise with the domestic C. hircus producing fertile F_1 generations, thus suggesting a close relationship between the three species. (Harrison, 1967) attempts to hybridise male Himalayan Tahr, Hemitragus jemlahicus H. Smith 1828 with domestic goats, have only resulted in abortions (Harris, 1962) thus indicating a more distant relationship.

The goat is not indigenous to Britain. It was probably introduced around 5,000 BC by Neolithic stock keepers, and in its domesticated form.

Like many other domestic mammals, the goat will readily go feral when given the opportunity. Truly wild goats are Palaearctic in distribution, with offshoots in Southern India, Southern Arabia and Ethiopia, but goats living in the feral state are now world wide in distribution. This includes the mainland of New Zealand and many off-shore islands (Riney & Caughley, 1959, Rudge, 1969), Cyprus (Whitehead, 1972) and Hawii. The latter supports large populations of feral goats descended from a male and two females left by Captain Cook in 1778. Feral goats are also reported from British Columbia (Geist, 1960) and in some Japanese islands, having originated from primitive oriental breeds (Asahi, 1960).

There are today approximately 60 populations of feral goats in Britain (Greig, 1970), the main strongholds being in Wales (Merionethshire and Snowdonia), with a number of herds in Wester Ross, Devon, the Hebrides, Galloway and the Moffat and Cheviot Hills (Boyd-Watt, 1937, Whitehead, 1972, Lever, 1977).

The date and origin of most of the British populations of feral goats is uncertain, though most are believed to be less than 150-200 years old. It is known that the majority of the Welsh 'wild' herds are descendants of large herds of goats allowed to roam the hills for much of the year, though many are believed to have been descended from escapees from Irish herds driven through Wales to sales in England up until c. 1891. (Lever, 1977). 'Wild' goats in Wales are referred to in Nicholas Cox's "The Gentleman's Recreation" of 1674, in which the 'wild' goat is regarded as a beast of the chase.

The origin of many of the Scottish feral herds is even more uncertain. Fraser-Darling (1937) indicated that many herds originated from the time of the Highland Clearances of the eighteenth century, particulatly in the west of Scotland, where more feral herds are found than in the East. Lever (1977) doubts this, suggesting that the goats of the crofters became uncatchable as they grazed further in the late summer when lactation decreased and herbage coarsened, with some never being caught up and continuing to live free.

Up until the mid eighteenth century in Scotland, goats played a major role in the economy of the majority of the Highland population, namely the lesser tenants and crofters. In the 1700's goat keeping was discouraged by many lairds in an effort to reduce damage done to woodlands by the browsing goats (presumably to increase financial returns from the timber). This practice may well have resulted in some herds of feral goats in the Highlands, and may be also in the Lowlands. There exists today a herd of feral goats in Morvern, not far from Ardnamurchan, where, in 1730 this is known to have happened. (Megaw, 1963, quoting from the Delvin Papers: Murray National Library of Scotland, M.S. 1415).

The now extinct Torrachilty herd in Ross and Cromarty, is known to have been introduced in around 1880 by a local farmer supposedly to keep down adders, while dubious legend has it that the 'wild' goats of Ailsa Craig originated from goats coming from an Armada wreck.

Both the date and origin of the feral population of the College Valley (Cheviot Hills) around which this study was made, is unknown. That at least some of the herds of the Cheviot Hills have a long history is certain. Tegner (1952) quotes the late T.R.Goddard in saying that '.... knowledge of the (Whickhope Linn) herd went back more than 100 years and that it was considered an ancient herd then ....' Unfortunately no date for this quote is given, and the Whickhope Linn herd died out in the severe winter of 1946-47. One theory maintains that the Cheviot feral goats may be descended from stock liberated by monks from Lindisfarne Priory, though no evidence for this has been found (Whitehead, 1972).

In about 1860 goats were reputedly brought to the College Valley apparently to replace an older herd existing at Southernknowe (Whitehead, 1972).

By 1946 28 goats existed in the College Valley, a number which was reduced to 14 in the winter of 1946-47, those on the S.E. face of The Cheviot dying out altogether. By 1950 they had recovered to 32 when all but 9, later found on top of Newton Tors, were shot for allegedly damaging crops (Tegner, 1952).

It appears that sometime prior to 1961, the then population of 23 goats was said to be 'competing' with hill-grazing sheep. Survival of the College Valley goats after a pre-1961 cull was due to the introduction by Sir Alfred Goodson of a feral billy from Scotland to the remaining herd of 7 nannies, but no billy (Tegner, 1961).

The goats numbered 30 in both 1969 (Greig, 1970) and in 1970 (Whitehead, 1972). In 1976, prior to the present study, the population numbered about 150, mainly situated on the eastern slopes of the Newton Tors (G. Elliot, P. Fergie, pers. comm.). In December 1976, the College Valley herds were culled, mainly as a result of serious damage to young plantations at Hethpool, and on Southernknowe inflicted by the goats eating out the apical shoots of young conifers, and uprooting them (G.Elliot, K. Robertson, pers. comm.) Electric fences proved inefficient, and the goats from the Eastern slopes of Newton Tors, above the College Burn, were rounded up with dogs. A small herd, living on Yeavering Bell at the Northern end of the College Valley, escaped the round up (P. Fergie, T. Welsh pers. comm.) and returned to Yeavering Bell, probably being the same animals that formed the nucleus of the present study. Two mature billies from the Southernknowe area are also known to have escaped the cull, one by refusing to pass through a certain gate, the other by breaking away from the herd. Both returned to their previous range (P. Fergie, pers. comm.).

Of the 150 goats rounded up, 55 were slaughtered, 25-30 allegedly being returned to the hills, and the remainder being sent to various zoos etc, e.g. Bellvue Zoo and Lambton Safari Park.

The reported ease with which the feral goats were rounded up (G. Elliot, P. Fergie, pers. comm.) is of interest, Unlike many primitive breeds of sheep, e.g. the Soay, the goats made no attempt to scatter, and allowed themselves to be turned and directed by well-trained sheep dogs, contrary to that which would be expected. They were also apparently surprisingly docile when being handled (loading for transport, slaughter etc.) considering feral goats exist effectively as wild mammals.

THE STUDY AREA

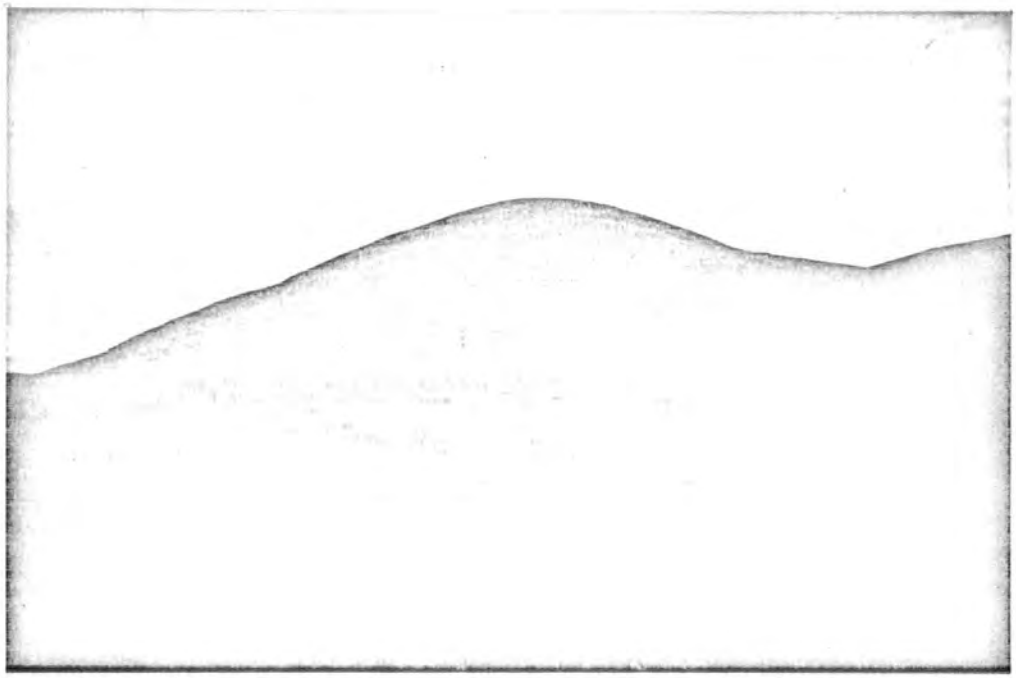
In the summer months of 1977 the home range of 12 of the 14 goats of the College Valley was centred on a hill known as Yeavering Bell. 360 M high, the hill lies at the North end of the College Valley, about 4 miles West of Wooler, Northumberland.

The geology of Yeavering Bell and much of the College Valley to the South is mainly of andesite, with outcrops of mica porphyrite. On the South West, West and North sides of the hill, thought not top, patches of scree exist, some of those consisting of a jumble of large boulders. Enclosing a large area on top of the hill are the remains of the wall of a large Iron Age fort or township.

Much of Yeavering Bell and the moorland to the South and South East towards Tom Tallon's Crag and East towards Akeld Hill is covered with a mostly thin layer of blanket peat. The ground to the South West and East is drained by two small burns, eventually joining the River Glen. No burn arises from the slopes of Yeavering Bell itself, the upper slopes being well drained, even after heavy rain. To the North of the hill, above Old Yeavering, the base of the hill adjoins farmland, the fields going up to the lower slopes and separated by a stone wall.

Yeavering Bell supports a reasonably diverse flora. On the North and North East of the hill the dominant plant is Calluna vulgaris with Deschampsia flexuosa as the dominant grass. These occur with Anthoxanthum odoratum, Agrostis tenuis and Nardus stricta plus Luzula sylvatica, Gallium harcynicum and Erica cinerea. Towards the top Vaccinium myrtillus became very frequent, though patchy in distribution, and Pteridium aquilinum became both small and sparse. On much of the

PLATE 1



Yeavering Bell from the South West

lower slopes, Pteridium became the dominant plant, especially the South East, North West, North and North East of the hill, where it occurrs with the grasses Holcus lanatus, D. flexuosa and A. tenuis, and with Oxalis acetosella, Gallium harcynicum, Campanula rotundifolia and Stellaria holostea.

An open oak wood of mature, though small trees is situated on the northern lower slopes of the hill. The ground flora consists of D. flexuosa, and Holcus mollis (the dominant grasses) with a fern Dryopteris sp. being very abundant. Also present were Urtica dioica and L. sylvatica. A few hawthorn trees (Crataegus sp) grow at the North East corner of the wood.

Ulex europaeus and Pteridium form the dominant plants on the lower South West slope, where D. flexuosa is also very abundant. Also present amongst the gorse (some of which was of small stature following burning several years earlier) were D. caespitosa, Aira praecox, A. odoratum, H. lanatus, Poa pratensis, A. tenuis, Thymus drucei, Endymion non-scriptus and G. harcynicum.

Higher up the slope Ulex and Pteridium gave way to a Vaccinium and D. flexuosa dominated vegetation amongst the scree.

The gentle slope of the South East aspect of the hill supports a different, grassland and flora, though with Pteridium being dominant on the lower slopes. D. flexuosa and P. pratensis are two of the dominant grasses, occurring with Anthoxanthum, A. tenuis and D. caespitosa (very sparse). Both Vaccinium and Thymus increase with height, and with Gallium, are fairly frequent towards the top.

To the East and South East of Yeavering Bell an area of moorland is dominated by Calluna, with rather sparse and stunted Pteridium in

patchy distribution. The Calluna appears to have been burnt in fairly recent years, and is much younger than that on the nothern side of Yeavering Bell. Erica is also present, though infrequent. D. flexuosa and Nardus are both very frequent in that area.

Festuca ovina only occurs in a small shallow gulley between Tom Tallon's Crag and Yeavering Bell, and then only sparsely. South West of the burn draining the ground to the South of Yeavering Bell and running North West, the hillside in common of much of the area, is dominated by Pteridium, amongst which D. flexuosa, P. pratensis, H. lanatus and Anthoxanthum grow abundantly. Also present are A. tenuis, D. caespitosa, Cynosurus cristatus and the herbs, Gallium, Stellaria, Potentilla, Campanula, Oxalis and small amounts of Vaccinium.

The vegetation of the approximately 250 x 150 M area enclosed by the hill fort contrasted sharply with that of the northern slopes, being of poor grassland dominated by Nardus and D. flexuosa, with L. sylvatica and Vaccinium also present.

Wet flushes along both small burns support a vegetation in which Juncus effusus, D. caespitosa, Carduus palustris, Urtica, H. lanatus and Carex pendula are often frequent. Also growing in these areas is Filipendula ulmaria, C. nigra, Mysotis and Ranunculus sp. Little Sphagnum was noted.

Other mammalian herbivores present in the home range of the Yeavering Bell goats were Roe Deer (Capreolus capreolus) which were mainly seen in the oak wood (though also on other parts of the range) Brown Hare (Lepus capensis) but few rabbits (Oryctolagus cunnicula) though the nearby West hill supported a very dense rabbit population.

Yeavering Bell and the moorland to the South and South East carried Blackface sheep at a fairly low density, in contrast to the nearby fields which at times were quite densely stocked. Red Grouse (Lagopus lagopus) appeared fairly common in both the long mature heather on the North of Yeavering Bell, and in the younger growth between Yeavering Bell, Tom Tallon's Crag and White Law.

Foxes (Vulpes vulpes) were frequently seen on and around the hill, with about eight individuals being recognised, including three cubs from an earth East of the oak wood.

METHODS

(i) Visits and Observations

Visits were made to the study area daily in the periods May 18-29, June 8-20 and July 5-17 and 25-31. The goats were usually located by scanning the area with 8 x 30 binoculars. In the case of Yeavering Bell itself, this was usually done from the surrounding lower lying ground, or neighbouring hill, enabling a greater section of the hillside to be observed. Failing this, a more detailed search on the hill was sometimes necessary, when the goats may have been hidden from view by the contours of the hill, or in vegetation. Once the home-range of the goats and their preferred areas became clear, the animals became easier to locate, though a search of 3-4 hours was on occasion necessary before the goats were located. This was especially true if the herd was lying down when a particular area was being searched. By the middle of June the bracken had grown sufficiently tall to hinder location of the goats, and by July often completely hid the animals, thus making observations difficult.

Although, as the study, progressed, it proved fairly easy to get quite close to the goats, most observations were made at a distance with the use of a 15-60 x 60 telescope mounted on a tripod. Not only did this reduce disturbance and therefore behavioural upsets to a minimum, but also enabled all or most of the goats present to be kept under observation at once, and observations of their movement was greatly facilitated at times when the maximum area possible could be watched.

In the event of the herd dividing into two, the larger group was normally chosen for observation. Some degree of stalking was sometimes necessary when the goats were in the oak wood, or when

the goats were inside the ruins of the hill fort where they could not be observed from anywhere else.

(ii) Number of goats present, and individual identification

In the summer of 1977 a total of only 14 feral goats was found in the College Valley. A search of the surrounding area did not reveal any additional herds, and none of the shepherds spoken to, who between them covered large areas almost daily, had not seen or heard of any other goats in or around the Valley. Neither were any others reported to Jack Hope, Chief Warden of the Northumberland National Park, in which the College Valley lies. It is thus assumed that the 14 present, including 4 kids, in the Valley between May and July 1977 represent the sole survivors of the 1976 cull, as it is known that nanny herds and young will stick to a definite home range, which they are normally reluctant to leave. Lone billies, which are known to wander up to 50 miles normally do not do so until the rut, from the beginning of September until the end of October (Whitehead, 1972).

For the duration of the study, 12 of the 14 animals existed as one herd with a home range on and around Yeavering Bell. This herd comprised 6 nannies, 2 young billies and 4 kids (being twins plus two singles).

The remaining two were mature 'batchelor' billies that (from May to the end of July at least) had a home range of just over 2 km on the Western slope of Hare Law and Southernknowe by Whitehall East of the College Burn and ranging from the Cuddy stones to Harrowbog.

Due to the very dense stands of gorse on the East banks of the College Burn at this section, the woods and later on the tall bracken above the woods, observation of these two billies was often difficult. Usually no more than a glimpse was had as they moved in the gorse patches and woods. It was mainly for this reason that attention was concentrated on the female herd on Yeavering Bell. The two 'batchelor' billies were on average just over 5 km from the female herd.

There is no fixed pelage colour in Britain (Whitehead, 1972) amongst feral goats, colours ranging from black and dark brown, pied and skewbald and blue roan through to pure white.

It is locally believed that the original colour of the College Valley herds was a blue roan, the large proportion of skewbald animals found today being the result of a skewbald domestic billy running wild in the hills some 20 years ago (G. Elliot, pers. comm.) Whitehead (1972) and Lever (1977) both state that the goats North of The Cheviot, and East of the College Burn - i.e. the range of the goats culled in 1976 - are (or were) mostly blue-grey, though they are possibly using an old source of information as in 1976 the dominant colour was skewbald (E.M.Fergie, pers. comm). Tegner, writing in 1952 described the goats of the Northern side of The Cheviot as mostly piebald, though the now extinct herd on The Cheviot itself was of the blue-roan goats.

The majority of the remaining goats of the College Valley are skew or piebald, with a tendency for the hindquarters, head and forequarters to be dark with the middle white, the pattern on some resembling that of badly marked Belted Galloway Cattle. About

half had white tail tips, white rumps and white on the inside of the hind legs.

Two individuals, both female, showed white stripes running down the face above each eye, similar to the 'Swiss Markings' of the modern domestic Toggenburg goat.

In stature the goats resembled that of the Toggenburg/Alpine breeds of domestic goat, being small in stature, well proportioned, with the facial profile being slightly concave, the muzzle fairly large and the ears short and erect. The dished facial profile and pricked ears are also characteristic of the Scottish feral goats (Craig, 1970) and of the Welsh ones (Milner, Goodier and Crook, 1968). Neck toggles characteristic of many domestic goats, were absent from the College Valley herd, as they are in the majority of feral goats, including those from New Zealand (Williams and Rudge, 1969).

In pelage type and colour, and horn conformation, todays feral goats of the Scottish Borders resemble the 'Upland' breed of the now-extinct and unimproved 'Old English' type of goat, the Upland and Lowland type distinction being postulated by Werner (1977). The 'Upland' type of goat included the Irish, Welsh, Highland and Hebridean breeds 'native' to Britain, having such characteristics as long coats, of variable colours, ears pricked but not directed forwards, and of small, light conformation. The horns were of the scimitar-shape, or the 'dorcas' form.

Goats of this type were formally run in large herds in upland and mountainous regions of Britain, without receiving much attention. It is possible that the old upland goat comtributed much to the appearance of the goats now found feral along the Scottish Borders.

Given the small size of the population, it was easy to identify individuals, each of which was named to facilitate recognition in the field. The use of the initial letter of each will be continued in this dissertation when reference is made to individuals.

Description of Individual Goats

Yeavering Bell Herd

Females

E

A large, rangy skewbald nanny with very long horns going back in a circular curve over her shoulders. She had pronounced 'Swiss' facial markings. More or less a faded brown on one side and a dirty white on the other, her summer coat was rougher than that of the other nannies. Although with no kid of 1977 at foot, her udder was grossly swollen, particularly on one side, with the teats not being visible as the finger like projections of the normal udder. In no apparent discomfort, the cause could possibly have been some form of mastitis, to which goats are prone. Her clear horn rings indicated she was about 10 years old.

P

A large 6 year old piebald nanny. She showed a lot of white and as such was often the first member of the herd to be located. She had a large white patch between the eyes. One side of her udder was noticeably swollen, though to a much lesser degree than E. She had a blue-roan and white kid at foot.

G

A blue roan 4 or 5 year old animal with a shaggier coat than the other females, and faint 'Swiss Markings' on her face. She had female twins at foot (one skewbald, one blue-roan and white) and appeared a good mother.

D

A very dark brown yearling with a white belly and tawny 'eyebrows'. Her horns were set very close together and were more parallel than the others. Probably the 1976 kid of female E, whose company she usually kept.

L

A pied animal thought to be about 5 years old, possibly younger. Her horn rings were too indistinct to assess her age, even when she approached the observer to within about 15 feet. Her white 'belt' was marked with black spots.

F

A piebald yearling with a skewbald female kid at foot. She was an indifferent mother and was thought to have been the previous years kid of L, the two often accompanying each other. She had a distinct white belt and a narrow facial blaze. Her beard was short and sparse.

Males

H

A three year old billy, with a shaggy dirty white coat with dark brown forequarters, brown saddle patch and brown hind quarters. The base of the anterior keel of one horn was pale in colour, sometimes appearing semi-translucent in sunlight. His horns were of the 'dorcas' type, and he had a broad white facial blaze.

B

Smaller than H, B had a shaggy grey/brown coat with dirty white patches on either side. Had a pronounced tuft of hair on the forehead, with a long tendril hanging between the eyes. He appeared to be about 2 years old, with horns beginning to show the 'dorcas' conformation. Often followed G and the twin kids.

Whitehall

Males

Pied Billy. The larger of the two Whitehall billies, he was predominantly black with white patches on either flank. He had large horns of the 'dorcas' type, though it was not possible to see the animal rings clearly, the animal was thought to have been 5 or 6 years old.

Blue Billy. He was the only goat of the 14 to exhibit the scimitar horn formation. His shaggy coat was blue-grey in colour, and he appeared to be aged about 4, possibly older. Usually, though not always, found in the company of the Pied billy.

(iii) Sex Differences

Sexual dimorphism in the adult feral goat is fairly well marked. In the field the billies can be distinguished from the nannies by their greater shagginess and the 'mane' of long hair hanging below the neck that merges with the beard is much longer and thicker than those of the females. The female beards, though smaller, were more distinct. This has also been observed in the feral goats of New Zealand (Williams and Rudge, 1969). The summer coat of most females contrasts to the shagginess of the males, whose long coats appeared matted. The winter coat of the females is long and shaggy (P.McDougall, G. Elliot, pers. comm.) By the time field observations were commenced in May, they had mostly moulted out the shagginess. The one exception was the grey nanny, G, who still showed a great deal of long shaggy hair. By July, she had lost most of it from the back, ribs and stomach, though still had a fair amount on the hind quarters, some on the forequarters, and a fringe along the spine. The other nannies also showed a retention of a fringe along the back, and a few tufts on the hindquarters, the ends of which

appeared a faded brown colour. This distribution of longer hair on the body is also seen frequently in the domestic Toggenburg goat (Jeffery no date).

It is commonly believed that the shagginess of most feral goats of the temperate zone is an example of reversion to the 'wild type' e.g. Fraser Darling 1937 who stated that this 'reversion' can occur in a very short time. However, the coat of the probable main ancestor, C. hircus aegagrus, whose natural distribution is far more southerly than that of the British feral goat, is short haired. It is far more likely that shagginess of coat is an example of adaptation to a harsh environment rather than reversion to 'wild-type', the wild-type not necessarily being adapted to the climatic conditions experienced by British feral goats.

The horns of the mature animals are markedly different from those of the kids, especially on close examination. From observation of both goats in the field and heads from the 1976 cull the horns of the males are of greater size in relation to age, much broader at the base and generally thicker. The male horn has a pronounced anterior keel, whereas the female horn does not, being more oval in cross-section. The annual growth rings (see page are often marked in the male by a notch in the anterior keel (c.f. the ridge of the Ibex horn) whereas those of the female are not. The annual ring itself was often (though not always) better defined in the females, and, in the field, the females were found to be easier to age by this method. Milner et al (1968) found female goats more difficult to age in the field. Determination of the number of horn rings is often impossible if they are worn away, particularly at the distal end of the horn, by fighting and fraying vegetation.

The horns of the males showed a greater diversity of form than those of the females. The female horn curves over the withers in a marked, though not exaggerated arc, with the tips being several times further apart than the bases. The male horns either rise in a parallel manner to curve over the back in the 'scimitar' conformation, or the distal end of the horn has a marked twist, the tips projecting laterally. ('Dorcas' conformation). The majority of the billies remaining in the College Valley, and those in the sample of heads, were of the 'dorcas' horn type.

Determination of the sex of the kids was more difficult, the only reliable way being the observation of urination, when the females assume a marked squatting position. Precocious sexual behaviour was found to be unreliable, as kids seem to mount others later proved to be female.

(iv) Range, Movements and Activity

Range

A 4½" to the mile map tracing was carried out in the field, and the position of the Yeavering Bell herd recorded every two hours from the time of location, when the goats were under continuous observation. This was not done for the two Whitehall billies as sightings were too infrequent. The direction of movement was also recorded.

Activity

Recordings were made every half hour of the percentage of the total animals visible at the time that were grazing, ruminating, and total lying down. As summer progressed it became increasingly difficult to observe the animals when amongst bracken etc. When

known to be lying down and hidden in the vegetation it was impossible to determine how many were ruminating at any one time. In such instances only the total lying down could be recorded. The averaged results for each observation period are shown in figs. 3-6.

(v) Analysis of Diet

Although observations were made on the feeding goats in an effort to estimate the consumption of their diet, it was usually impossible to identify food plants when the goats' muzzles, and often entire heads, were buried in long vegetation. Identification of food plants from direct observation was only possible when the goats were browsing on trees and shrubs, e.g. Ulex, Crataegus and and Quercus, and large herbaceous plants such as Carduus, Dryopteris and Pteridium.

Hunter (1960)calculated the grazing intensities (i.e. food preferences) of flocks of South Country Cheviot sheep on pre-marked plots representing the various plant associations of the study area. However, this only gave an inaccurate approximation of the diet of the sheep. It was necessary, therefore, to use some other method of diet analysis.

Early investigators of the diets of ungulates concentrated, under experimental conditions, on the analysis of rumen contents for identifiable plant fragments, e.g. Tribe (1950). Since this involves either the use of fistulated animals (which may give sampling difficulties) or the killing of animals for gut contents, it is obviously an unsuitable method for unenclosed mammals, especially any change in diet in relation to vegetation is to be recorded over a period of time.

Since the early 1960's attention has been paid to the identification of undigested plant epidermal fragments, by comparison to known reference material, in the faeces of herbivorous mammals. This is a means of estimating the qualitative composition of the diet, and has the obvious advantage that the animals need neither be handled, nor killed.

The epidermal cells are characteristic of the plant family, genus or even species, being especially well marked in the Gramineae (Martin, 1955). The overlying cuticle bears an imprint of the epidermal cells, is resistant to most chemicals and the action of gut microbes (Hercus, 1960).

With methods based on those of Hercus (1960), Zyznar and Urness (1969) and Henry (1975) faecal pellets were collected from both the goats and black-face sheep grazing the study area. Since faecal pellets of goats and sheep can appear almost identical only those seen to be eliminated from the animals were collected.

After storage of the pellets in 70% ethanol (three, or the equivalent of, per sample) were boiled in 10% sodium hydroxide for about 15 minutes to break down the mucus binding. This treatment was unlikely to have damaged any of the epidermal cells, since some mesophyll cells often remained adhering to the epidermis, mesophyll cells being less resistant to chemical treatment than epidermal cells (Stewart, 1967).

The sample was stirred and diluted, a subsample withdrawn stained with saffranin and examined wet under a 22 x 64 mm coverslip. The slides were examined at x100 under a binocular microscope, and the number of species from the first 15 occular fields with identifiable fragments were recorded. Since each

faecal sample was well stirred after boiling, examination of only one slide per sample was felt to be sufficient. At the same time the entire slide was scanned for presence of nematode infections as indicated by eggs.

The fragments of cuticle and epidermis were identified by comparison to reference slides made from plants collected from the study area. Fragments of fresh plant material were boiled, in a water bath, in 50% nitric acid until the epidermis had separated from the mesophyll (Stewart, 1965, Zyznar and Urness, 1969), the time varying from 10-30 minutes, depending on the nature of the plant. Separation of gross epidermis was facilitated by making incisions along the length of the blade. The excised epidermis was washed in very dilute NaOH to facilitate stain uptake, floated onto a slide and mounted in glycerine jelly stained with saffranin. The slides were then photographed.

(vi) Determination of Age

Many different methods can be employed to age mammals, though are not all necessarily applicable to individual species. One of the best indicators of age in the anatomy of a mammal are the teeth. From examination of the teeth, age can be assessed in a number of ways. One such method is based upon structural degradation is tooth wear (Morris, 1972) and is a method long used in animal husbandry and game management, (particularly ungulates). However, the method tends to be unreliable as tooth wear varies with harshness of diet and therefore locality, and is at the best only applicable to the older animals of a population. Younger animals

can be aged with a fair degree of accuracy from the sequence of eruption of the permanent teeth. This can reliably age roe deer (Capreolus capreolus) up to 13 months, red deer (Cervus elaphus) up to 2½ years (de Nahlik, 1974) and up to 26 months in the wild pig (Sus scrofa) when the animal has a full set of permanent teeth.

It is only fairly recently that attention has been paid to the determination of absolute age from incremental lines in the teeth. Although present in the secondary dentine (Morris, 1972) the most widely used growth increments are those of the cementum, which are laid down in response to annual environmental fluctuations. Each annual layer consists of two bands; a band of collagenous cement, usually calcified and containing a large number of cementocytes. The narrower translucent, or dark, band is strongly calcified with few cementocytes (Henry, 1975). The light band represents summer growth, the dark, winter. (Mitchell, 1963).

In recent years the method has received much attention after the initial work of Laws in 1952 on the elephant seal (Mirounga leonina) followed by many others e.g. Mitchell (1963) and Almason and Rieck 1970 on Red deer (C. elaphus), Ransome (1966) on White tail deer (Odocoileus virginianus) and White (1974) on roe deer (C. capreolus). These workers all investigated incremental lines in the cementum of polished sections of first molar (M_1) viewed under reflected light.

Success has also been reported from histological sections of first incisor (I_1) by Sergeant and Pimlott (1959) on Moose (Alces alces), Low and Cowan (1963) on Mule deer (O. hemionus) and Gibert (1966) on O. virginianies. No reference was found to such work on the goat.

In the domestic goat and some related ungulates discontinuities of horn growth occurring during the winter result in the formation of annual growth increments. These are not often clearly visible. This has been demonstrated in the Himalayan Tahr (H. jemdahicus) (Caughley 1965), Tall sheep (Ovis dalh) (Hemming, 1969) and bighorn (O. canadensis (Geist, 1966).

However, it appears necessary for sharp seasonal variation in climate and food supply for the formation of annual horn growth increments, as suggested by Rudge (1972) for feral goats living in New Zealand. Here the relatively constant climate and food supply result in year round breeding and horn rings that are not strictly annual in sequence. As feral goats in the British Isles are subjected to pronounced seasonal differences in climate, and therefore food, it is generally assumed that the major growth rings in the horns will be annual ones, corresponding to a cessation of growth in the winter. As none of the animals nor material used in the present study were of known ages, the growth rings were taken to be annular, and their occurrence was correlated with other criteria of (relative) age.

Because the mammalian eye lens is continually added to throughout life, even in times of under feeding, and is subjected to a nil degree of wear, it increases in mass exponentially, the weight therefore being proportional to age (Friend, 1967; Morris, 1972). Lens weight is one of the most accurate methods available for age determination in mammals, and was first described by Lord (1959) for cotton tail rabbits (Sylvilagus floridanus).

Growth of the lens can also be measured by determination of the protein content (Birney et al 1975) and has been done so for a variety of mammals, including humans (Satoh, 1972, not seen). Increase of protein in the lens is affected by the conversion of new soluble protein from outside to the insoluble state (Dapson and Irland, 1972), the total amount being related to age.

Following the cull of the College Valley goats in 1976, a number of heads became available. Since no evidence for previous work on age determination on feral goats from growth increments in the tooth cementum was found, this was to be attempted. As the goats were of unknown age, it was decided to attempt a correlation between any possible cementum layers and the major growth increments of the horns, in addition to the pattern of tooth eruption.

M_1

Being the first permanent tooth to erupt, the first molar was chosen as the most suitable for sectioning. The lower jaws were removed from a random subsample of 14 heads, the right half held in a vice and the M_1 sawn vertically between the cusps, as shown by White (1975), the cut continuing through the jawbone. Ideally the teeth should have been removed from the jaw to facilitate grinding the desired section, but as the jaws were fresh, this would have been difficult without possible damage to the cementum, so the teeth were retained in a section of jaw.

The two cut surfaces were initially polished on a grind stone using two grades of aluminium oxide and water paste. This proved tedious and the sections were ground on a faster water cooled

diamond impregnated wheel, this giving a sufficiently fine polish. The polished surface was then examined by reflected light under a binocular microscope using varying powers of magnification. Because of the poor results this gave, the method was modified by grinding away the base of the jaw section until the root tips were just visible, and using these with the notch between the cusps as a guide, the tooth was carefully ground away until the desired section was reached. This in fact gave no better results and attention was turned to the first incisor.

I_1

I_1, was histologically examined using a modified version of the method used by Henry (1975). I_1 is the first permanent incisor to erupt. On removal from the jaw, the teeth were decalcified for 48 hours in 5% HNO_3, and then washed for 24 hours in running tap water to remove all traces of acid. Longitudinal sections from the central portion of the tooth were cut at 20 microns on a cryostat, and affixed to slides using albumen glycerol. After staining for 5 minutes in haematoxylin, they were washed in distilled water to remove all traces of excess stain, immersed in alkaline alcohol, followed by one minute each in 70% ethanol and two changes of 90% ethanol. The sections were counter stained in eosin for 5 seconds and dehydrated by immersion in 2 changes of absolute alcohol. After cleaning in xylene for 10 minutes, the sections were mounted in DPX mounting medium, and examined under high power.

Horn Rings

The number of rings on the horns of a subsample of heads were counted, and the distance between the rings measured. The same heads

were used as a source of material for I_1, sectioning and eyes for lens weight and protein content analysis.

Eye Lenses

The lenses were removed from the heads whilst still deep frozen, and fixed in formalin, the frozen lenses being less prone to damage than when in the fresh state. Any adhering tissues were carefully removed. Both lenses were then oven dried at 80°C to constant weight, and weighed.

Estimation of the protein content was made using a modified version of the method used by Dapson and Irland (1972). As fixation in formalin had precipitated the protein, the dried right lenses were ground with a pestle and mortar, and made up to 10 cm^3 of 1 M NaOH which effectively dissolved the ground material. The solutions were then read colourimetrically on an SP 1800 ultra violet spectrophotometer at 500 nm, using the Folin test. Because the original 10 cm^3 volume was too concentrate to give accurate readings, it was diluted 50 times, this concentration being found to give the most accurate reading after several trial runs at different concentrations. The readings were converted to μ grams of protein by comparison with a standard curve prepared with bovine serum albumen (in the range of 0-400 $\mu gm/cm^3$ of B.S.A., and multiplied by the dilution factor of 50.

PLATE 2

(a)

The goats often grazed in close proximity to agricultural land. The six annual horn rings of nanny P (photographed with her kid) can clearly be seen.

(b)

Billy B on the only occasion a goat was seen to cross a wall.

RESULTS

(i) Home Range

Female Herd

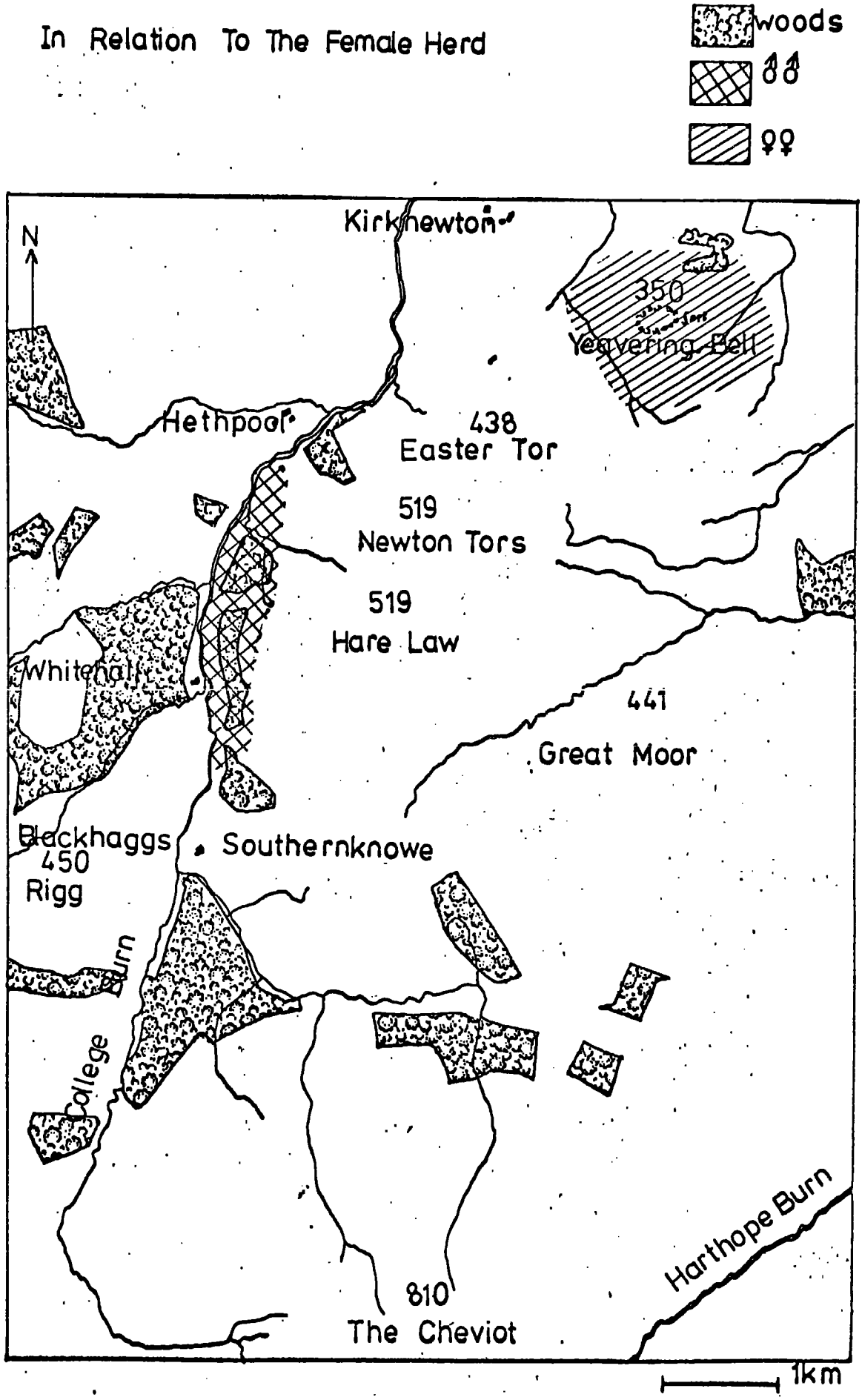
Home range can be defined as the area over which an animal normally travels in pursuit of its routine activities (Jewell, 1966, after Burtt).

The home range adopted by the goats on Yeavering Bell in the summer of 1977 was a joint one, the area being used by the entire herd. The daily excursions were usually undertaken as a group. The boundaries of the area concerned were well defined. Figure 2 shows the home range from mid May to the end of July. Local residents claim that goats that had habitually been in the Yeavering Bell area had had a home range up to 3 years prior to this study covering the flatter moorland on and around Tom Tallon's Crag. They were existing then, as they were apparently prior to the cull of 1976, as a distinct herd from the once large population of the Newton Tors.

As the summer progressed, the female herd tended to range more widely than in the earlier part of the study, though still within a well-defined and voluntarily restricted area.

The preference for certain parts within the range appears to have been related to the state of the vegetation in different areas. In May, and slightly less so in early June, the goats tended to spend the greater part of their feeding time in the large patch of Ulex on the South west of Yeavering Bell. It was then in flower and the goats spent a considerable amount of time browsing on it. In that time, new growth of Pteridium was negligible, and had not yet hidden the young growths

FIG. 1. Home Range Of The Whitehall Billy Goats
In Relation To The Female Herd



of Anthoxanthum, Holcus, Poa and Deschampsia flexuosa and several herbs. This may account for the goats in theory often crossing the stream running SE-NW along the base of Yeavering Bell to graze amongst the dead bracken on the hill side opposite. Once the bracken had started growing, the goats rarely visited the area, though black face sheep in the area continued to do so. Ground along both sides of the stream were often visited during May, and its close proximity to the often frequented Ulex patch may have accounted for this.

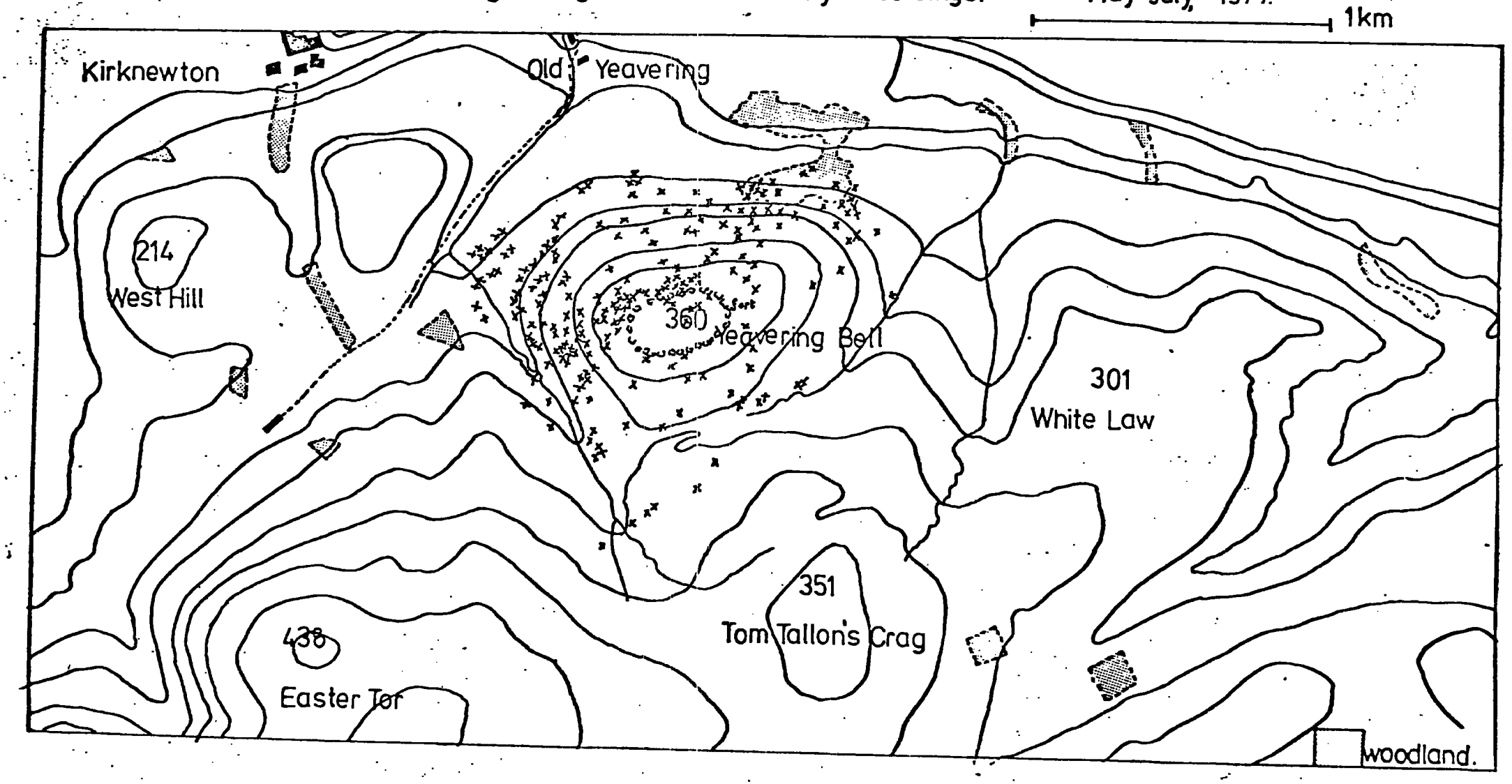
The frequency of visits to the oak wood situated on the lower slopes of the Northern side of Yeavering Bell in early June was possibly correlated with the palatability of the young Dryopteris fronds, which were observed to form the bulk of the food taken when the goats were feeding in the wood in that period. By July the goats were, in their daily movements, covering the greater part of their range. Although faecal analysis indicated no apparent drop in the amount of Ulex eaten (see later) the goats in fact spent considerably less time feeding in the parts of their home range on which this plant grew.

When disturbed towards the boundaries of their home range, the goats usually ran back onto familiar ground, even if by doing so the path of flight was not directly away from the source of disturbance. This reluctance of the female feral goats to leave the home range has also been noted by Greig (1970).

Males

The two mature billies of the Whitehall area, appeared, from fewer observations, to have had a summer home range of approximately 2.5 x 0.5 km, stretching from along the College Burn from the ruins of Harrowbog to the Cuddystones, on the west of the Newton Tors, Harelaw and Southernknowe. In height it extended from the east banks of the

FIG 2. Home range of Yeavering Bell goats from 2-hourly recordings. May-July, 1977.



Burn to a height of about 320 M (Figure 1). They were never observed at or near the tops of the Tors, unlike the female herd who would, at times, frequent the top of the 360 M Yeavering Bell. The two billies were never observed across the College Burn on its western bank. Although generally feral billies have a much less ridgedly defined home range than the nanny herds (Riney and Caughley, 1969, McDougall 1975) no sightings of the two billies were made outside this area either by the author or by the shepherds of the College Valley Estate, who between them, cover a wide area.

(ii) Movements

In early summer the Yeavering Bell nanny herd showed a well defined pattern of movements through the day. As summer progressed their daily movements became less predictable. Throughout the study, they would often be left at dusk near or heading towards the area where they would be discovered the following morning. This was frequently below the fort wall, high on the north, north west or western side of Yeavering Bell. It was concluded that the animals were spending most nights there.

Because of the infrequency of a clear night with a full moon in the study period, only one all night visit could be attempted. This was on 7 July. In the late afternoon of that day the goats had been grazing to the south of Yeavering Bell, west of Tom Tallon's Crag. However, instead of moving towards the north side of Yeavering Bell as they usually did, the goats bedded down for the night on the grassy slopes on the south side of Yeavering Bell.

During May, the goats usually descended each morning from the north of the hill down into the large patch of Ulex on the south west. They would work their way round, rather than over the hill, and reached the stream usually by mid to late afternoon. Generally, the goats would work their way up stream from the gorse patch, or up the slope on the other side of the stream before heading back towards the high slopes of the north, grazing as they walked. This pattern was changed in June to include the oak wood to the north of their range. It was frequently entered, usually from mid morning to late afternoon from the south west, or west. Although less time was spent feeding in the gorse along the lower slopes of the hill to spend periods of up to 4 hours browsing on the fewer, more isolated gorse bushes above Old Yeavering.

When feeding in the wood, the goats would either pass through it to browse on the hawthorn trees at the eastern edge, or would move randomly within the upper half of the wood. On disturbance, the goats would run straight from the trees onto the open hill. In June and July, the goats were frequently found grazing on the lower slopes of the hill, above Old Yeavering, sometimes right up to the stone wall enclosing the fields of Old Yeavering (Plates 2 a+b) there they would graze on bracken and associated vegetation.

It was not until July that the herd was first observed on the south side of Yeavering Bell, in the shallow gully between the hill and Tom Tallon's Crag, and on the area of moorland to the south. In most instances this area was used between mid-day and early evening.

The wood was rarely visited in July, one possible reason being the increased numbers of bothersome dipterans, though a change in the palatability of the ground flora may also have been a contributory factor.

The patterns of movement were readily upset by the increasing disturbance from tourists and hill walkers in mid June and July. On repeated disturbance the movements would become non-directional or zig-zag.

Thick sea mists typical of the Cheviots, came in from the coast on three occasions during the study period, and lasted up to six days. As these sometimes did not lift until as late as 16.00 hours, descending again in the evening, observations were seriously hampered, and especially when even the low lying ground was obscured. However from the few sightings made whilst searching for the herd in the mist, it appeared that, although the animals did not move much under these conditions, the height at which they were found was not affected by poor visibility. The goats often grazed in the mist towards the top of Yeavering Bell, where visibility could be as little as a few feet, the lower slopes at such times could be clear of mist. They tended to remain in a close bunch in such conditions, however. Rain also tended to cause a cessation of movements. Although the goats often continued grazing, albeit half-heartedly, they tended to remain in the same place, sheltering on the leeward side of bushes. This was often observed under conditions where sheep in the same area would be actively grazing and moving around. Milner et al (1968) observed this distinction also.

Unlike sheep, which tend to follow clearly defined self-made paths, the goats tended to move in a broad front, though they might occasionally follow a sheep path when moving across a steep slope on which a path happened to be leading in the direction of travel.

(iii) Types and Patterns of Activity

Like other herbivorous mammals, the goats spent the greater part of the day feeding. Intervening periods not spent feeding were normally spent in lying down and ruminating. Although the animals almost invariably lay down when ruminating, they were sometimes noted to do so whilst standing. Casual observations indicated that rumination whilst standing was more frequent in the sheep than in goats.

It was not found to be possible to distinguish periods of paradoxical from the deeper grades of ordinary sleep. The goats were assumed to be in a deep sleep when lying in a completely relaxed state, with no obvious bodily movements. This was observed most frequently in the early morning from about 4.00-6.00 hours. (Visibility earlier than this was usually too poor to determine accurately and from a distance what the goats were doing. There was a second peak from mid to late morning (not shown in figs.3-5). The kids were seen to be in apparent deep sleep more frequently than adults.

In the only all night visit, the light was too poor to determine how much of the period of darkness was spent in the position of apparent deep sleep, the only scarcely visible parts of the goats being the white markings. They spent the entire night lying in the same spot. Individuals occasionally stood up to change position. Sheep, in contrast, were seen to move around and graze all through the night, with intervals spent lying down. Sleeping adult sheep, where the loss of vigilance (i.e. paradoxical sleep) was obvious from the ability of the observer to quietly approach the animals very closely, usually slept whilst lying on the stomach with the legs tucked underneath, and the chin resting on the ground. The goats differed in that apparent

sleep occurred when the animals, both adult and young, were lying flat on one side with the legs either outstretched in a manner reminiscent of many juvenile ungulates, or tucked underneath. They were less frequently observed apparently asleep in the position adopted by sheep, though usually with one or both forelegs outstretched. On some occasions goats were observed sleeping with the head propped up on a large stone.

Before lying down the goats often pawed the ground with a front hoof. This was only noticed when the animal intended lying in very short vegetation, or bare ground, but was not observed when the goats lay down on rock. It was seemingly limited to adults, though on two occasions a kid was seen to paw its mother before lying down beside her. Favoured resting or sleeping places gave a good view of the surrounding area. Rocky outcrops and block scree were also favoured locations.

The Yeavering Bell goats had two primary grazing periods (Figs. 3-5). One was in the early morning from approximately three hours after sunrise to about 9.00 hours, and the second, which formed the main feeding period from about noon until dusk. The grazing intensity increased towards the evening. Rumination reached a mean peak towards noon, and a smaller peak in the early morning. The general pattern of rumination followed that of the time spent resting.

The patterns of activity were modified slightly by bad weather. The goats showed a tendency to feed less in rain and heavy mist. Very wet vegetation discouraged the goats from lying down, and under such conditions they showed an increased tendency for rumination whilst standing.

FIG. 3. DAILY ACTIVITY OF GOATS MAY 17-29

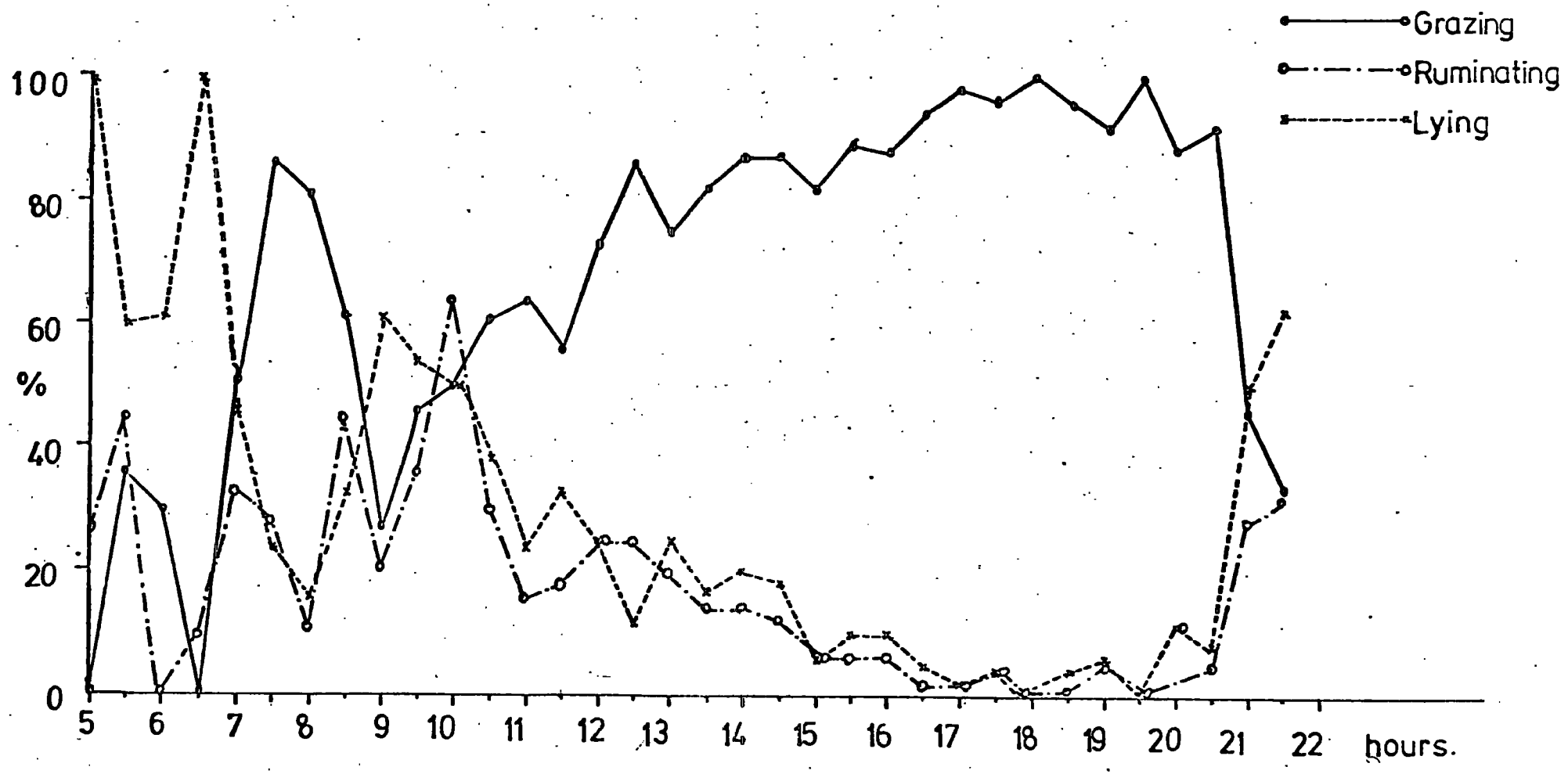


FIG. 4. DAILY ACTIVITY OF GOATS. JUNE 8-20 (Key as before)

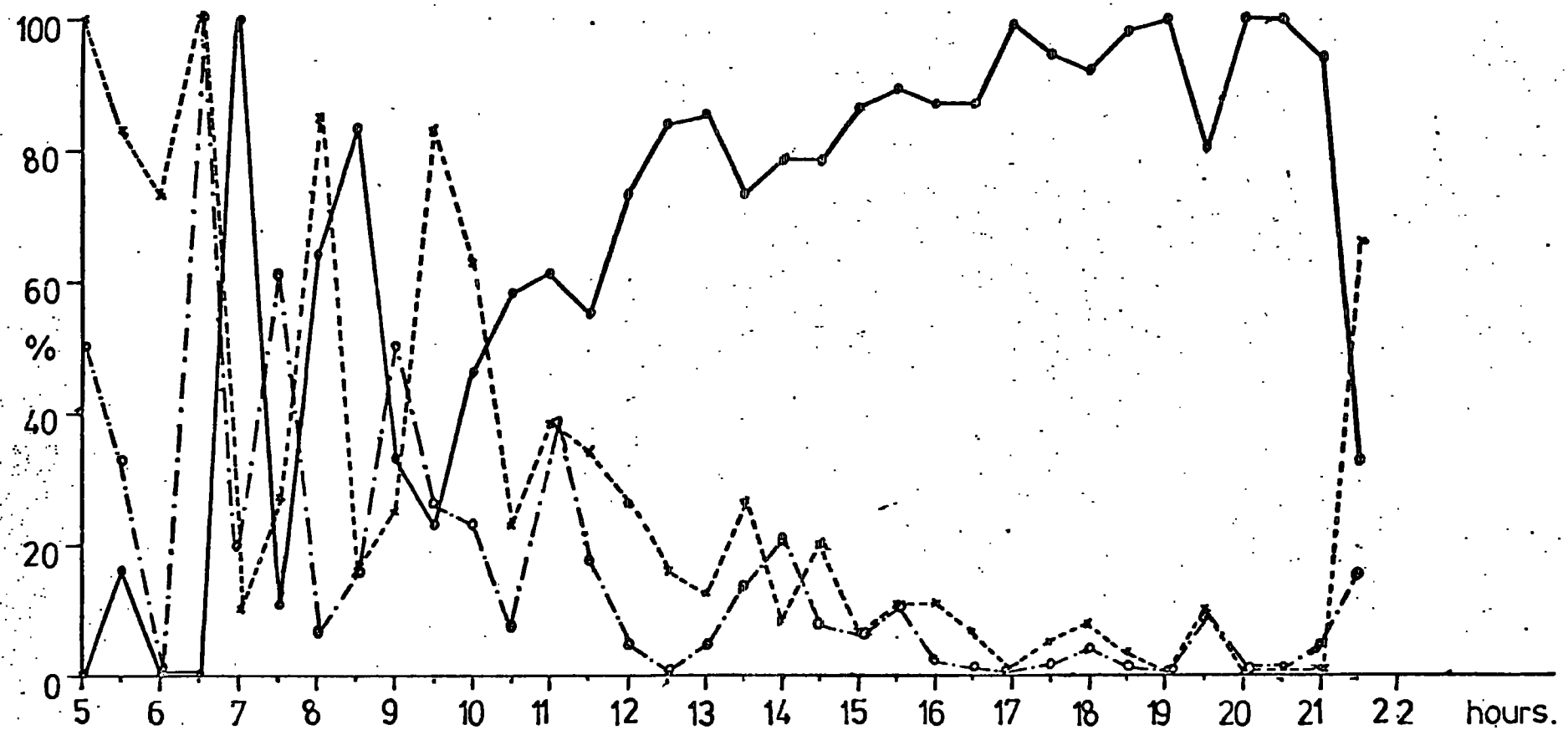
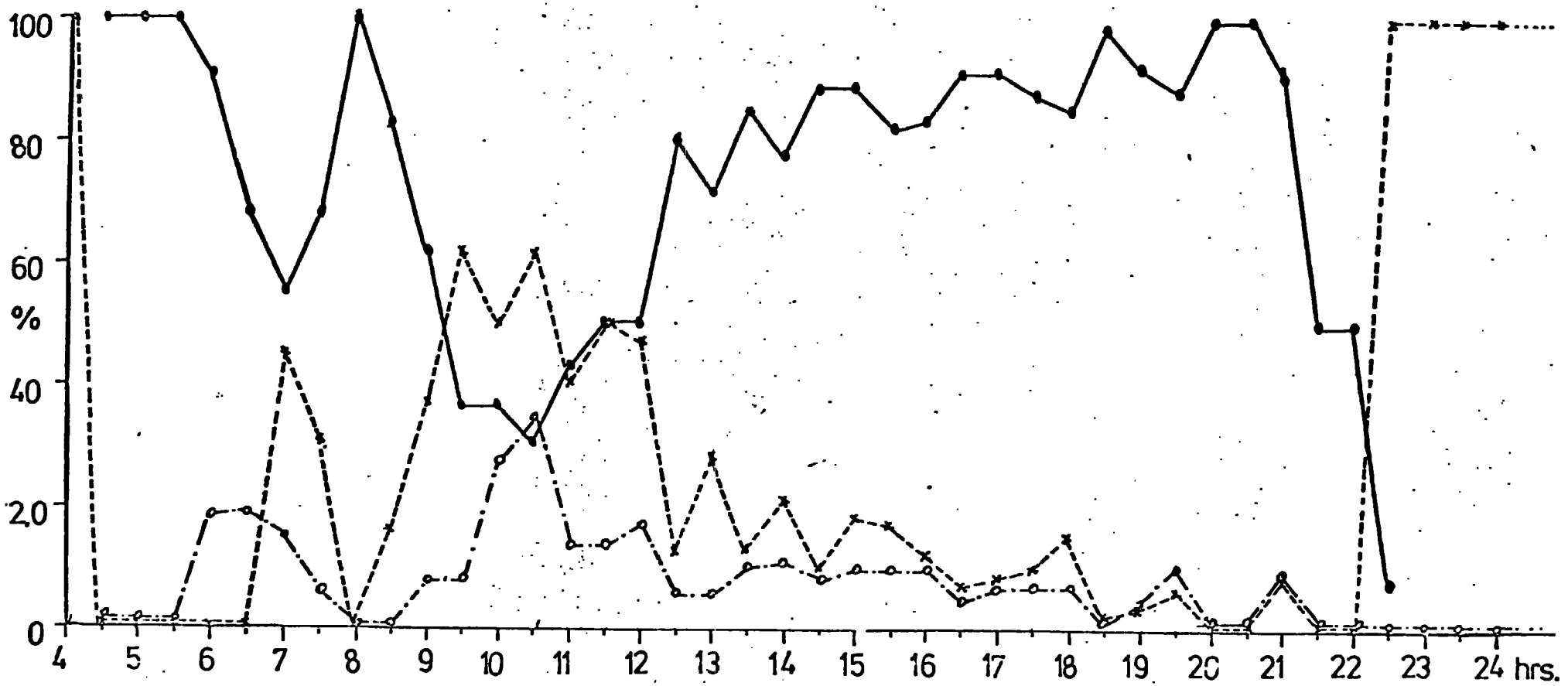


FIG. 5. DAILY ACTIVITY OF GOATS JULY 5-16/26-31 (Key as before)



No significant change in pattern of daily activities was found during the period of field observations. It is possible that the slight differences in the times of activity peaks may have resulted from activity records being averaged over too short a period. This is reflected in the fact that it sometimes took several hours to find the goats in the mornings (for example when hidden in bracken), thus the surves from mid morning onwards are smoother. Figure 5 in which data from the periods July 5-17 and 26-31 is combined, is however, considerably smoothed. Human disturbance may also have contributed to a certain amount of distortion to the pattern.

Minor activities such as play and scratching followed no set pattern of daily movements, though the goats showed a slight tendency to play more in the afternoon and early evening than at other times. Scratching and rubbing occurred intermittently through the day. A hind hoof was employed for scratching the forequarters and face, for the hindquarters and back a horn was used. The goats would often rub the sides of their bodies and backs along the rough vegetation such as Calluna and tall Vaccinium when walking across a slope where this could easily be achieved by leaning into the slope. The sides of sheep erosion crescents on the hillside were also used for this purpose, though never a tree trunk or rock as are used by many other ungulates such as deer, sheep, and equines. In the kids, the use of a horn for scratching was first noticed in early July, when the horns were approximately the length of the ears.

As in most juvenile ungulates, the degree of play was affected by the weather. Sunny, warm or slightly windy weather

was more inducive to play than cold, overcast, and, above all, wet weather. Although playfulness was more characteristic of the kids, the adults including the old ones, sometimes indulged in bouts of playfulness. In the kids play took the form of mutual head butting, butting each other from the rear, racing and chasing one another. Rocky outcrops were strongly favoured for play - the kids running up them only to jump off again, the whole procedure sometimes being repeated several times. Often two kids together would climb onto a large rock and engage in mock fighting, one having chased the other up. The object of the game sometimes appeared to be to push the opponent from the rock. When available, kids would, with great agility, climb into the lower branches of oak and hawthorn trees. They were apparently motivated by the desire to play, rather than browse, the animals running up and down slanting trunks and walking along branches rather than feeding. The two yearlings F and D, and the two year old goat B were also seen to climb into the lower branches of oak trees, though only to a height of about 1 M. Kids were observed as high as 2-3 M from the ground.

When moving in a definite direction, the herd would occasionally make a detour to include a large rocky outcrop, or an area covered in large loose boulders in their path, of which there were several on the north and west sides of Yeavering Bell. These would be clambered over with no obvious motive, the goats having gone out of their way to do so.

If a February birth date is assumed, the kids were about 3 months old at the commencement of field observations. At this age they would frequently roll onto their backs and wave their feet in the air for a

few seconds, behaviour not seen in any of the adults. As the summer progressed, this habit, together with playfulness in general, declined somewhat. At comparative ages, the goat kids were much more playful than the lambs of sheep grazing the same area. Adult sheep, unlike adult goats, were never observed indulging in play.

(iv) Social Interactions

Within the female herd of Yeavering Bell the social structure seemed to be based on the relationships of the nannies and their offspring of either the current or the previous year. No evidence was found for the existence of a herd 'leader' (Tegner, 1961) in this herd. When on the move, whether peacefully grazing and walking, or in headlong flight, no one animal was observed to persistently take the lead. The leading animal was simply the one being in the front at the time, and was frequently a kid. No order or leadership was observed when the goats were fleeing a source of disturbance, the animals rushing off in a closely bunched group that frequently damaged its order as individuals dropped behind to glance back at the source of disturbance. When a long distance was covered in flight, a female was usually seen in the lead. However, with a greater number of females than males present, the probability of this happening was increased anyway. In flight the tail was held vertically, or curled over the back in both adults and kids. Shank (1972) describes this as a mostly male characteristic, though in the present study this was observed in the females just as much as in the males. The kids frequently carried the tail in a horizontal position when moving peacefully. Romping adults also carried the tail in an elevated position.

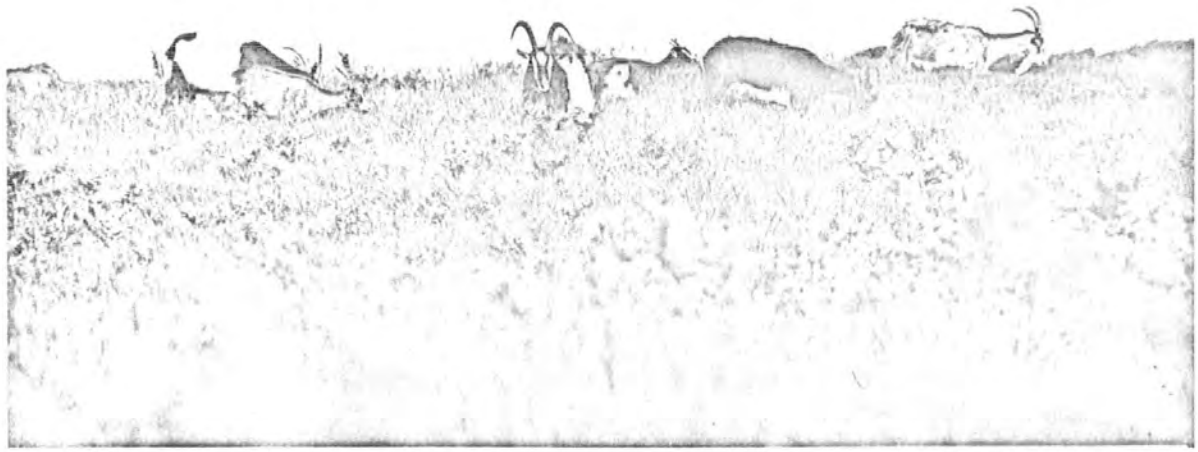
It became evident, however, that a social hierarchy did exist within the female herd, though was not immediately obvious. The social status of individual goats became apparent during play, or mock fighting amongst the 6 nannies and 2 young billies. In an encounter between two individuals, the goats would face one another and vigorously bang the horns together in a forwards and down wards direction in the 'clash' association of Shank (1972). Very often, however, one of the contestants would rear up and almost vertically on the hind legs, take one or two steps forwards and hurl itself downwards to clash its horns against those of the opponent, who stood braced, waiting for the impact. Usually when rearing, one foreleg would be outstretched, the other flexed and the head deflected to the side of the outstretched leg. The sound of the impact could be heard up to about 200 M away. It was noticed that of each combination of two nannies, the rearing animal in each encounter was the same. The rearing goat was consistently the older and therefore larger animal. When equally sized, however, as was the case with G and L, each was seen to rear in different encounters.

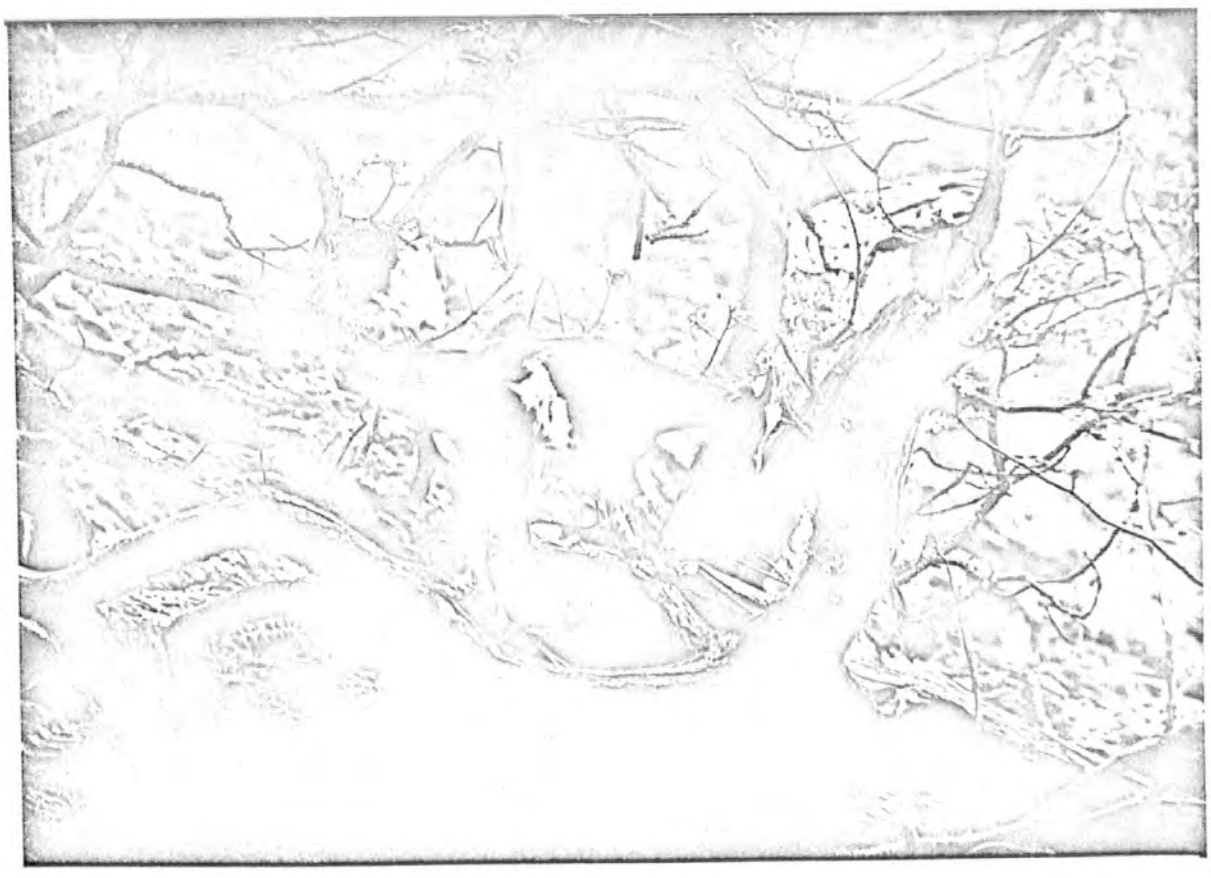
That the rearing goat was the dominant one was confirmed during observation of the animals grazing. If one goat grazed too close to another, one of the two would suddenly charge the offender. Unless it moved out of the way first, the dominant animal would hit the subordinate recipient broadside in the ribs with the horns. The subordinate nanny always retreated a few metres, and in this kind of encounter was never seen to be pursued, or to retaliate. In the Yeavering Bell herd, the animal charged in this manner was not necessarily the closest to the nanny expressing dominance, though was always the closest subordinate animal to the challenger. With the exception of the G and L, and F and D combinations,

in every instance was the giver of the blow and the same animal that would rear up in a mock fight encounter between the same two individuals. On a number of occasions when 2 nannies were engaged, a third animal would be observed walking up to the combatants and take over the 'fight'. When this happened, the interfering goat would take over the dominant role (by rearing) and the original subordinate goat would wander away leaving its opponent, previously in the dominant position, receiving the blows as a subordinate. Very often, the rearing animal was, in fact, at a disadvantage when, for example, it was standing down hill from its opponent. This situation never caused the roles to be reversed.

Subordinate animals were sometimes goaded into a mock fight by repeated jabs in the rare and flank from the horns of a dominant goat. In the event of a subordinate not immediately responding it was harassed until it did so. If an attempt to retreat was made, the dominant goat might, but not always, move in front of the subordinate animal in an attempt to resume the encounter. It became apparent that the dominant nanny in the female herd was the nanny E. At about 10 years of age she was easily the oldest, and her dominance was never seen to be challenged by the other goats. It was often she who interfered in the mock-fights of the other goats.

The correlation between age and position in the hierarchy extended to the kids, which were fairly frequently butted aside by nannies other than their own mothers, if they approached closely in a manner reminescent of the Rocky Mountain goat, Oreamnos americanus (Lentfer, 1965). This applied to nannies both with and without their kids at foot. Sometimes a short rush preceded the act, the adult usually going out of its way to butt the kid. Kids were never seen to retaliate, and neither of the 2 young billies was ever seen butting a kid.

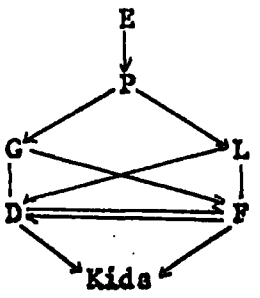




Encounters between the 2 billies, H and B were less frequent, but when they did occur they might continue for as long as 20 minutes, compared with less than 5 minutes by the females. On such occasions both males were seen to rear up (never simultaneously) though normally it was the larger H who did it. It was also H who normally initiated the head banging preceding a 'rear clash'. No social encounters were observed between the two Whitehall billies.

Encounters between the nannies and 2 young billies were infrequent, although they had slightly increased in frequency by late July. Interactions between billy H and the females were very few, and the outcome difficult to interpret. The 2 year old billy was, on several occasions, seen to run up behind one of the younger nannies and deliver a butt on the rump. In every case the nanny retaliated and B invariably retreated. Although probably playful in motive rather than an attempt at exerting dominance (where the two animals face each other) his retreats each time indicated a position of subordinance. The few 'rear clash associations' witnessed between him and females were half hearted in nature, neither animal rearing up and usually only lasting for 2-3 blows. It was difficult to place the 2 billies within the order of dominance of the nannies. This is summarised below:

Dominance



Subordinance

H
↓
B

Arrows indicate direction of expression of dominance

For description and ages of individuals see page 14

Although normally moving as a single herd, the group sometimes split up. Human disturbance at times resulted in the herd dividing, each half travelling in different directions. Within a day the herd usually reformed. A second, more natural kind of herd division occurred when some of the herd got up from a resting place, and moved on leaving the rest still lying down. The goats left behind in this manner were usually a female and kid, or kids, the latter normally having lain close to the mother. No single nannies were observed to isolate themselves from the rest of the herd, but Yocum (1967) did observe this in the Hawiian feral goats. On occasions B and H would leave the herd. They would remain in each others company, and at such times were often quite distant from the rest of the herd, but still on the same home range. They rejoined the herd after periods of up to 3 days. On two occasions in the study (11-13 June and 10-12 July) H isolated himself from the herd, and was usually found living alone in the gorse patch on the west and south west of Yeavering Bell. At such times he appeared more alert, but did not break into a run on disturbance by hill walkers etc. as did the female herd. Instead he tended to retreat into the gorse bushes.

Although usually content when alone, it was seen on one occasion 30 July, to be ill at ease on becoming aware of having been 'left behind' by the herd. Out of sight of the rest of the goats,he wandered in the general direction taken by the herd, not grazing and bleating continuously until he sighted the herd.

On re-amalgamation of the temporary sub-groups, no sign of recognition or antagonism was made, the two groups merely drifting together until grazing ws one. This applies also to the feral goats in New Zealand (Riney and Caughley, 1959).

(v) Mother-Kid Relationships

By May the 4 kids on Yeavering Bell gave the impression of being able to fend for themselves if necessary, though they were still small in size in comparison to the adults, and still following their mothers closely.

Interactions between the female goats and their kids seemed to be centred around the act of suckling. When very young, kids suckle frequently, but at 3 months, suckling was infrequent. The frequency declined further towards late summer. There seemed to be no particular time of day when suckling reached a peak, though it was noticed that the twins of G normally suckled together. In contrast to sheep, suckling by the kid was of short duration only, and was nearly always terminated by the kid itself, the nanny standing patiently. Ewes, even though their lambs were considerably younger, were observed to almost invariably walk away whilst the lamb was still suckling. This occurred even when the lambs were still very young. Both wag their tails when suckling. Lambs up to 3 months of age (and probably older) will often rush up to the ewe to suckle on being disturbed. The kids at a similar age were never seen to do this. Suckling by the kid was sometimes initiated by the mother apparently calling the out of sight kid or kids to her with a series of bleats. In suckling the kids showed none of the vigorous butting of lambs and calves, stimulating let down of the milk, though might on occasions give the udder a gentle poke with the head.

From the age of at least 3 months the kids would wander greater distance from their mothers than the lambs were observed to do at that age. Sometimes division of the herd would result in the kids being in one group, and the parent in another. Seldom in such instances was either visibly distressed.

The three nannies with kids at foot (P, G and F) paid different degrees of maternal attention to their kids. Twins are the rule in the feral goat (Whitehead, 1972) and it was probably no coincidence that the only nanny to rear twins (G) appeared the most attentive mother of the three. 'Single' kids are frequently the sole survivors of twins. Not only were the twins observed to suckle more frequently than the single kids, but G frequently called them when out of sight by bleating. When out of sight of their mothers, the thin, high pitched bleatings of the twin kids were far more likely to be answered by G than were those of the two single kids by their mothers P and F. The yearling F seemed a particularly indifferent mother. Only twice was she observed to answer the bleating of her kid, whose attempts to suckle were at times cut short by F walking away. Although F had a smaller udder and suckled her kid less often than either P or G, the kid was of similar size to the others. Sometimes a kid lying away from its mother would suddenly stand up and bleat. On hearing an answering bleat from the mother, the reassured kid would like down again in the same place.

A kid calling its mother generally got more response than a nanny calling her kid. On one occasion the herd moved away from a small clump of gorse bushes on which they had been feeding, leaving the kid of P behind in the company of B. By the time the herd had travelled about 50 metres, P had began lagging behind, and frequently stopping to look back and call the kid with persistent bleating. The kid ignored its mother completely, not even raising its head from the gorse bush. It eventually caught the herd up in its own time. No nanny was seen to interfere when her own kid was playing with that of another nanny, though Rudge (1970) did note this.

In view of the association between a female goat and her offspring lasting until well after the kid is sexually mature at 6-7 months (Collins, 1956) a behavioural trait also seen in domestic sheep, there is reason to believe that since the yearling D was nearly always in the company of the dominant nanny E, and nearly always resting by her, this yearling was her kid of the previous year. Neither had a 1977 kid at foot, though the possibility of either female having had and lost a kid cannot be ruled out. The other yearling F, spent more time in the company of L than of her own kids, but the degree of association between them was less marked than between E and D. This was possibly another example of a maternal relationship continuing after the sexual maturity of the offspring. However, L, F and F's kid were never seen as a trio, L butting the kid aside as she would the others if they approached too closely. B, who was often in the company of A and her twins, and making fairly regular attempts to mount her, could possibly have been still following his mother, though at 2½ years this was felt to have been unlikely.

(vi) Reactions to other mammals and human disturbance

Apart from human disturbance, encounters observed with other mammals were few. In the evening of 22 May, a hunting fox was seen near the grazing herd. It was approached by the curious kid of P, with outstretched neck, pricked ears and raised tail. By the time the kid was a few feet away from the now crouching fox, P had also spotted it, and walked towards it with horns held low and directed towards it and ears back. The fox retreated. On another occasion in July, a hunting dog fox trotted past the lying herd at 4.20 a.m. The goats watched it pass with acute interest, but made no attempt to move. However, three hoggets in its path scattered.

Roe deer were fairly abundant in the study area. In the two encounters witnessed between them and the goats, the latter appeared frightened by the deer. In mid June the goats were grazing in a woodland clearing at the edge of which a young roe deer doe was also grazing. The deer and nanny D gradually worked their way towards each other until only a couple of metres apart. The goat, on suddenly becoming aware of the deer bolted, putting the rest of the herd to flight. A roe doe was startled by the observer from bracken on the lower north-eastern slope of Yeavering Bell, resulting in the herd bunching and running. That the goats were fleeing the deer rather than the observ er was evident as by running away from the bounding deer, they came towards the observer.

A few times the herd was seen to sud denly bunch up and run, with raised tails characteristic of flight, although no visible source of disturbance could be found. Immediately prior to one of these flights 2 hares (leverets) were seen chasing each other towards the goats. It is possible that such reactions having no apparent cause could result from unusual movements of this kind.

Sheep were frequently observed in close proximity to the goats. The sheep normally moved aside when these approached. No instances of direct conflict were noted between the two species and only twice were sheep seen to be mildly threatened by the goats. On being approached by an inquisitive ewe, the pied Whitehall billy lowered his head, slightly pointing the horns forwards. The ewe backed away. Similar behaviour was observed in nanny E, but this time the ewe and goat lightly touched heads before the ewe retreated. Sheep unaccustomed to the goats treated them with curiosity rather than respect. Billy H, when at the extreme edge of the home range (an area seldom used) was observed standing on his hind legs browsing in a hawthorn tree. In this position he was approached by two inquisitive hoggets, who cautiously sniffed him. On dropping

to 4 feet, he lowered his head, and the sheep fled.

By far the most usual causes of disturbance were humans. As reported by Shank (1972) and Craig (1969) the males and kids were far easier to approach than the nannies. They were seldom the first to detect any cause of alarm, rarely kept their attention on any potential cause of disturbance and usually resumed feeding after no more than a glance. This behaviour contrasted with that of the nannies, which were extremely watchful in the suspected presence of humans. This was demonstrated frequently when the goats were moving towards the motionless and hidden observer. A nanny would invariably become aware of the human intruder before the billies and kids, who might approach to within 2-3 metres before suddenly stopping dead and staring.

As the summer progressed, disturbance of the goats by tourists increased, especially at weekends. On some days the goats were repeatedly disturbed by groups of people, and sometimes ended up running in large zig-zags across the hill side. On such occasions any patterns of behaviour were completely disrupted. When disturbed, the goats usually ran up hill. People with dogs were given a wider berth.

Unlike hill sheep, which bolt, then slow down, stop and turn to stare at the source of alarm, the goats would, if not duly alarmed, move off at an easy trot. It was not until the herd disappeared from sight, e.g. over a ridge, that they would break into a gallop to put the maximum distance between themselves and the disturbance. Only in cases of mild panic, such as hill walkers suddenly coming upon them over a brow of a hill would they immediately break into a gallop. After galloping 100-200 M they would slow down to a trot before stopping altogether.

Sometimes individual nannies would pause to give a backwards glance.

When disturbed by shepherds collecting sheep from the hills goats are reputed to sometimes join and run with the flock of sheep (P.Fergie, pers. comm.) This was observed at noon on 23 May when sheep were being collected from Harelaw for docking and castration of the lambs. The pied billy, feeding in the gorse bushes by the College Burn and disturbed by the shouting shepherd and the sight of his two dogs, ran uphill to meet the flock of sheep. For about 150 M he ran with them at the head of the flock before turning aside to disappear from view in a dense wood.

When a source of alarm was suddenly discovered to be very close (e.g. the author stalking the goats for photographic purposes) the discoverer would emit a warning sound. Perhaps best described as something between an explosive snort and a 'raspberry' noise, the sound could carry some distance. It was usually only uttered once, and stimulated the rest of the herd to flight only when the giver bolted as well. In June, the nanny L developed the temporary habit of giving the warning snort when other individuals had already become aware of the prone, motionless and downwind observer though showed no sign of uneasiness. They would, however, on hearing the warning snort, immediately lift the head and look in the direction the observer was last seen. If at such times L bolted on giving the snort, the others usually followed, even having been aware of human presence prior to the warning snort.

Although most observations were made at a long distance, the goats got used to the author extremely quickly. At the beginning of the study period the goats were once inadvertently put to flight from a distance of approximately 200 M. By the end of July it was possible to approach the goats upright (as opposed to the prone stalking position) visibly

moving and with the animals fully aware of a human presence. This was once done deliberately at the end of July, when the grazing animals tolerated the observer walking slowly and directly towards them to a distance of about 3M. At this distance they showed some uncertainty and milled around before making off at an unhurried trot. No alarm snort was given, and the goats did not break into a gallop. That they had become used to one particular person rather than people in general was indicated by the goats being put to flight on the same day by a party of hill walkers when about ½ mile distant. On each return after a few days absence from the study area the goats were sufficiently more wary than they had been at the end of the previous visit.

(vii) Sight, hearing and smell

The goats usually seemed to be disturbed by humans through a combination of both auditory and visual awareness. Distant, though noisy hill walkers when seen at distances up to ½ mile could results in the goats fleeing. However, as sometimes occurred, hill walkers could approach the herd to within about 20 yards with neither being aware of the others due to the slope of the ground. In these cases, although conversation could be perfectly audible to the observer at far greater distance, the goats would not become frightened until the people came into view of the goats. Conversely, single and silent people walking on an opposite hill would be ignored by the goats, especially if walking in a direction away from them.

Feral goats are reputed to have an acute sense of smell (Yocum 1969). It was found to be possible on testing this, to approach the goats fairly closely upwind with the animals showing little agitation

unless the observer happened to be spotted as well. This, however, would seem to contradict most other people's observations. An incident that seems to suggest that the goats were reacting to a combination of visual and olfactory stimuli, rather than either alone, occurred when the goats were being stalked on an open hill side. The goats on suddenly doubling back came upon the unhidden observer when they approached, and walked past with suspicion but no obvious fear. It was not until they had moved down wind, still in sight of the observer, that they all suddenly broke into a gallop. Since flight, when not unduly alarmed was not rapid until the goats were out of sight of the cause of disturbance, presumably the sudden catching of human scent when already aware of human presence precipitated a stampede.

Recognition of humans seemed to be based upon the typically upright stance, since the goats could be approached to and tolerated by at closer distances when lying prone. The goats would, at times, approach the prone observer to within a few feet. On becoming aware of this, the goats would stop and stare intently, and usually took a few steps forward for a better look, apparently full of curiosity. The sudden discovery of an upright person at a similar distance would immediately initiate flight.

The goats were apparently used to the very low flying fighter jets from R.A.F. Acklington that frequently flew down the Valley. The adults would scarcely flinch at the sudden loud noise, though the kids might run a few circles in a confused manner. This reaction was in contrast to that in response to the click of a camera on a still day. This was obviously an unaccustomed though small sound, and had the effect of immediately stampeding the herd. However, although some disturbance was inevitably caused by the people ascending the hill, once air bourne the hang gliders were ignored by the goats. Likewise, gliders

from a nearby gliding club were also ignored. On only one occasion was a low flying glider seen to startle the goats.

Communication amongst the goats by either visual, auditory or olfactory means seemed to be of little importance other than in maternal relationships. Here vocal communication seemed to be of importance, though the sniffing by the mother under a kids tail whilst suckling probably served to reinforce the maternal bond. Nannies appeared to be able to recognise their own kids visually, as no kid was ever seen to be sniffed before being butted aside by a female other than its own mother.

(viii) Feeding Behaviour

The goats had a much larger feeding area than the Black face sheep, and grazed in a group of larger size than ever observed in the sheep in the low stocking densities found on Yeavering Bell. In their daily grazing movements, the goats travelled much further than the sheep. However, recognition of individual sheep was difficult. The goats frequently grazed in a tight bunch, and only taking one or two bites before walking on. Although Yocum (1967) reports goats trotting between bites, and Crook (1969) in winter, this was never observed in the College Valley goats.

When browsing in small trees, the goats frequently stood on the hind legs with the back vertical and the fore feet resting in the tree. Sometimes the fore feet were used to hold down a particular branch while the leaves were nibbled off. The fore foot would be placed on top of the branch, usually with the fore foot flexed, and the branch between the hoof and dew claws, the other leg supporting the animal in the tree. Less frequently, a thin branch might be held between the claws of the hoof, the branch being deliberately 'caught' by pawing

PLATE 4

(a)

Part of the female herd grazing between Yeavering Bell and Tom Tallon's Crag. The difference in texture of summer coat between the two adult females and male (centre) can be seen.

(b)

Females feeding amongst and on bracken.

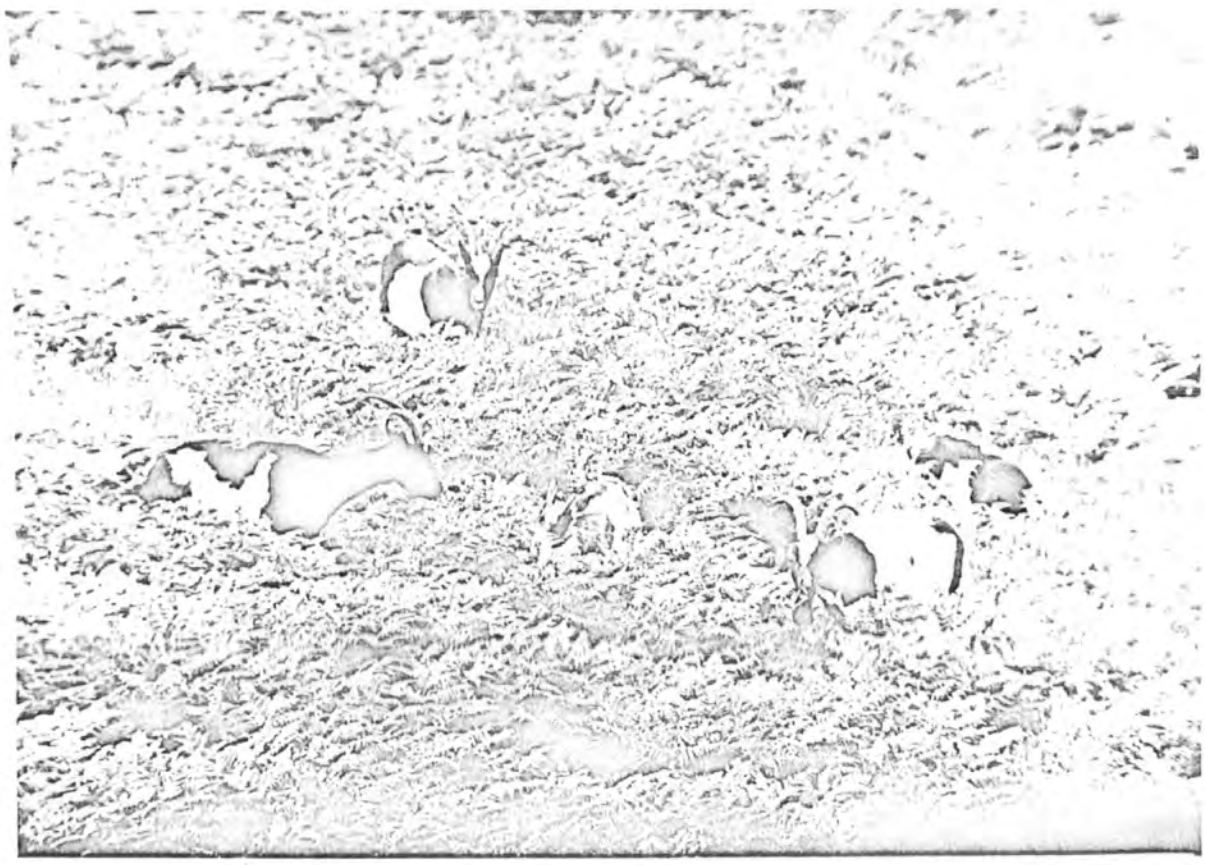


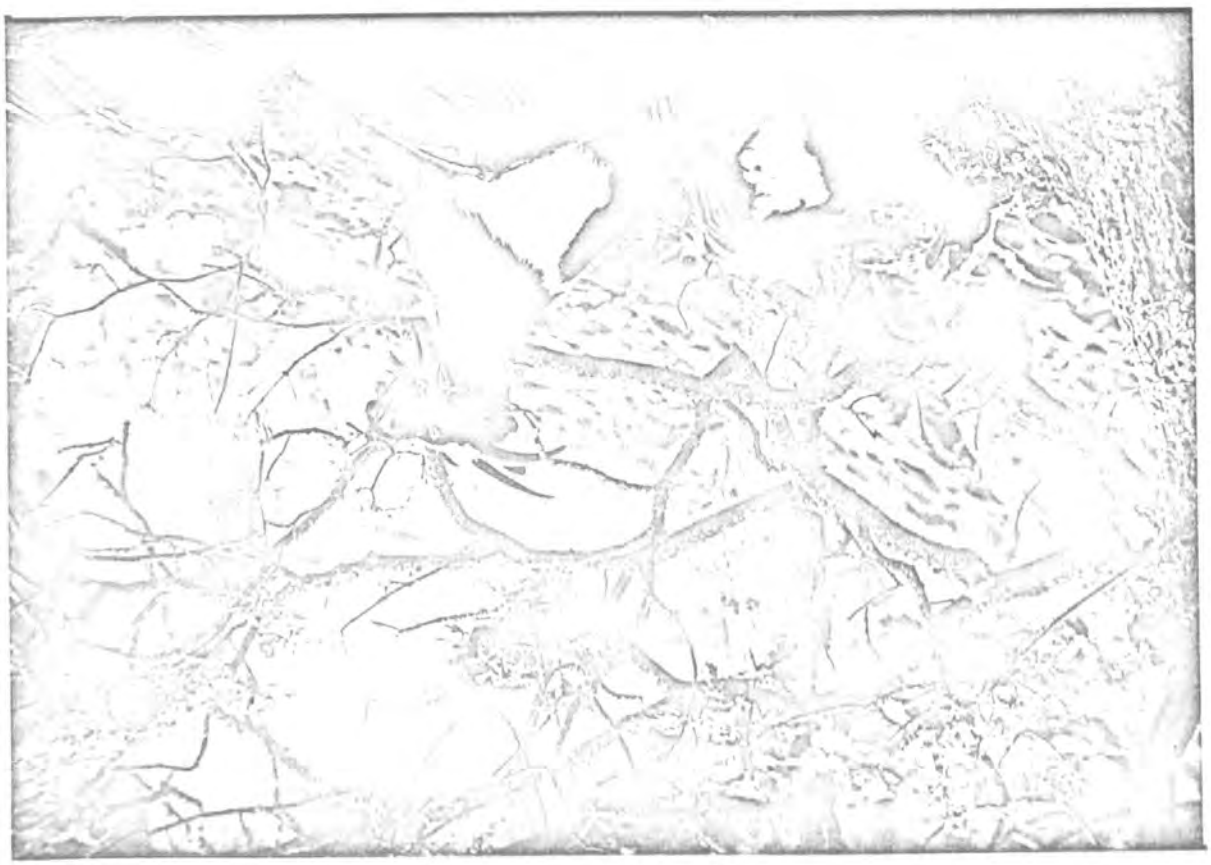
PLATE 5

(a)

Although not appearing in the faecal analysis, the goats were frequently observed browsing on oak. Pictured is yearling F with her female kid.

(b)

Nanny L photographed whilst browsing.



movements in the air. On one occasion, a goat (P) was seen to paw a hawthorn branch before feeding on it. Kids often climbed into a tree to browse, though tree-climbing was more associated with play.

The goats seemed to show a liking for some plants that were either very coarse in texture, or thorny. When browsing on gorse, or feeding on thistles, both sexes were seen to thrash the plants with the horns, using several vigorous forwards and downwards movements of the head. Every thistle seen consumed received this treatment, which often completely severed the leaves from the stem. On examination of the thistles after the goats grazing, the plants were found to have been completely eaten down to the ground, with no stem or leaf remaining. The leaves of plants such as Urtica and those of similar shapes and sizes were delicately picked off, one by one. This has also been observed in Merino sheep (Arnold, 1961).

Although the goats spent at least some of each day grazing by a stream during May, only once was one observed drinking at it, and then for a short period only. Apart from a billy seen to drink in July, no other observations of drinking were made. It is assumed therefore that most of the water requirements were provided by the vegetation.

ANALYSIS OF DIET

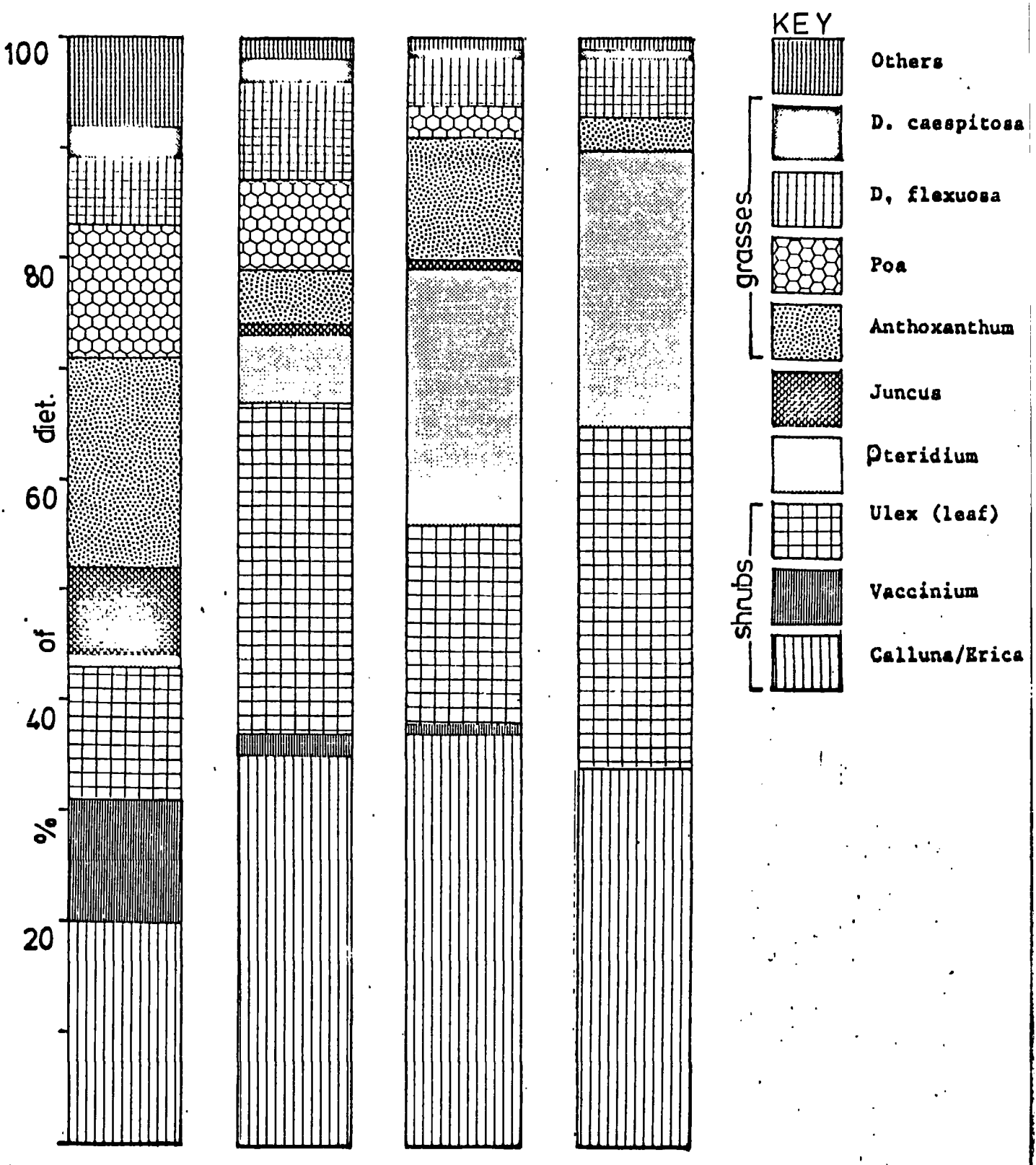
Characters useful in the identification of plant epidermal fragments included overall cell shape, shape and arrangement of stomatal guard cells, and, in some plants, trichomes. Although Martin (1955) states that epidermal characteristics of the Graminae differ widely

between species, there was a considerable degree of overlap in the characteristics of the grasses in the present study. Identification of some graminiferous cells was aided by examination of the silica bodies, which were deeply staining in both the reference and faecal samples. Monocotyledons were easy to distinguish from dicotyledons and Pteridophytes by their rectangular and usually elongated epidermal cells. The degree of corrigation of the cell wall were also an aid to identification. Some epidermal fragments were too small to identify, and many were observed by adhering mesophyll tissues. These were omitted from coondieration, only those fragements where identification was positive being included. In most cases, it was possible to identify plants down to the species level. Calluna and Erica epidermal cells, however, proved indistinguishable from each other, and simply recorded as Ericaea.

As the study area supported both sheep and goats, evidence for overlap of diets was sought. X^2 tests were applied to the raw faecal analysis data, and the differences between that of the goats and sheep were found to be highly significant, with $P < 0.001$ for each study period.

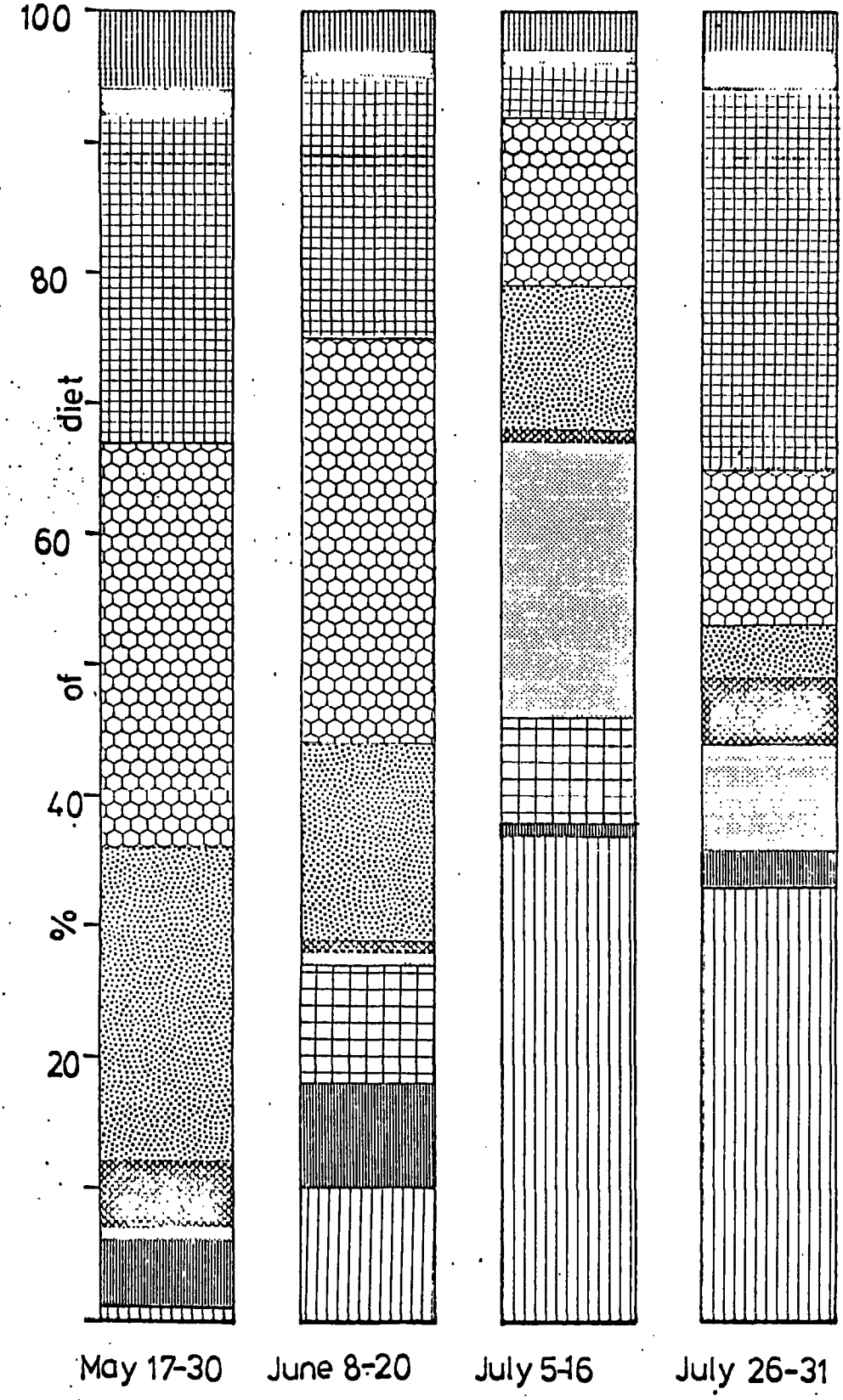
As expected from casual observations, the goats took a lower total percentage of grasses than did the sheep during the summer months. Since such grasses as Anthoxanthum and Poa flower early in the summer, and are consequently more available than other species to herbivores, it is reflected in the analysis of faecal pellets where the amounts eaten by both the sheep and goats of these two grasses diminish through the summer. The amounts of Anthoxanthum taken by the sheep and goats is

FIG. 6. DIET OF GOATS



%=% of epidermal fragments.

FIG. 7 DIET OF BLACKFACE SHEEP.



(Key as before)

similar by the end of July. Even after Poa (together with Anthoxanthum) had died down, the sheep were still finding a substantial amount of it (Figs. 6 and 7).

Although the spring of 1977 was very late, and growth of heather did not commence until well in June, Calluna was nevertheless an important food plant to the goats during May, and when the new growth appeared, it apparently constituted as much as a third of the diet. When grazing on Calluna, both the goats and sheep seemed to be taking the tips of the young heather shoots only. Until June Calluna formed only a small part of the sheep's diet. During July both sheep and goats were taking equal amounts of the plant.

If the effects of random variation due to the small sample sizes are allowed form it appears that Deschampsia flexuosa was grazed more by the sheep than the goats, the amounts taken remaining more or less constant from May to July. This was the dominant grass over much of the study area. D. caespitosa is a very coarse grass, so as expected did not form a large part of the diet of either the sheep or goats. It was noted, however that in adjacent fields heavily stocked with sheep and had apparently been so for some time, that D. caespitosa tussocks were eaten down very short. Although seemingly unpalatable, it would appear therefore that sheep at least, will utilize D. caespitosa when other grazing is scarce.

Although abundant, especially before the growth of bracken, Holcus lanatus appeared in very small amounts in the faecal pellets of goats and sheep. The possibility that, due to its soft and delicate

epidermis, fragments did not survive passage through the gut and the plant is therefore under-represented and cannot be ruled out (see page 77). Sheep certainly, were observed grazing upon Holcus amongst growing bracken, yet the faecal analysis showed a very low frequency of the grass (Tables 1 and 2 Appendix). Before the growth of bracken, goats were also observed grazing in areas where there was a high frequency of Holcus.

The decline of Juncus in the diet during the summer might reflect its increasing coarseness and unpalatability. In July the goats sometimes spent long periods feeding in Juncus stands. It seems, however, that they were taking plants growing in the wet flushes other than Juncus although it was never easy to observe which plants were being taken.

Although Ulex might be expected to be a somewhat unpalatable plant it formed a considerable part of the diet of the goats. The goats spent more time in May than any other study period browsing on the gorse, but the amounts appearing in the faecal pellets did not decrease. The explanation may lie in the flowers being eaten in late May when the gorse was flowering heavily. At this time, the goats were observed to be carefully pulling the flowers from the stems, rather than eating the young shoots which were still very small. It could be seen that the contents of the mouth were bright yellow. Since difficulty was experienced in making reference slides of Ulex flowers, whereas the leaves and spines made very good reference slides, it is suggested that Ulex flowers are too delicate to survive as recognisable fragments, resulting in the under-estimation of Ulex in the

May diet of the goats. By the time the gorse had finished flowering in late June, the young shoots were well grown, and the goats appeared to be concentrating on these. If the small samples sizes and the inevitable discrepancies are allowed for, this is in agreement with the results from the faecal analysis, which shows an increase in Ulex consumption after June. Although sheep on the lowly stocked Yeavering Bell were only rarely seen to browse on gorse, the plant appeared to form about ten percent of the diet during June and early July. However, in this instance, the plant may be over-represented.

As the bracken became more available, the goats took increasing quantity, and by the end of July it constituted as much as a quarter of the diet. Apart from the period July 5-18, when the bracken fronds were fully opened but still fairly soft, and presumably more palatable, the sheep took considerably less than the goats, through on average they appeared to spend more time than the latter feeding in Pteridium dominated areas. The goats were observed to select and eat ferns (Dryopteris sp) when feeding in the wood. However, even after examination of many reference slides of both Dryopteris and Pteridium the difference between the epidermal cells were not great enough to exclude confusion. It is possible, therefore, that the amount of Pteridium could be over-estimated.

Although both sheep and goats were frequently observed feeding upon Vaccinium it is suspected that the intake of this plant as shown in Figs. 7 and 8 is under-represented. The goats did appear to consume less as other plants became available as the summer progressed.

Other plant material observed in the field to be fed upon by the goats, but which did not show up in the faecal analysis u included Quercus sp, Urtica and Carduus sp. However, the total bulk

of each of these plants ingested appeared from observational data to be low.

Although present in some parts of the study area in large patches, Luzula sylvatica did not appear in any of the faecal samples of either sheep or goats. No animal was observed eating this plant, and an examination of the stands shows no evidence of grazing in the plants. This is apparently the only common plant in the study not utilised by either species. The much smaller and considerably less abundant L. campestris did appear in very small amounts in the faecal pellets during May.

An overall impression of this comparative faecal analysis was that a greater number of recognisable epidermal fragments survived passage through the gut to appear in the faecal pellets of the goat than the sheep.

Nematode Infections

The sheep are supposedly wormed several times a year in the College Valley (G. Elliot, P. Fergie, T. Welsh, pers. comm.) so it was surprising to find the sheep of Yeavering Bell had a higher worm egg count than did the goats, who receive no worming at all. Accurate identification of the parasites would have necessitated the culturing of larvae from the eggs, but storage in 70% alcohol had rendered them non-viable. No larval stages were recorded from the slides presumably having been destroyed if present, by boiling in 10% NaOH.

Although nematodes are notoriously difficult to identify with any certainty from the ova (R. Thomas, pers. comm.) it was possible that the bipolar, eliptical eggs found in both the sheep

and goats belonged to the genus Trichuris, a parasite of the caecum (Soulsby, 1965). The frequent, similarly sized but thinner walled ova, which were not bipolar, could have possibly been a Strongyloides sp., common in the small intestine of sheep, goats and other ruminants (Soulsby, 1968). Nematodirus, having ova similar in shape and appearance to Trichuris, but very much larger, was not found in any samples. It is reported to have been virtually eliminated from the College Valley sheep (G. Elliot, P. Fergie, pers. comm.).

Coughing in sheep and goats is commonly a symptom of infection by Dictyocaulus filaria ('Husk') (Soulsby, 1968). The adult goats were frequently observed coughing, especially P and F. However, infection with this parasite is only one cause. The sample sizes were too small to determine whether the levels of infection (as indicated by egg counts) changed through the course of the study.

Criteria of age

(i) M_1

Examination of gross sections of the first molars of animals nos. 1-9, 11, 13 and 14 yielded no firm evidence concerning the validity of cementum growth increments as a criterion of age in the British feral goat.

Mitchell (1963) and subsequent workers investigating dental cement layers in temperate zone ungulates found that the best results were obtained from examination of the pad of cementum between the roots of M_1. Not only is the cementum here considerably thicker, but the less distinct layers from younger animals with thinner cement deposits are more clearly seen than elsewhere. The roots of most ungulates molars

investigated by other workers were markedly bifurcated, the cementum pad occurring between the roots. In none of the molar sections examined did the cementum appear as a pad, and, with the possible exception of goat no. 5, aged approximately 6, the roots seemed to remain together for most of their length and with little or no bifurcation. The teeth were fresh, and firmly held in the jaw, so removal for examination for possible lines of cut between the roots was impossible.

The majority of goats in the sample from the College Valley cull were very young most being about 18 months of age. If the roots of the young caprine molar are, as described, un-bifurcated, then the growth of the sample may explain the absence of a visible cementum pad between them. This is supported by the fact that the apparent oldest animal in the sample, no 7, a female aged about 7 years, did, in fact appear to have separate roots to the M_1. In both the oldest, and next oldest goat (no. 5) in the sample, the roots ended abruptly, and were shorter than those of the younger animals. However, a much larger sample size would be needed to confirm this or show otherwise.

Very faint and discontinuous lines were found on some molars from the cementum around the root. However, they were not convincing and always less than the number expected on the bases of one translucent band being laid down per year (see page 22) and so were disregarded.

Tooth wear was only found in the molars of goats no 5 and 7, and then was only of a slight degree. The rest of the jaws were presumably too young to have shown any visible signs of wear.

(ii) I_1

Dark narrow bands were found in the cementum of the first permanent incisor of those goats where I_2 had, at least, also erupted. These bands representing winter growth and staining a dark blue, were thin and widely spread (Plate 6). In most places the dark bands were faint and discontinuous. The total number present was recorded as the maximum count from examination of up to 15 sections per tooth. The dentine-cementum interface, also a narrow blue-staining band, appeared as a much more clearly defined and continuous line than the incremental lines.

Goats having only one erupted permanent incisor showed no visible growth increments, though four of the five temporary incisors examined showed one incremental line. In these cases, however (2,3, 12 and 14) the dark bands were less distinct than those of the permanent incisors (Table 1).

One discrepancy was in goat 5, where, although the second permanent incisor was erupted, no incremental lines were found. It is possible that they may have been present but faint to show up in the staining techniques, or too much of the cementum destroyed on extraction of the tooth from the jaw.

In only one case was layering of the dentine observed in this instance the lines being very distinct. No other evidence of even indistinct growth increments was found from examination of the dentine.

(iii) Correlation between dental cement layers and horn rings

The major horn rings are taken as annual and therefore indicate the true age of the goat. A correlation was found between these and the number of dental cement layers.

TABLE 1

Horn Rings and Dental Cement Layers

Goat No.	No. Increments	No. Horn Rings	Sex	Estimated Age (in months)
	I_1			
1	2	3		46
2	1^D	1		22
3	1^D	1		22
4	0	1		22
5	5	6		22
6	0	1		22
7	6	7		94
8	0	1		22
9	0	1		22
10	0	1		22
11	0	1		22
12	1^D	1		22
13	0	0		10
14	1^D	1		22
15	1	2		34
16	0	1		22
17	4*	?5**		70
20	0	1		22
21	7	8		106

1^D = Increment in Deciduous I_1

* Incremental lines in dentine

** Horn badly worn

If animal no. 8 is disregarded, the total number of incremental lines was, in the few animals old enough to show them, consistently one less than the number of annual horn rings. The first permanent incisor does not erupt in the goat until well into the second year. Thus animals with one horn ring and I_1 permanent, would not, by early December, be expected to show any incremental line in the cementum, as the I_1 would not by then (date of death) have been present through a winter. This, in fact, was found. It is suggested, therefore, that the absolute age of British feral goats as assessed from dental cement layers of the first permanent incisor is the total number of layers, plus one.

As the deciduous I_1 is retained throughout the animals first winter, when the first horn ring is also formed, it would be expected that this tooth would form a growth line. This was found to be so, though the deciduous growth lines were indistinct.

Sequence of Tooth Replacement

From the College Valley cull sample, it would appear that when full mouthed, the dental formula would be

$$I\ {}^{0}/_{4}\ \ PM\ {}^{3}/_{3}\ \ M\ {}^{3}/_{3} = 32$$

Since the jaws examined all came from a single cull, when the youngest goats would have been about 10 months old, it was not possible to investigate the sequence of eruption of deciduous teeth. For this, a much younger sample would have to be examined, with representative jaws of all ages from birth to attainment of a full mouth.

As most of the sample of heads were from animals who had not yet gained a full mouth of permanent teeth, it was possible to see the sequence of replacement of the deciduous teeth by the permanent (Table 2). This, from a limited sample, would appear to be

M_1 M_2 I_1 (PM_{1-3}) I_2 I_3 I_4 M_3

or PM_1 (PM_{2-3})

Although the deciduous PM_3 is tricuspid, the permanent tooth is bicuspid. M_3 is also tricuspid, M_1 and M_2 being bicuspid. PM_1 has only one cusp, both in the deciduous and permanent tooth.

No firm conclusion concerning the ages at the times of eruptions of various permanent teeth could be made owing to (a) the small sample size with a high proportion of yearlings, and (b) the fact that the date of death was the same for each specimen, thus reducing the age range available.

If a February birth date is assumed, and taking the absolute age from the horn ring, and dental cement layer data, a tentative suggestion for ages of eruption of permanent teeth in the College Valley goats, in months, is as follows:

M_1 already present at 10 months of age

M_2 10–22 +

I_1 about 22

PM_{1-3} about 22 or later

I_2 about 22 or later

I_3 by 34

I_4 by 46

M_3 from 34

TABLE 2 — Sequence of Tooth Replacement in Individuals from Cull

Goat No.	Approx. Age (months)	I_1	I_2	I_3	I_4	PM_1	PM_{2-3}	M_1	M_2	M_3
83	10	D	D	D	D	D -all firm		✓	erupting	-
2	22	D	D	D	D	D -all firm		✓	erupting	-
3	22	D (P close to eruption)	D	D	D	D -all firm		✓	-	-
4	22	D	D	D	D	D -all firm		✓	-	-
14	22	D	D	D	D	D -all firm		✓	-	-
20	22	P	D	D	D	D -all firm		✓	✓	-
6	22	P	D	D	D	D-on point of shedding		✓	Just erupted	-
12	22	P	D	D	D	D-on point of shedding		✓	✓	-
11	22	P	P erupting	D	D	D-on point of shedding		✓	✓	-
9	22	P	D	D	D	D-on point of shedding		✓	✓	-
10	22	P	P* erupting	D	D	P- Just erupted		✓	✓	-
8	22	P	P	D	D	P- Just erupted		✓	✓	-
16	22	P	P* erupting	D	D	P- erupting P - functional		✓ ✓	✓ ✓	-
15	34	P	P	P	D	P	P	✓	✓	erupting
1	46	P	P	P	P	P	P	✓	✓	Just erupted
17	70	P	P	P	P	P	P	✓	✓	✓
5	82	P	P	P	P	P	P	✓	✓	✓
7	94	P	P	P	P	P	P	✓	✓	✓
21	106	P	P	P	P	P	P	✓	✓	✓

D = Deciduous dentition
P = Permanent dentition

* Deciduous I_2 still present

TABLE 3

Lens Weight and Protein Content

Goat No.	Lens a Lens Weights (Gms)	Lens b	Mean	Protein Content (gm)	Estimated Age (months)	State of Deciduous PM_{1-3}
2	0.2220	0.1370	0.1795	51,000	22	Firm
13	0.2028	0.1839	0.1933	48,000	10	Firm
3	0.2308	0.2241	0.2274	54,000	22	Firm
4	0.2155	0.2542	0.2333	68,000	22	Firm
6	0.3121	0.2897	0.3009	96,000	22	Loose
11	0.3033	0.3171	0.3102	81,000	22	Loose
9	0.3150	0.3189	0.3169	78,000	22	Loose
8	0.3259	0.3251	0.3255	69,000	22	Perm anent PM_{1-3}
1	0.3864	0.3838	0.3851	99,500	46	"
5	0.4749	0.4891	0.4820	110,000	82	"
7	0.5173	0.5013	0.5093	107,000	94	"

14* (0.1729 -)

* Both lenses damged on removal from eye and disregarded

Lens weight and Protein Content

The results of the lens protein assay and lens dry weights are summarised in Table 3.

Estimation of age based upon lens weight is known to be most reliable in the younger mammals investigated, the rate of lens growth slowing down with increasing age (Friend, 1967). That this is so for the goat is indicated by the fact, that within the major age class of the sample (approximately 22 months) the lightest and heaviest lenses differ by about 0.12 gm. The difference within this age group are considerably greater than between the other three, older age class. However, it is possible that results from a larger sample size with more than one animal per age class may not necessarily show this.

As expected, the protein content of the lens was (Table 3) more or less related to lens weight. However, quite large discrepancies occurred which may be explained as loss of dry lens material during grinding, prior to dissolving in NaOH.

DISCUSSION

Feral populations of goats exist in many parts of the world. There are, perhaps, more legends and beliefs attached to the goat than any other mammal. Local residents of the College Valley (and elsewhere) strongly believe that feral goats will deliberately destroy adders by trampling them with the front hoofs. In the past goats were run with cattle along the borders in the belief that they prevented outbreaks of brucellosis (T. and A. Elliot, pers. comm.). The goats supposedly did this by eating ergots in the rye that were reputed to cause brucellosis in the cattle. Their presence was also supposed to prevent outbreaks of enzootic ataxia in horses. In Merioneth, the mere smell of a billy goat was thought to keep infection away (Lever, 1977).

Some feral goats owe their origin to the belief that being more agile than sheep, they will graze the rock faces and cliffs, and thus keep the sheep from the dangerous areas (Whitehead, 1972). Feral goats are generally regarded as good 'weather prophets' reputedly leaving the high ground prior to a snowstorm, enabling the sheep to follow in their paths through the snow (T. Elliot, pers. comm.) However, they will sometimes allow themselves to be covered and suffocated by snow whilst sheltering from it, as happened in the winter of 1976-77 when about 8 of the Hindhope herd were buried and killed when sheltering in a ruin in a small plantation (A. Elliot, pers. comm.)

In many parts of the world where indigenous mammalian herbivores are absent, the feral goat, once introduced and out of control, has done irreparable damage to native floras which have evolved without the competition and grazing pressures from herbivores. A prime example of this is Hawii, where a lot of the native flora has been destroyed largely by grazing pressures from large introduced herbivores such as the goat. Here, one of the most important of native trees, the Koa (Acacia Koa) has been seriously depleted from the Hawiian Islands through goat damage of the defoliation, girdling, stem breaking and killing of saplings type (Spatz and Mueller-Dombois, 1973).

Like many ungulates the feral goat exhibits a well defined home range, which as is typical in gregarious ruminants is used by the herd jointly, rather than each individual having a definite home range. Joint home ranges are described for the feral goat in New Zealand (Riney and Caughley, 1959), British Columbia (Geist, 1960), Japan (Asahi, 1960) and in Britain by Whitehead (1972). Home range

behaviour has been described in the Welsh herds (Milner et al 1968, Crook, 1969) in the Scottish feral goats by Greig (1970) and in the nearby Kielder herds by McDougall (1975). A number of authors have reported that female herds of goats remain faithful to a restricted home range. This attachment to a particular area can last some years.

Features such as stone walls and fences seemed to form natural boundaries to the home ranges. Although at points during the summer of 1977, the College Burn was only a few inches deep, neither of the two Whitehall billies were ever seen on the west bank although they frequently browsed on the gorse bushes growing close to the water on the eastern bank. The dry stone walls and wire fences enclosing the Yeavering Bell area appeared to form natural boundaries to the home range of the female herd. They grazed on numerous occasions close to fences and walls (Plate 2a), yet on only one occasion was a goat seen to squirm under a fence into a field. It left the field after a few minutes by jumping onto and off a dry stone wall just over 1 M high (Plate 2b). Goats are known for their agility and are perfectly capable of crossing such barriers. McDougall (1975) reports goats clearing a 1M fence, and K. Robertson (pers. comm.) reports an adult nanny squirming (with difficulty) under a plantation gate, the bottom bar of which cleared the ground by only about 25 cm. From discussions with local shepherds it appeared that goats were in the habit of crossing walls and fences in the winter to graze in low lying fields. Observations carried out in the summer in dicated that this habit was restricted to the winter months only, when the goats might be expected to feed at lower altitudes. The feral Soay sheep of Hirta, St. Kilda are also reported to be slightly restricted in movement by barriers such as streams (presumably wide ones) dykes and walls (Grubb and Jewell, 1966).

The home range of feral goats can be surprisingly small, with areas as small as 500 x 50 square yards reported by Geist (1960). The most widely spaced observations of the Yeavering Bell herd were about 1.5 Km apart, and the Whitehall billies about 2 Km apart, though the bulk of observations came from areas smaller than this. During the rut, males may wander 120 KM or so.

The reported size of home ranges (hefts) of hill sheep in similar habitat types are considerably smaller than those of the goats. The home range of Cheviot and Blackface sheep is given as not normally more than about 48 ha (Griffiths, 1970. The few casual observations of one or two black-marked and therefore recognisable sheep in the area seemed to support this. The boundaries of the goats home ranges were not influenced by the home ranges of the sheep, several of which lay within the area traversed daily by the goats. No antagonism indicating territorial conflicts between sheep and goats were observed, either in this study, or in Riney and Caughley's study of home range in New Zealand feral herds (1959). Crook (1969) reports instances of inter-specific aggression, the goats butting sheep out of their path, though usually the two species fed peacefully side by side. He does not, however, indicate whether be believed this to be a form of territorial behaviour or not. The overlapping of home ranges of adjacent herds of feral goats in Snowdonia (Crook, 1969) indicate that goats are not territorial amongst themselves. While sheep and goats are observed to have overlapping home ranges, it is of interest to note that in a mixed stocking, Blackface and Cheviot sheep will occupy different home ranges in a common pasture (Hunter, 1964).

Daily movements of the goats included a descent from the high ground in the morning and an uphill movement at dusk, indicating that the favoured over night areas are on the higher ground. Patterns of daily movement have been noted in the domestic sheep (Scott, 1945) were a fairly well set pattern of movement around fields through the day was noted. Sheep were, in the present study, noted to move uphill at dusk, and to descend the following morning to feed, as did the goats. Feral Soay sheep can perhaps be better compared with feral goats than can domestic sheep. The former show too, set patterns of daily movement (Grubb and Jewell, 1966) like the goats and domestic sheep, they move to higher ground at night (Morton-Boyd et al, 1964). The movements of Soay sheep towards the evening grazing grounds were fairly rapid, again reminiscent of the goats.

Allelomimetic behaviour seemed to be very common in the goats. This was particularly true of grazing where the rising and commencement of feeding by one or two animals would invariably result in the whole herd getting up to feed. Play in adults appeared at times to be an allelomimetic form of behaviour as well, the sight of a couple of nannies sparring seemed to initiate similar behaviour amongst other adults.

The observed patterns of activities are in basic agreement with the limited existing data (Crook, 1969, McDougall, 1975). The latter author, however, did not observe the Kielderhead Moor goats to ruminate before 11 a.m. whereas the College Valley goats had a small early morning rumination peak, followed by a main peak towards noon. The studies of Bullock, North & Williams (1976) on the Galloway feral goats which were slightly later in the year showed a slightly earlier time of dawn

grazing peak, and the main afternoon feeding period commencing slightly later. In an entirely different habitat type, the domestic Angora goats studied by Askins and Turner (1972) on a West Texas range also showed peaks of grazing activity. The main difference in this study was that the high day time temperatures caused the goats to rest in the shade until about three hours before subset, when the second major feeding period began - the first being from dawn to mid morning.

It has been shown by Squires (1975) that similar patterns of activity occur in domestic sheep, but with the grazing activities ceasing well after sunset. The Yeavering Bell goats were almost invariably grazing intently when left at dusk each day, though the one all night observation, made in fine weather, possibly indicate that grazing in the feral goat ceases just after sunset.

Slow sheep (S.S.) has been demonstrated experimentally to occur in ruminants. Since they are often sitting down ruminating and apparently aware of their surroundings, SS is difficult to detect in the field. Recent studies indicate that periods of paradoxical sleep (P.S.) total only a very short period in each 24 hours (Ashby 1972 after Ruckbush). Although SS occurs for longer in each 24 hour period, its difficulty of detection in field conditions made it impossible to estimate the total time spent in sleep in the goats.

Goats are naturally gregarious animals, and with the exception of some old billies, and young billies wandering in the rut to find an unchallenged female herd, are usually found in herds or small groups.

TABLE 4 Ages at Eruption of Permanent Teeth (Ages in months)

Source	This study (feral goat)	Greig Feral goat (Scotland)	Nettleton (1934) Domestic Goat (Britain)	Anon Domestic Goat (Britain)	Santiago (1941) Domestic Goat (Portugal)	Basu (1959) Domestic Goat (India)	Morton-Boyd et al 1964 Feral Soay Sheep (St. Kilda)	Hemming 1969 Dall Sheep (Alaska)
M_1	by 10	3-5			5-8			1-4
M_2	10-22+	15-18			8-12			8-13
I_1	≈ 22	18-22	12-14	12	18+	12-18	12-15*	13-16
PM_{1-3}	22+	23-26			18-30			27-30
I_2	22+	25-34	≈ 24	28	20-30	15-27	18-24*	25-28
I_3	by 34	34-41	≈ 36	42	32-42	24-30	22-30*	33-36
I_4	by 46	41-46			36-48	39	36-48*	45-48
M_3	34+	29-50			18-24			22-40
full month			≈ 48	52-60				

* may be a good deal later

In Northumberland, these wandering billies are described as 'banished' from the herd by local shepherds. The formation of one-sex herds for at least part of the year is by no means confined to the goat. It is well marked, for example, in the red deer hind herds, where the matrilinearly based sub units may include daughter hinds in their third year (Darling 1937a). An old hind in the group, with almost invariably a calf at foot, characteristically leads the herd to cover and feeding areas, and away from danger (Darling, 1937a, de Nahlik, 1974). In domestic sheep the flock is often lead by an old ewe (Scott, 1945). Some authors describe leadership existing within feral goat herds. Darling (1937b) described it as patriarchal, whilst Tegner (1965) described it as matriarchal in the feral goats of the Cheviots, the 'leader' being a dominant nanny. Whitehead (1973) states that the 'leader', also female, is not necessarily dominant and Greig (1969) found no evidence of either a patriarcheally or matriarcheally governed herd. Yocum (1967) only reports one clear case of (matriarchal) leadership. However, Scott and Stewart (1946) found no correlation between leadership and dominance in a herd of domestic goats under experimental conditions. This certainly seemed to be the case in the feral goats of the present study, where in fact no clear cases of leadership were observed. Tegner (1961) described the dominant female as the 'guardian' of the herd. Although the dominant nanny of the Yeavering Bell herd showed no tendency towards leadership, she was the most alert and wary member of the herd. She seldom initiated flight, but would keep the observer in sight (when observed) whilst the rest of the herd grazed (Plate 3a). She was inevitably the first member of the herd to appear aware of distant hill walkers and shepherds. It is possible that this is directly related to age, greater experience rather than the dominant position in the herd being the important factor.

She was also seen to ruminate in a standing position to a greater extent than the others. As would be expected from this, the young kids were the least alert, and frequently seemed to be unaware of the danger even when the herd took flight, and merely following the reactions of the adults. While Darling, 1937b) reported that in movement, and presumably flight, a billy led the way followed by the kids and then the nannies, the habit found by Shank (1972) of the feral goats of British Columbia remaining in a closely bunched, orderless group when in flight was typical of the Yeavering Bell herd.

Most descriptions of social hierarchies in seasonally breeding ruminants are of male behaviour during the rut when dominance systems are greatly intensified as the sexually aroused males compete for estrous females. Male dominance hierarchies have been described by Darling (1937a) in red deer, Geist (1964) in Rocky Mountain goats (Oreamnos americanus), in rutting feral billy goats by Crook (1969) and Shank (1972) and by Schaller and Laurie (1974) in C.L. aegagrus living in Pakistan. Lever (1977) refers to female feral goats also having a 'pecking order' though McDougall (1975) did not observe any of the Kielderhead Moor nannies clashing horns and rearing in an expression of dominance and subordination. In contrast to these findings, Asahi (1960) found no evidence of hierarchy in the free ranging domestic goats of Tomogasima Island, Japan. A possible explanation of this discrepancy lies in the low latitude of the study area. This results in year round breeding, with no closely defined rut, during which any male social hierarchy would be most obvious.

No reports were found describing the actual mechanism of dominance expression in female feral goats, but the observations of Reed (Schaller, 1968) in fighting male caprines does contradict the findings in the female goats of the present study. He describes that, during a fight, it was

usually the subordinant, and not the dominant male that reared up. This was definitely not the case in the Yeavering Bell females. It is not clear, however, to which species of Capra he is referring. Crooks' (1969) detailed account of social behaviour in the feral goats of the Glynder Mountains, Caernarvonshire, does not mention any signs of expression of dominance amongst the females. Dominance amongst rutting males is described as being expressed by the socially superior billies standing on higher ground than his subordinates, who stand in a group below. This behaviour, which is possibly limited to the males was not noted in the College Valley females. No information on rutting behaviour from the College Valley goats was available.

Since age is possibly correlated with body size, Crooks (1969) and Whitehead (1972) suggestion that the social position within the herd is correlated with age was bourne out by the observations that the dominant goats in the Yeavering Bell herd were the bigger, and therefore older animals. Crooks observation that hornless males often occupy a position of social dominance during the rut suggest that possession and size of horns is of minor importance in the goat in determination of social rank, though the hummels concerned were consistently larger than their horned rivals. Certainly, hummel red deer stags are frequently seen to be successful 'master' stags during the rut, and appear to be at no social disadvantage to their antlered counterparts. That the role of horn size in determining social superiority is of little importance was supported by the fact that the horns of G were longer than those of L, even though they had equal social status. They were close in body size. With the exception of these two nannies, horn and body size in the rest of the herd were positively correlated with age, so no separation of these factors was possible. However, Collias (1956) reports that in young domestic

Goats, horned animals of both sexes regularly dominated polled ones. Observations of play and head butting in the young kids did not result in any conclusions as to the development of social dominance within the four. At least three of the kids were female. The fourth, whose sex was not determined, was not observed to show any of the precocious male sexual behaviour characteristic of young billy kids (Collias, 1956) such as pelvic thrusts accompanying mounting of other kids, penile erections, front kicks and the vocalisations of sexually aroused males. All kids were seen mounting others, but without the above mentioned accompanying behaviour. It was probable that the fourth kid was also female.

In the temperate zone, the rut and therefore the kidding, is determined by photoperiodic changes. The kids are born from late January to the end of March, following a gestation of 150-151 days (Greig, 1969, Whitehead, 1972, Lever, 1977). Although the main kidding time of the nearby Kielder head Moor feral goats seems to be the second half of March (McDougall, 1975) residents in the College Valley, some 38 km distant, report having seen new born kids in early January. Where the photoperiod is relatively more even through the year, feral goats do not show the well defined breeding season of the temperate zone. Some New Zealand feral nannies kid twice yearly (Williams and Rudge, 1969) while those of Hawii will breed to a limited extent throughout the year (Yocum, 1967).

The early kidding season in Britain which occurs at a time when environmental conditions are harsh, is responsible for the high mortality of kids in feral goat herds along the borders. Sheep grazing the same areas are artificially restrained from breeding until

later. The lambing season occurs in the Cheviots from late April to mid May, when conditions are more favourable. The gestation period is similar to that of the goat.

The maternal relationships in the goats tended to be of a looser nature than those of the Blackface sheep for lambs of a similar age. Even so, the maternal bond between female goats and their kids is long lasting and can, in fact, be stronger between mother and daughter than between daughter and kid, as described by Rudge (1970). The degree of maternal association between the yearling F and her kid seemed to be of the same intensity as that between her and nanny L, thought to have been her mother. Matrilineal relationships of this nature form the basis of the 'hefting' system of hill sheep raising areas. Matrilineal relationships also exist amongst the feral Soay sheep of Hirta, St. Kilda.

Collias (1956) states that domestic kids will suckle up to about 6 months of age, and the College Valley feral kids were still suckling, infrequently, at the end of July, when the study ended. McDougall, however, did not observe kids to suckle in the daytime from early June when they were aged about 11 weeks.

Yocum (1967) has described the feral goats of Hawii as having extremely acute senses, and being harder to approach than deer. However, the College Valley goats were found to be fairly easy to approach once the animals had become accustomed to the observer. This was probably due to the fact that Yeavering Bell, being easily accessible by road, is an area fairly heavily used for recreational purposes, so the goats would be more used to disturbance by tourists and shepherds than populations in more remote parts of Britain.

The Blackface sheep, whose home ranges were superimposed on that of the goat herd, are a less gregarious breed then most British sheep. Individuals are usually found in very small groups, with a home range centred around a patch of good grazing (Hunter, 1960). The goats grazed a considerably larger area than the sheep and were observed feeding in a wider diversity of vegetational types.

Yocum's (1967) interpretation of horn-thrashing of vegetation suggests play as the motive, while Shank (1972) describes this behaviour in both sexes as 'comfort' behaviour, or in males as having agonistic implications. In the latter case, several males would horn-thrash simultaneously. In the present study only single animals were seen doing it. Since this behaviour was observed during periods of peaceful feeding, and seemed directly concerned with the ingestion of thorny broken plant material, it would seem that, in the present case, this behavioural trait was associated purely with feeding, rather than play, or agonistic behaviour. The thrashing of wire-fence strands by billy H (but not B) does, as stated by Shank (1972) suggest 'comfort' behaviour, especially as in these instances he would rub the area between the horns along the wire, behaviour never seen when thrashing horny plants. The wire-thrashing bouts occurred during periods of peaceful grazing, therefore suggesting no displacement of aggressive behaviour.

The conclusion from the faecal analysis of the goats and sheep is that the goats utilised browse to a greater extent than do sheep. Likewise, in an arid zone of New South Wales, Australia, feral goats were also found to take a greater proportion of their diet as browse than do

the Red Kangaroo (Megaleia rufa), Hill Kangaroo (Macropus robustus erubescens) and Merino sheep that utilise the same range (Dawson et al, 1975). However, this is probably determined by habitat type as Malachek and Leinweber (1972) found that domestic Angora goats utilised a greater proportion of grasses and herbs on a lightly grazed range in Texas (than they did on a heavily grazed range). The stocking density was about 40 acres per animal - slightly lower perhaps than that of Yeavering Bell, and with a very different vegetational type.

With two similar species feeding in the same area, some competition between the two would be expected. On Yeavering Bell at least, the goats and sheep in fact showed a considerable difference in their dietry components, although there was some degree of overlap. Vaccinium because of its early growth is reputed by shepherds to be preferentially grazed by sheep in spring (G. Elliot, pers. comm.) before the growth of other plants has resumed. It is possible that some competition for this plant between sheep and goats may occur at that time of year. Certainly, both sheep and goats were utilising it, though the plant is possibly under estimated in the diet of both.

Although described as being of lower palatability than Poa pratensis (Hubbard, 1954) Anthoxanthum odoratum generally formed a larger proportion of the diet of both sheep and goats. However, since the graminae are often difficult to identify from epidermal fragments, and errors of identification cannot be entirely ruled out as the explanation. Little competition occurs for Ulex. Its appearance in June and early July in the sheep faecal pellets probably reflects the higher palatability of the new shoots at that time. That goats are capable of dealing with plants of thornier nature than sheep is indicated

by the fact that , in late July, when the spines of the young Ulex shoots had hardened, this plant formed 31% of the goats diet, yet did not appear in that of the sheep. Neither were sheep observed eating thistles, but the goats frequently were. The high quantity of Pteridium appearing in the faeces of the goats is of interest. Reputed to be toxic to livestock, e.g. Hall (1938) who described bracken poisoning in the goat to be cumulative in action and leading to internal haemorrage and coma. Changes to the blood and bone marrow have also been reported, and the symptoms of poisoning appear a month or two after the ingestion of the plant. The plant apparently constituted an average of 24% in the diet during the month of July, having increased to this level as the plant became available. This correlates with the observed frequency of bracken ingestion. (Plate 4b). As much as 21% of fragments in the sheep faecal pellets from early July were of bracken, but by the time the plant was fully grown by the end of July, (the season being late) the frequency had dropped. This was possibly related to a decrease in palatability of the plant.

McDougall (1975) suggested that the feral goats of Kielderhead Moor consumed more Calluna than sheep during most of the year. In the present study this was so during May and June but in July the percentage taken seemed to be the same for both species. However, the two habitat types differed considerably in vegetational type. Ericacaea seemed to be an important dietry constituent for both the sheep and goats, and some degree of competition for this plant may be assumed.

Unlike roe deer, which will readily take advantage of supplementary food put out for the sheep in winter (hay etc), the goats would appear, from local reports, to seldom interfere with the artificial winter feeding of sheep.

Analysis of diet by faecal analysis has proved the most suitable method for diet determination of the dietry constituents of wild herbivorous animals, since it does not necessitate the slaughter or use of fistulated animals. However, even this method has its drawbacks, since the observed herbage intake by the animals did not fully agree with the results of the analysis of faecal pellets. The goats were frequently observed feeding upon the foliage of Quercus (Plate 5a) and Crataegus sp and eating Carduus and Urtica whereas in none of the samples examined did fragments of any of these plants appear. Difficulty was experienced in making good reference slides of all these plants, the cuticles and epidermal cells readily disintegrating. Some plants, for example Holcus lanatus were found to apparently form a lower percentage of the total diet than was expected from direct observation of the animals grazing. Its frequency in the faecal pellets was extremely low (Tables 1 and 2 appendix). Direct observation suggested that the goats were eating sufficient quantity of it to show up in a faecal analysis, especially in May. The sheep definitaly were. Like the above mentioned plant species, this plant appeared to have a thin and delicate cuticle. It is assumed, therefore, that a lower degree of lignification and in consequence, a higher digestability of certain plants taken by animals resulted in some components of the diet being under represented, or even totally absent from the faeces. This may in part explain the low percentage of Ulex (12%) recorded for the goats in May, at a time when the animals were feeding extensive ly on this plant. If the goats were taking mainly the flowers, as was indicated from observation, then a low degree of lignification and delicate epidermal cells of the flowers could well account for a probable under estimation of Ulex in the diet. Evidence for this lies in the difficulty in preparing a good reference slide

from Ulex flowers. Similarly, the robustness of some epidermal cells, for example, Calluna, Ulex and Pteridium may have resulted in some degree of over estimation of the relative percentages of these plants.

Further distortions of the analysis may have arisen from errors and difficulties experienced in identification of some plants. Although apparently robust from ease of preparation of reference slides, Vaccinium fragments were frequently hard to identify from faecal pellets due to adhering mesophyll cells obscuring the features of the epidermal cells. Fragments that could not be identified with confidence were omitted, which undoubtedly caused an under representation of the amounts of Vaccinium in the diet.

That errors can occur when using this method of diet analysis was shown experimentally by Stewart (1967) who fed diets of known species composition to selected East African ungulates. Subsequent faecal analysis showed that differential digestability of some plants resulted in under or over representation of some of the plants investigated. Neal et al (1973) reported similar errors caused by differences in digestability of different food plants of the meadow vole (Microtus pennsylvanicus). Here the percentage of sedges and dicotyledons was considerably under represented in faecal samples, being approximately half of what it had been in the stomach. In contrast, Todd and Hansen (1973) claimed that frequencies of occurrence of recognisable plant fragments remain relatively similar in passage through the gut of Colorado Bighorn sheep (O. canadensis), and that digestion only removed the soluble material from fragments of all plant species. The evidence from the present study, and those of Stewart (1967), Neal et al (1973) disagree with this and strongly suggest that differential digestability of plant species does cause a distortion to the picture

obtained for quantitative analysis of diet. Another possible source of error lies in the daily movements of the goats and the resulting utilisation of different vegetational types within one day. The time lapse from ingestion to defecation of plant material is roughly 36 hours in Odocoileus hemionus and O. virginianus (Zyznar and Urness 1969) and a similar time may be assumed for the goat. The Sward type from which the faecal pellets would be representative is thus never known. The mixing action of the rumen may particularly compensate for this.

Some of the errors of this method could be reduced, perhaps, by preparing reference slides from faecal material of captive animals artificially fed over a period of days on a diet of the plant under investigation.

It would appear that the number of horn rings in the British feral goats are a fairly reliable guide to the absolute age of the animals. In the present instance the number of annual growth increments in the dental cement corresponded fairly well with the number of horn rings.

Estimation of the age of artiodactyls under field conditions is important in the management and ecological studies of many of them, especially where live animals are to be aged. Ageing by horn rings would seem to be a suitable method for some bovids, particularly males, where the horn rings are often clearer than in females (Caughley, 1965, Geist, 1966), but the age at which the first ring appears must be known. This appears to form in the British feral goat at about the first birthday, and at the latest, early in its second year. (Table 1).

However this is not so in all species. Both the Bighorn sheep (O. canadensis) and Dall sheep (O. dalh) from the first ring before the first birthday, (Geist 1966, Hemming, 1969) and in the Dall sheep can form as early as the first winter. The Himalayan Tahr (H.jemlahicus) is in contrast in that the first ring does not appear until the animal is two years old, (Caughley, 1965). Since the formation of horn animals is caused by a temporary cessation of growth under winter conditions, the formation of subsidiary rings due to stress (such as the rut, pregnancy etc) might be expected to occur under some conditions. In New Zealand, where seasonal climatic differences are nit marked enough to produce clearly defined annual rings, goats will form double major rings. This is tentatively suggested to be more common in males than females (Rudge, 1970).

In the present study, gross sectioning of M_1 for the presence of annual growth increments in the dental cement proved unsuccessful whereas the same procedure has been successful in various cervids including the Red deer (Mitchell, 1963) Almasan and Rieck (1970) Ransome (1966) on white tailed Deer and White (1975) and Henry (1975) on Roe Deer. Partial success was reported by Lockard (1972) who found no more than four layers in M_1 cementation from white tailed Deer, even from old animals. In the current study the sample was small and only consisted of mainly young animals, and the absence of dental cement layers in the M_1 of British feral goats remains unconfirmed. However, their occurrence is suspected since the histological sectioning of I_1 from the same animal did reveal annual growth increments in the cementum. Possibly more sophisticated techniques must be employed in sectioning the M_1.

Sectioning of the I_1 of feral goats would seem a suitable method to employ for the determination of absolute age in feral goat populations when the horns are unobtainable. However, it is suggested that they can only be taken as annual in animals living in temperate zones since the formation of horn rings, positvely correlated with the occurrence of dental cement layers (Hemming, 1969 on Dall sheep, and this study) requires the animals exposure to sharp seasonal climatic changes. (Rudge, 1972). The method, however, has proved to be unsatisfactory for ageing Rupicapra rupicapra (Almasan and Schroeder, 1970) In some equatorial ungulates experiencing two wet and two dry seasons a year, as in the Water buck (Kobus defassa ugandae) two major lines are formed each year (Spinage 1973). Nutritional stress cannot explain the average two clear lines per year formed in the I_1 of the Greater Kudu (Tragelaphus strepsiceros) which only experiences one dry season per year. The presence of cementum lines in the I_1 of impala (Aepyceros melampus) could not be demonstrated by Spinage (1971) The use of dental cementum growth increements as a means of age determination in tropical mammals may be limited, but it has, however, been insufficiently investigated in the tropical situation to be certain (Spinage, 1973).

A possible source of confusion in ageing feral goats from the first incisor lies in the fact that since the deciduous I_1 is not shed until an estimated 22 months of age, one growth line will be present in its cementum, and also one in the permanent I_1 of animals of approximately 2 years of age. Care must be a taken therefore, in using this method to check that the permanent I_1 is sectioned. Counting of the cementum dentine interface as a ring can compensate for the fact that the first winters incremental line is absent from the permanent I_1.

From the literature it appears that the ageing of young goats from the sequence of tooth eruption and replacement tends to be unreliable as considerable variations in the eruption of each permanent tooth seem to occur. The information available is summarised (Table 4) together with data from feral Soay sheep, and Dall sheep living under natural conditions in Alaska.

Although the results of eye lens weight and protein contents were unsatisfactory in the present study (mainly due to the small sample size and errors in preparation of lens material for protein assay), age determination by protein content of eye lenses has proved reliable in a number of cases, but particularly in the younger age classes, as in Dapson and Irland (1972) where the insoluble protein fraction was shown to reliably age deer mice (Peromysius polionatus) to 750 days. In cotton rats (Sigmodon hispidus) lens protein content and weight have been found to be of roughly equal reliability as age indicators up to 130 days of age (Birney et al 1975). Above this age the amount of the insoluble protein fraction was found the most reliable criterion of age.

The use of lens weights has proved satisfactory for the ageing of Columbian blacktail Deer (O. Hemionus Cdumbianus) in the early years of life. After five years of age the method was unreliable (Longhurst, 1964) Henry (1975) found it less satisfactory than the condition of the denti on as an index of age.

The sample size was too small to investigate any lens weight difference between sexes in material from the College Valley feral goat cull. Differences have been found in Black tailed Deer (Longhurst, 1964) and in Peromyscus polionatus (Dapson and Irland, 1972).

The correlation between the increase in lens weight and the state of the deciduous premolars and eruption of the first permanent incisor in the approximately 22 month age class of the College Valley goats is of interest. If it is assumed that goats No's 2,3,4,6,8,9 and 11 are ranked according to age (Table 3) increase in lens weight being directly related to increase in age) it would seem that although some authors give fairly wide age ranges for the eruption of some permanent teeth (Table 4), it may be somewhat more age specific in at least some cases. This takes into account that, although an average birth date is assumed, births have been recorded in the feral goats of the Borders from early January to mid-March, thus giving an age range of some 2½ months within each year class. It would, however, be unwise to accept this as so without examining a far greater sample size.

Most populations of feral goats along the borders are small in size, and local in distribution (Greig, 1969, McDougall, 1975). Most herds today are not managed in anyway, although a few might occasionally be shot for sport, or persistent damage to plantations or walls. The College Valley herd is culled every 4-6 years (G. Elliot, pers. comm.) if the numbers become too large. The presence of feral goats in the College Valley does not seem to clash with farming interests apart from winter damage to coniferous plantations, which at times has been severe (K. Robertson, pers. comm.) and especially prior to a cull. Contrary to popular belief competition between the feral goats and the sheep of the valley is not intense, and given a due amount of careful management, there is no reason why the Borders should not continue to support feral goat herds for a long while to come.

SUMMARY

The history of the feral goats of the Cheviot area is reviewed. Their origin is uncertain, but feral goats have been present in the area for many centuries.

During the summer of 1977 the movements, activity patterns, food and social behaviour of the goats to the N.E. of the College Valley were monitored. Those present were a female herd centred on Yeavering Bell, and two mature males to the West of the Valley.

The female herd was found to have a well defined group home range of approximately 2 km^2. Likewise, the two billies showed a home range of about 1.25 km^2. The main feeding period was from noon onwards, until dusk, with a smaller peak around 8 a.m. Peak ruminating and resting periods were at dawn and again from about 9 - 11 a.m. A social hierarchy was present amongst the female goats, dominance being expressed in mock fighting and aggressive encounters. Maternal relationships were fairly close. The reactions of the goats to other mammals and human disturbance were recorded.

Analysis of diet by examination of plant epidermal fragments in faecal pellets indicated that the overlap between the goats and Blackface sheep in herbage selection was not marked, suggesting minimal competition for food between the two species. In general, the goats utilised browse to a greater extent than the sheep, forming an average of approximately 56% and 26% of the diet respectively. Plants common to the diet of both included Calluna, Vaccinium, Poa, Deschampsia, and Anthoxanthum. The relative degrees of overlap in the various species varied as the summer progressed. The limitations of the method are discussed.

Histological examination of the first permanent incisor for growth increments in the dental cementum proved a reliable means of age determination, the absolute age being the total number of lines, plus one. The correlation between this and the number of annual horn rings was positive. Sectioning of the first molar proved unsatisfactory for ageing, no lines being visible in the cementum. The results of eye lens weights and protein content were inconclusive, partly due to small sample size and experimental difficulties which might be overcome in a future study.

APPENDIX

TABLE 1 Mean Composition of Diet of Goats Expressed As Percentage of Fragments in Faecal Pellets

	May 17-30	June 8-20	July 5-18	July 26-31
Calluna/Erica	20	35	37	34
Vaccinium myrtillus	11	2	1	0
Ulex europaeus	12	30	18	31
Juncus effusus	8	1	1	0
Carex sp.	6	0	1	0
Luzula campestris	2	0	0	0
Anthoxanthum odoratum	19	5	11	3
Poa pratensis	12	8	3	0
Deschampsia flexuosa	6	9	4	5
D. caespitosa	3	2	1	1
Holcus lanatus	0	1	0	0
Nardus stricta	0	0	0	0
Pteridium aquilinum	1	6	22	25
Dryopteris sp.	0	1	2	1

APPENDIX

TABLE 2 — Mean Comparison of Diet of Sheep Expressed As Percentage of Fragments in Faecal Pellets

	May 17-30	June 8-20	July 5-18	July 26-31
Calluna/Erica	1	10	37	33
Vaccinium myrtillus	5	8	1	3
Ulex europaeus	0	9	8	0
Juncus effusus	5	1	1	5
Carex sp.	2	1	1	2
Luzula campestris	1	0	0	0
Anthoxanthum odoratum	24	15	11	5
Poa pratensis	31	31	13	12
Deschampsia flexuosa	25	20	4	29
D. caespitosa	2	2	1	3
Holcus lanatus	1	2	0	0
Nardus stricta	3	0	0	0
Pteridium aquilinum	1	1	21	9
Dryopteris sp.	0	0	2	0

REFERENCES

Almasan, H.A. and Rieck, W. (1970) Investigation of tooth structure for ageing red deer (Cervus elaphus L.) J.Jagdwiss. 16(2) 49-55.

Almasan, H.A. and Schroeder, W. (1970) An attempt at age determination in the wild mountain goat (Rupicapra rupicapra L.) from the structure of the teeth and mandible. J.Jagdwiss 16 (2) 89-90.

Arnold, G.W. (1961) Diet of Sheep. Nature Lond. 192 113-114.

Asahi, M. (1960) On the free ranging herds of Tokara goats on Tomagasina Island. Physiology and Ecology 9 44-53.

Askins, C.D. and Turner, E.E. (1972) A behavioural study of Angora goats on West Texas Range. J. Range Mgmt. 25 82-87.

Basu, P.T. (1959) A preliminary note on the determination of age of Black Bengal Goats. Indian J. Vet. Res. 379-381.

Birney, E.C., Jenness, R. and Baird, D.D. (1975) Eye lens proteins as criteria of age in cotton rats. J.Wildl. Mgmt. 39 718-729.

Boyd, J. Morton, Doney, J.M., Gunn, R.G. and Jewell, P.A. (1964) The Soay sheep of the Island of Hirta, St. Kilda. A study of a feral population. Proc. Zool. Lond.Soc. 142 129-163.

Boyd-Watt, H. (1937) On the Wild Goat in Scotland. J. Anim. Ecol. 6 15-20.

Bullock, D.J., North, S., Williams D. (1976) The feral goats of Cairnsmore of Fleet (Unpublished report for the Nature Conservancy Council).

Caughley, G. (1965) Horn rings and tooth eruption as criteria of age in the Himalayan Tahr, Hemitragus jemlahicus N.Z.J.Sci. 8 333-351.

Clapham, A.R., Tutin T.G. and Warburg, E.F. (1968) Excursion flora of the British Isles. University Press: Cambridge.

Collias, N.E. (1956) The analysis of socialisation in Sheep and Goats Ecology 37, 228-239.

Crook, I.G. (1969) Ecology and behaviour of feral goats in North Wales. M.Sc. Thesis, University of Wales, Bangor.

Dapson, R.W. and Irland, J.M. (1972) An accurate method of determining age in small mammals. J. Mammal. 53(1) 100-106.

Darling, F. Fraser (1937a) A herd of Red deer. Oxford: University Press.

Darling, F. Fraser (1937b) Habits of wild goats. Supplement to "On the wild goats in Scotland" J. Anim. Ecol. 6, 21-22.

Dawson, T.L., Denny, M.J.S., Russell, E.M. and Ellis, B. (1975) Water usage and diet preference of free ranging kangaroos, Sheep and feral goats in the Australian amid zone during summer. J. Zool. (Lond). 177(1) 1-23.

Douglas, M.J.W. (1970) Dental cement layers as criteria of age for deer in New Zeland with emphasis on Red deer, Cervus elaphus. N.Z. J. Sci. 13, 352-358.

Erickson, J.A. and Seliger, W.G. (1969) Efficient sectioning of incisors for estimating age in Mule deer J. Wildl. Mgmt. 33 384-388.

Friend, M. (1967) A Review of research concerning eye lens weight as a criterion of age in mammals. N.Y. Fish and Game J. 14 (2) 152-165.

Geist, V. (1960) Feral goats in British Columbia Murrelet 41, 34-40.

Geist, V. (1964) On the rutting behaviour of the mountain goat J. Mammal. 45 551-568.

Geist, V. (1966) Validity of horn segments counts in ageing bighorn sheep. J. Wildl. Mgmt. 30 634-635.

Gilbert, F.F. (1966) Ageing White tail deer by annuli in cement of first incisor. J. Wildl. Mgmt. 30, 200-202.

Greig, J.C. (1969) The Ecology of the Scottish feral goats M.Sc. thesis, University of Edinburgh.

Griffiths, J.G. (1970) A note on patterns of behaviour and grazing in hill sheep Anim. Prod. 12 (3) 521-24.

Grubb, P. and Jewell, P.A. (1966) Social grouping and home range in feral Soay sheep. Symp. Zool. Soc. Lond. 18 179-210.

Hansson, L. (1970) Methods of morphological diet microanalysis in rodents. Oikos 21 255-266.

Harris, D.R. (1962) The distribution and ancestry of the domestic goat. Proc. Linn. Soc. Lond. 173 79-91.

Harrison, D.L. (1967) Observations on a wild goat, capra aegagrus, from Oman. E. Arabia. J. Zool. Res. 15, 27-30.

Henming, J.E. (1969) Cemental deposition, tooth succession and horn development as criteria of age in Dall sheep. J. Wildl. Mgmt. 33 552-558.

Henry, B.A.M. (1975) Dispersion, diet and criteria of age in Roe deer (Capreolus capreolus L.) in Hamsterley Forest, Co. Durham. Ph.D. thesis, University of Durham.

Hercus, B. (1960) Plant cuticles as an aid to determining the diet of grazing herbivores. Proc. Int. Grassl. Congr. I.B., (Reading) 443-447.

Hubbard, C.E. (1954) Grasses. Penguin.

Hunter, R.F. (1962) Hill sheep and their pasture J.Ecol. 50 651-680.

Hunter, R.F. (1960) Aims and Methods in grazing behaviour studies on hill pastures. Proc. 8th Int. Grassl. Congr. I.B. (Reading).

Hunter, R.F. (1964) Home range behaviour in hill sheep. Grazing in Terrestrial and Marine Environments. Symp. Br. ecol.soc. 4, 151-171.

Jeffery, H.E. (no date) Breeds of goats and breed points, British Goat Society Publication.

Jensen, B. and Nielsen, L.B. (1968) Age determination of the Red fox (Vulpes vulpes) from canine tooth sections. Danish Rev. Game Biol. 5 1-16.

Laws, R.M. (1952) A new method of age determination for mammals. Nature, 169 972-973.

Lockard, G.R. (1972) Dental annuli in white tail deer. J. Wildl. Mgmt. 36 46-55.

Longhurst, W.M. (1964) Evaluation of the eye lens technique for ageing Columbian black tail deer. J. Wildl. Mgmt. 28 (4) 773-784.

Lowe, W.A. and McT.Cowan, I. (1963) Age determination in deer by annular structure of dental cement. J. Wildl. Mgmt. 27(3) 466-471.

Lever, C. (1977) The Naturalised Animals of the British Isles. Hutchinson: London

Malachek, J.C. and Leinweber, C.L. (1972) Forage selectivity by goats on lightly and heavily grazed ranges. J. Rang. Mgmt. 25 (2) 105-110.

Martin, D.J. (1954) Features of plant cuticle - an aid to the analysis of the natural diet of grazing animals, with special reference to Scottish hill sheep. Trans. Bot.Soc.Edinb. 36, 278-288.

Martin, D.J. (1964) Analysis of sheep diet utilising plant epidermal fragments in faeces samples. Grazing in Terrestrial and Marine environments. Symp. Br. Ecol.Soc. 4 173-188.

McDougall, P. (1975) The feral goats of Kielderhead Moor. J.Zool.Lond. 176 215-246.

McNab, B.K. (1963) Growth layers in dental cementum for determining age of Red deer (Cervus elaphus L.) J.Anim.Ecol. 36 279-284.

Megaw, B.R.S. (1963) Goat-keeping in the old Highland economy. Scottish Studies 7, 201-209.

Milner, C., Goodier, R. and Crook, I.G. (1968) Feral Goats. Nature in Wales 11, 3-11.

Mitchell, B. (1963) Determination of age in Scottish red deer from growth layers in dental cement. Nature, 198 350-351.

Morris, P. (1972) A review of mammalian age determination methods. Mamm. Rev. 2 69-103.

de Nahlik, A.J. (1974) Deer Management, Improved herds for greater profit. David and Charles, London,

Neal, B.R., Pulkinen, D.A. and Owen, B.D. (1973) A comparison of faecal and stomach contents analysis of the meadow vole, Microtus pennsylvanicus. Can. J. Zool. 51 715-721.

Neetleton, H. (1934) Estimating the age of a goat. Yb.Br.Goat.Soc.

Paul, D.L. (1946) Judging of age by dentition in goats. Indian Farming 7 (3) 133-135.

Ransom, A.B. (1966) Determination of age of White tail deer from layers in cementum of molars. J. Wildl. Mgmt. 30 (1) 197-199.

Riney, T. and Caughley, G. (1959) A Study of home range in a feral goat herd. N.Z. J. Sci. 2 157-170.

Rudge, M.R. (1970) Dental and periodontal abnormalities in two populations of feral goats (Capra hircus L.) in New Zealand. N.Z.J.Sci. 13 (2) 260-267.

Rudge, M.R. (1970) Mother and kid behaviour in feral goats (Capra hircus L.) Z. Tierpsychol. 27 (6) 687-693.

Rudge, M.R. (1972) Horns as indicators of age in goats (Capra hircus L.) N.Z. J. Sci. 15 (2) 255-263.

Santiago, A.A. (1941) Determination of age of sheep and goats Boletin Industria Animal (S. Paulo) 4 (3-4) 236-238.

Schaffer, W.M. (1968) Intraspecific combat and the evolution of the Caprini. Evolution 22 817-825.

Schaller, G.B. and Laurie, A. (1974) Courtship and behaviour of the wild goat. Z. Saengetierkd. 39 (2) 115-127.

Scott, J.P. and Stewart, J.C. (1946) Lack of correlation between leadership and dominance in a flock of goats. Anatom. Record. 96 552-553.

Sergeant, D.E. and Pimlott, D.H. (1959) Age determination in Moose from sectioned incisor teeth. J. Wildl. Mgmt. 23 (3) 315-321.

Shank, C.C. (1972) Some aspects of social behaviour in a population of feral goats (Capra hircus L.) Z. Tuerpsychol. 30 (5) 488-528.

Soulsby, E.J.L. (1965) Textbook of veterinary clinical parasitology vol. 1. Helminths. Blackwell, Oxford.

Soulsby, E.J.L. (1968) Helminths, Arthropods and Protozoa of domestic animals (Monnig) Balliere, Tindall and Cassell

Spatz, G. and Mueller-Dombois, D. (1973) The influence of feral goats on Koa tree production. Ecol. 54 (4) 870-876.

Spinage, C.A. (1971) Gerotodontology and horn growth of the impala (Aepyceros melampus). J. Zool. Lond. 164, 209-225.

Spinage, C.A. (1973) A review of the age determination of mammals by means of teeth - with special reference to Africa. E. Af. Wildl. J. 11 165-187.

Stewart, D.R.M. (1965) The epidermal characters of grasses with special reference to E. African plains species. Bk.Jb. 84 63-174.

Stewart, D.R.M. (1967) Analysis of plant epidermis in faeces: a technique for studying food preferences in grazing herbivores. J. Appl. Ecol. 4 83-111.

Squires, V.R. (1965) Ecology and behaviour of domestic sheep (Ovis aries) Mamm. Rev. 5 5-37.

Tegner, H. (1952) "Wild" goats of the Border, Country Life, February 29, 1952.

Tegner, H. (1961) Beasts of the North Country. Galley Press.

Tegner, H. (1965) "Wild goats in Great Britain" Scottish Field February 1965. 70-71.

Todd, J.W. and Hansen, R.M. (1973) Plant fragments in faeces of bighorns as indicators of food preference. J. Wildl. Mgmt. 37 363-365.

Tribe, D.E. (1950) The behaviour of the grazing animal. J. Brit. Grassl. Soc. 5, 209-224.

Werner, A.R. (1977) Observations on the English goat. The Ark 4 (3)

White, G. (1974) Age determination in Roe deer from annual growth layers in dental cementum. J. Zool. Lond. 174, 511-576.

Whitehead, G.K. (1972) The Wild goats of Great Britain and Ireland. David and Charles, London.

Williams, G.R. and Rudge, M.R. (1969) A population study of feral goats (Capra hircus L.) from McAuly Islands, New Zealand. Proc. N.Z. Ecol. Soc. 16 17-28.

Yocum, C.F.C. (1967) Ecology of feral goats in Haleakala National Park, Maui, Hawii. Am. Mid. Ecol. 77 413-451.

Zeuner, F.E. (1963) A history of domestic animals. Hutchinson: London.

Zyznar, E. and Urness, P.J. (1969) Quantitative identification of forage remnants in deer faeces. J. Wildl. Mgmt. 33 506-510.