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Source: *Journal of Applied Ecology*, Vol. 14, No. 1 (Apr., 1977), pp. 17-29

Published by: British Ecological Society

Stable URL: <https://www.jstor.org/stable/2401823>

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THE EFFECT OF HOODED CROWS ON HILL SHEEP FARMING IN ARGYLL, SCOTLAND

HOODED CROW DAMAGE TO HILL SHEEP

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INTRODUCTION

Hooded crows, *Corvus cornix* L., are widely blamed by sheep farmers in the west Highlands of Scotland for killing young lambs, and to a lesser extent for attacking the eyes of 'couped' ewes—animals which roll on to their backs and are unable to right themselves. These attacks occur among lambing flocks of blackface sheep in remote hill areas where shepherding cannot be intensive. They rouse strong emotions among farmers which makes it difficult to obtain objective information on the extent of true damage. A large-scale questionnaire survey of farmers in 1962 showed that farmers blamed crows (and to a lesser extent greater black-backed gulls) for causing over £60 000 damage each year within the county of Argyll alone (D.A.F.S., unpublished report). This paper considers the amount of damage caused by crows and whether this is sufficient to justify control measures.

Hooded crows are common predators and scavengers throughout the Highlands. They take a wide range of foods and feed extensively on carrion during the winter (Houston 1976). There is an abundant supply of carrion on the hill at lambing time from ewes that have died shortly before lambing, from afterbirths and from dead lambs, and crows are frequently seen feeding from carcasses. However, some farmers assume that any lambs which they find dead and which have been attacked by crows have been killed by the birds, although other factors may have been involved and the actual cause of death difficult to determine. To estimate the damage caused by crows the distinction must be drawn between scavenging, predation of viable lambs and of weak lambs that have a low chance of survival. Crow attacks must therefore be viewed in relation to the other causes of mortality of young lambs on the hill. Similarly with attacks on ewes, it is necessary to consider what proportion of the attacked ewes would otherwise have survived.

This present work was done from 1973 to 1974 on a study area near Oban in Argyll (Houston 1976) and the effects of the crow population on hill farms in this area are described.

HILL SHEEP FARMING

Rearing of hill sheep is the major part of the agriculture in this region and is subsidized by the government. Blackface sheep were first introduced into the Scottish Highlands about 200 years ago. The existing form of subsistence farming by a crofting community, which involved intensive cultivation of arable land and limited grazing by mixed stock, gave way to extensive sheep grazing with neglect of arable land and consequent depopulation. The subsequent history of sheep grazing has been one of 'extractive' farming

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where the hill pasture has been exploited and the plant communities have deteriorated in value for grazing animals: it is only recently that attempts have been made to arrest this decline. The stock of ewes that can be carried on the hills is thought to be considerably lower than the carrying capacity of the land when sheep were first introduced. The form of sheep management has not altered greatly over the past century and the ewe flocks still graze extensively over heather and coarse grassland throughout the year. The rams are released on to the hills in late November for several weeks and the ewes give birth during late April and early May. Because of the large distances over which these flocks roam the shepherding can usually only be spasmodic. Sheep density in the study area was at an average of one ewe per 3–4 acres (1.6 ha). The causes of lamb mortality have been studied in other breeds of sheep (Alexander 1961; McFarlane 1965), but there is no information on the relative importance of the causes of death of lambs in Scottish hill sheep. In order to obtain this information a survey of mortality factors in lambs was made.

METHODS

Ten typical sheep farms were selected in the study area, all lambing blackface flocks on hill ground with some rearing a few cross-bred lambs on lowground fields. These farms were chosen chiefly because shepherds were willing to co-operate. The farmers were asked to collect all the lambs that they found dead on their land and a payment of 50 p was made for each lamb as an encouragement to carry the lambs off the hill. A few dead lambs were kept by the farmers for skinning so that a deserted lamb could be fostered, but this was unlikely to have biased the sample. This method of sampling does not include all lamb mortality because a few lambs disappear, possibly taken by foxes, and the size and nature of this 'black loss' could not be studied. However, this is a small proportion of lambs and their omission does not affect the aims of this study. The lambs were collected from the farms regularly and brought into the laboratory.

Each carcass was examined for any wounds. Attacks made on a lamb while it is still alive can be clearly identified by haemorrhages around the wound site and there is usually considerable bleeding from the wound. Attacks made after death show no haemorrhages and little bleeding. A series of body measurements were taken from each lamb, together with the body weight and paunched weight (weight of the body after the digestive tract and associated organs were removed). Each carcass was then examined for aeration of the lungs to see if the lamb had breathed—aerated lung tissue has a light pink colour with a spongy texture and will float in water, while unaerated lung has a dark red colour, firm consistency and sinks in water. The hooves were examined for the presence or absence of the hoof membrane which indicates if the lamb has walked because this delicate covering is rapidly worn away. The stomach and intestine were also examined for milk to see if suckling had occurred. These post mortem features are described in detail by McFarlane (1965). Many of the lambs were also given a post mortem examination by Mr J. Maddox, veterinary officer of the West of Scotland College of Agriculture. This included bacteriological examination of liver and lung tissue, the preparation of cultures from stomach contents, examination of brains for macroscopic evidence of sway back, tests for *Toxoplasma* by fluorescent antibody technique and in suspect animals attempts were made at virus recovery.

Each lamb was then dissected to determine the general fat condition of the carcass by a visual scoring of the extent of fat storage in the area of the kidney, heart mesentery and subcutaneous tissues. Each of these areas of fat storage was scored as very large,

large, medium' small or absent. A proportion of lambs were analysed for total body fat content. These lambs had the digestive tract removed and the main muscle blocks opened by a series of knife cuts. The carcass was then dried at 105° C to constant weight. The mesentery tissue was separated from the alimentary tract and dried separately (the alimentary tract has not been included because of the difficulty of separating the tract from the gut contents). The dried carcass and mesentery were then placed in a canvass bag and crushed by hand. The bag was then weighed and extracted with chloroform for 12 h. The bag was then removed, dried and re-weighed. The fat content was determined by the weight difference before and after extraction. The fat stores present in some lamb foetuses were also examined. These animals were kindly supplied by the West of Scotland College of Agriculture from their experimental farm at Kirkton after the ewes had been killed as a part of their studies of the effect of body condition on lamb wastage.

The muscle condition of the lamb was determined by the weight of muscle tissue present on the left hind limb, selected because it could be easily dissected out. The limb was removed from the body with its associated muscles, skinned and the muscle tissue removed from the bone, and dried to constant weight.

RESULTS

Crow attacks on ewes

Ewes may roll on their backs during an accidental fall and may become trapped, particularly towards the end of winter when their wool is thick. If the fleece becomes waterlogged it may be so heavy that some ewes find it difficult to right themselves once they have rolled over, especially if they are in lamb. In this position a ewe is helpless and hooded crows may then peck at the eyes and so blind the ewe. They may completely remove the eye although this is not necessarily eaten.

Shepherds at five of the farms reported four ewes alive after they had been attacked by crows in the two years out of a total ewe stock on the farms of about 2300. All these animals were found with one of the eyes severely damaged or missing. One ewe died later, the other three recovered after treatment and antibiotic injections. The loss of one eye does not always prove fatal provided attention is given to the wound to prevent it from becoming infected but if both eyes are removed then the ewe has to be destroyed.

In addition to ewes found while still alive there are also those dying each year on the hill (annual mortality rates are on average from 6 to 7% (A. McLeod, personal communication), and a number of these are found with their eyes removed. Crows may be blamed by some shepherds for the loss of these animals, although in virtually all cases the crows are not responsible for the death of the ewe. A sheep trapped on its back can only survive for a limited time as the rumen gases cannot escape and they distend the stomach wall and eventually lead to death by choking or by pressure on the diaphragm causing suffocation. Death usually follows within 12 h of a sheep becoming coupé, but it may come earlier. If the ewe is not found by the shepherd within this time, righted and the pressure of the rumen gasses relieved, the ewe will die anyway whether a crow attacks it or not. Since shepherding is often spasmodic during the winter, and ewes are wintered on large areas of land, most coupé ewes are not found until after death.

A shepherd finding a dead ewe that has been blinded by a crow before it died will obviously have strong feelings about the rather macabre activities of these birds. However, in most cases the ewe would have died anyway. On the few occasions when a shep-

Table 1. *Causes of death of lambs found dead on the hill, excluding those killed by crows or other predators*

| | 1972 | 1973 | 1974 | Mean |
|---|------|------|------|------|
| Accidents (%) | 8 | 5 | — | 5 |
| Still-born (%) | 10 | 22 | 33 | 22 |
| Breathed but not walked (%) | 2 | 7 | 7 | 5 |
| Diseased (%) | 8 | 10 | 11 | 9 |
| With normal fat levels (%) | 7 | 7 | 7 | 7 |
| With reduced fat levels (%) | 8 | 3 | 4 | 5 |
| With exhausted fat levels (%) | 57 | 47 | 37 | 47 |
| Number examined, excluding a small number badly composed or damaged by scavengers | 59 | 149 | 46 | |

herds finds a ewe that is still alive after a crow attack the ewe stands a reasonable chance of survival. The problem of attacks by crows on couped ewes is therefore largely an emotional one. Crows can, however, inflict dreadful wounds on the face of a helpless ewe but in economic terms, crow damage to ewes is slight.

Observed attacks among lamb flocks

The other, and major, complaint against hooded crows is that they kill young lambs. Marriott (1971) watched lambing flocks of 170 blackface ewes at Dalnacabeg and Torinturk, Argyll, in lowground fields and rough hill land. Over 117 h he observed six lambs being born, and also saw seventeen afterbirths, from ewes that had lambed before dawn. One attack by a hooded crow was observed. In this attack the bird (one of a nesting pair) approached the week-old twin lambs and started pecking at the anus of one lamb and occasionally lunged at the eyes of the lamb during an attack that lasted 5–10 min. The crow finally gave up the attack, having caused no damage, and was subsequently seen with its mate in the field on many occasions, but made no more attacks, even when younger lambs were present.

The continuous watching of lambing flocks is a difficult way to study the problem of crow predation because crow attacks are usually infrequent and chiefly occur in remote hill areas where sheep are at a low density. To make a reasonable number of observations it is necessary to watch an area where ewes are at a high density, which may make it difficult to apply the findings to a wider context. Because of Marriott's experience young lambs were not watched continuously, and only one attack by a crow on a lamb was observed. This was a small lamb, abandoned by its mother, which was too weak

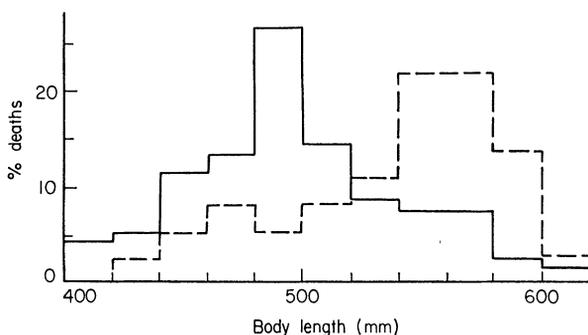


FIG. 1. Size of lambs born dead (---) and those dying within ten days after birth (—).

to stand and could only raise its head. The crow repeatedly attacked its head, and although the attack was seen from a distance, the crow appeared to kill it and the lamb was later found with a wound penetrating into the brain. Several farmers had observed attacks involving lambs that were either abandoned by the ewe or accompanied by a ewe that made no attempt, or only very feeble efforts, to drive away the attacker. One attack occurred immediately after birth, when the tongue was torn by a crow. This lamb was collected by the farmer and reared by bottle feeding because the tongue was damaged which made feeding difficult.

The causes of lamb mortality

To consider crow predation on lambs it is first necessary to understand the general factors responsible for lamb mortality: only then can the effect of crow predation be considered in relation to these other causes of death. This section therefore considers causes of lamb death other than predation by crows.

A total of 297 lambs were examined, but not all carcasses are included in the following data since some had been partially eaten by scavenging birds and mammals before they were found. A preliminary survey made in 1962 of sixty-eight lambs was extended to 175 lambs in 1973. Only fifty-four lambs were examined in 1974 due to exceptionally good weather which resulted in very few lamb deaths.

The causes of mortality of these lambs are summarized in Table 1. Of the lambs examined, 5% were killed by dogs, hit by cars, sat upon by the ewe or strangled in fences. In 22%, the lungs were not aerated and death had therefore occurred before or during the birth (in 36% of these still-born lambs there was an accumulation of fluid under the skin causing swelling of the head and forelimbs (oedema) indicating that they had died during the birth process). These were larger ($\chi^2 = 28$, $df = 10$, $P = 0.01$) in size than lambs which died after birth (Fig. 1). Five per cent of the lambs had fully inflated lungs, and had therefore survived the birth, but they had never walked since their foot membranes were intact so they must have died shortly after birth.

Of the remaining animals which had breathed and walked, disease was responsible for 9% of deaths (Houston & Maddox 1974). This figure is based on a third of the lambs which were given a routine veterinary examination; other animals were only examined if gross pathological lesions were discovered during the other post mortem examinations. The infective agents thought to have caused death were necrotic hepatitis, lamb dysentery, tick pyaemia, liver abscesses, *Pasteurella pseudotuberculosis* infection, coliform septicaemia, and pleural effusion.

After excluding the lambs that were accidentally killed, those born dead and those where gross disease was involved, 59% of the deaths were unaccounted for. The cause of mortality in this group was investigated by examination of the body condition of the lamb.

To determine the body condition of healthy animals lambs which died an accidental death were used. It is possible that these animals may have been weak and with reduced energy reserves, and so predisposed to accidents, but this is unlikely because the fat and protein levels of lambs killed accidentally shortly after birth were the same as those of still-born lambs. Lambs at birth have extensive fat stores (Fig. 2) with large deposits of white fatty tissue covering both kidneys and extending back towards the posterior wall of the abdomen cavity. Subcutaneous fat stores, visible as clear strands of fatty tissue, were also extensive particularly in the shoulder region, with other small deposits in the mesentery and around the heart. These fat reserves represent from 12 to 16% of dry

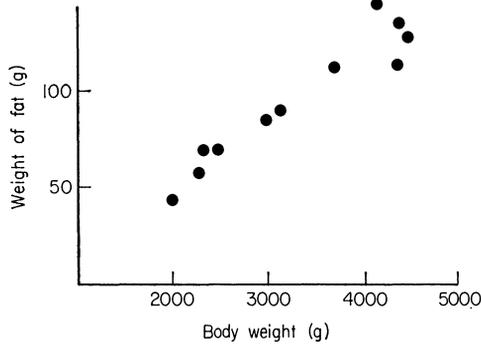


FIG. 2. Relationship of fat weights with body weight in still-born lambs.

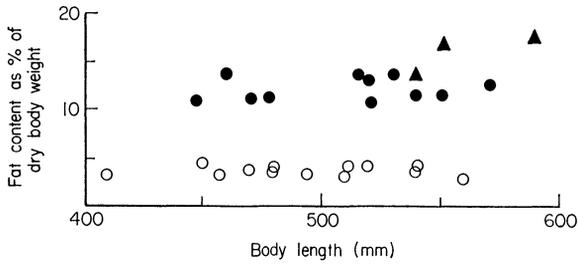


FIG. 3. Percentage of fat stored in the body of lambs still-born (●), dying accidentally ten to twenty days after birth (▲) and dying with no visible fat reserves (○).

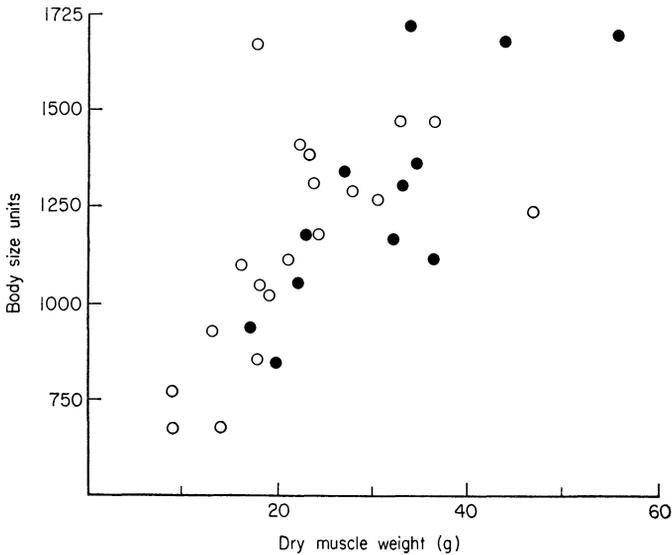


FIG. 4. Muscle tissue present on the right hind limb of lambs dying with large (●) and with depleted (○) fat reserves. Body size units = (length of tibia)³.

body weight. A healthy lamb which begins to suckle shortly after birth maintains and increases this level of body fat storage (Fig. 3) although the sites of fat deposition change. Within the first three weeks of life fat accumulates in the mesentery and the kidney fat deposits decline, the fat in the subcutaneous and heart deposits apparently remaining constant.

Of the 59% of lambs whose deaths were unaccounted for, 7% (of the total lambs examined) had fat levels of from 10 to 15% of dry body weight, similar to those of healthy lambs, and 5% had fat levels of 5 to 9% of dry body weight. The cause of death of these lambs is unknown, although exposure may possibly have been involved in some cases. Hill lambs are susceptible to rain, low temperatures and high winds which may extract heat from a lamb at a faster rate than the animal can expend energy to maintain the body temperature. In this situation the lamb may die from exposure, although the body energy reserves are still extensive (Alexander 1961).

The remaining 47% of lambs had their visible fat reserves completely exhausted. Tissues around the kidneys were red, gelatinous and transparent in these animals. They might have succumbed to an undiagnosed disease, but this possibility is discounted because in 82% of lambs with no visible fat stores there was no milk present in the digestive tract, indicating that they had never fed. In 14% of cases the stomach contained

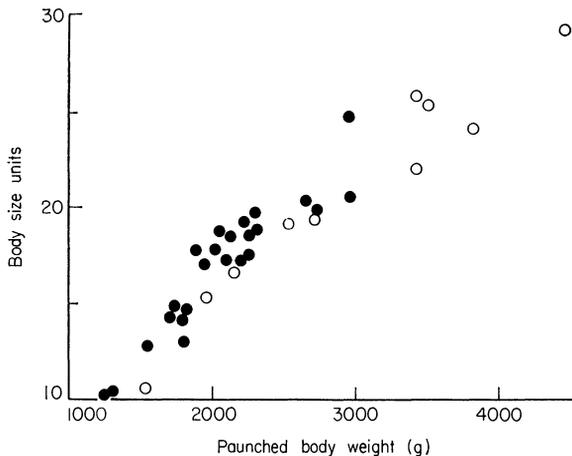


FIG. 5. Comparison of size and weight of lambs dying with normal fat reserves (○) and with depleted fat reserves (●). Body size units are the cube of the sum of body, skull, tarsus, radius, fore and hind foot lengths.

a mat of hair or grass that had been swallowed. The total body content of fat in animals in this condition was from 3 to 4% of dry weight (Fig. 3). The uniformity of fat content in these lambs also suggests that it was uncomplicated depletion of the energy reserves which was responsible for death. Some of the remaining fat might come from the lanolin content of the wool. Wool was cut off one side of two lambs, dried to constant weight and the fat extracted. The fat content of the wool was negligible (0.6% fat content: wool weights 25.6 and 29 g, from half the fleece.) Most of the fat remaining in the lambs with no visible fat stores is therefore present in the body, where it is probably required for structural tissues and is not available for maintenance requirements.

In Fig. 4 the muscle tissue present on the hind limbs of lambs that had died with exhausted fat stores are compared with those from lambs with large fat stores. The weight of muscle tissue is similar in both groups, and protein does not therefore appear to be used as an important energy reserve during starvation. Because the muscle tissue is not depleted

during starvation it is difficult to tell by a casual examination whether a lamb has exhausted its energy reserves. Figure 5 shows that there is not enough difference in body weight between healthy lambs and those which died from starvation to allow weight to be used as a reliable indication of a lamb's condition.

Figure 6 shows the amount of fat present in lamb foetuses six weeks before birth, obtained from ewes in good, medium and poor body condition. There is no consistent difference in the amount of fat stored by the foetus in ewes on different levels of nutrition (average fat content is 4.5% of dry body weight), consequently the fat stores of the lambs must be laid down during the final six weeks of pregnancy.

The fat reserves of a lamb at birth are sufficient to satisfy its energy requirements for several days without food. One recently born lamb was found beside its mother, which had died after giving birth. Although the farmer was told of this lamb, it was not collected and three and a half days later the lamb was still beside the dead ewe but now too weak to stand and died within a couple of hours. Not all lambs can survive over three days on their body reserves; their survival time depends on the extent of the reserves and the rate at which they use them (see Alexander 1961).

Crow predation as a mortality factor among lambs

Table 2 shows that 48% of the lambs found dead on the hill had been attacked by crows. The attacked carcasses were distributed throughout the study area and there was no indication that crows in one area were specializing in attacking lambs. It appears to be a widespread habit among all birds that have the opportunity of feeding in this way.

Of the attacks, 81% were made after the lamb had died since there was little bleeding around the wound site, 17% had been attacked before death and 2% were uncertain. The body condition of lambs attacked while still alive is shown in Table 3.

Seventy-two per cent of these lambs were found to have completely exhausted their

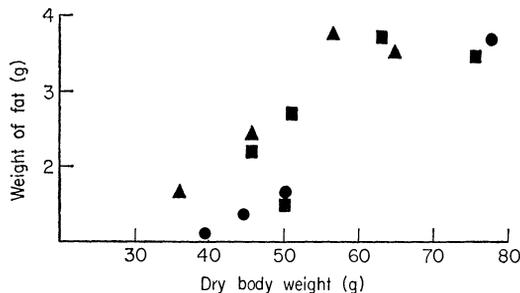


FIG. 6. Fat reserves found in lamb foetuses six weeks before birth, derived from ewes estimated to be in good (▲), average (■), or poor (●) condition. Animals supplied by the West of Scotland College of Agriculture.

visible fat reserves; extraction showed fat contents of 3–4% dry body weight. They were in the terminal stages of starvation when attacked and would almost certainly have died anyway shortly afterwards. One lamb was attacked after it had been injured in a road accident, and two others attacked had severe infection of tick pyaemia. The remaining lambs attacked had no disease conditions diagnosed. Twelve per cent had fat reserves of 10–15% dry body weight, and 4% had reserves of 5–9%. Although no other cause of death was apparent in these lambs, it cannot be assumed that they were all healthy and would have survived had it not been for the crow attacks. It was shown earlier that a similar proportion of lambs were found dead on the hill in this condition, although they

Table 2. *Time of attacks by crows on lambs*

| | 1972 | 1973 | 1974 | Total | % of total |
|--------------------------|------|------|------|-------|------------|
| Number of lambs examined | 68 | 175 | 54 | 297 | — |
| Number attacked | 24 | 88 | 31 | 143 | 48 |
| Attacked after death | 16 | 75 | 27 | 118 | 39 |
| Attacked before death | 7 | 13 | 4 | 24 | 8 |
| Time of attack uncertain | 1 | 1 | — | 2 | 1 |

had not been attacked by crows. Table 3 shows that statistically there is no evidence that crows select healthy lambs, because the distribution of body condition in dead lambs is similar for those attacked and for those not attacked. However, two of the lambs which were attacked by crows were probably healthy animals which might otherwise have had a reasonable chance of survival. Both were seen by the farmer with the ewe, and appeared to be healthy. They were later found dead, with their tongues torn by a crow, and these attacks must have occurred several days before death because an infection was developing in the wounds. The lambs had both depleted their energy reserves, presumably because the damage to their tongues prevented them from suckling.

It may be concluded that, of the twenty-four lambs attacked by crows before death, the crows were primarily responsible for the death of only two. Out of the 143 dead lambs found bearing signs of injury by crows, either before or after death this is just 1.4%. On the study area during 1972–74, 297 lambs were found dead from all causes. Records provided by the College of Agriculture give the average lamb mortality in Argyll as 15–20%. Taking the average value of 17.5% an estimated 1700 lambs were born in the study area. Thus two extra lambs out of 1700 might, if they had not been attacked by crows, have been healthy enough to have survived.

This survey only detected lambs which were attacked by crows and which later died. It is possible that crows may also have attacked some lambs which survived the attack and the extent of these attacks would go unrecorded. Virtually all attacks are confined to the head of the lambs, at either the eyes or tongue. Any lambs whose tongues are torn are unlikely to survive, and any lambs blinded by attacks on the eyes would be noticed by the shepherds; no such lambs were reported. It is therefore presumed that no attacks resulting in damage were made by crows on lambs which survived the attacks.

The nature of the crow attacks

Table 4 shows that attacks are largely confined to the head of the lamb and that usually only the eyes and tongue are taken. In addition, in 24% of the carcasses the crow had

Table 3. *Condition of lambs dying on the hill*

| | Number examined | Affected by | | % Fat levels g dry body wt | | |
|-------------------------------------|-----------------|-------------|---------|----------------------------|----------------|------------------|
| | | Accident | Disease | Normal (10–15%) | Reduced (5–9%) | Exhausted (3–4%) |
| Lambs not attacked by crows | 186* | 7 | 13 | 9 | 7 | 64 |
| Lambs attacked by crows while alive | 24 | 4 | 8 | 12 | 4 | 72 |

* Dying after birth from other causes than still-born and 'breathed but not walked' categories.

Table 4. *Parts of lambs attacked by crows*

| | 1972 | 1973 | 1974 | Mean |
|-------------------------------|------|------|------|------|
| Total attacked lambs examined | 22 | 81 | 31 | |
| Percentage damaged | | | | |
| one eye | 55 | 62 | 42 | 57 |
| both eyes | 18 | 22 | 44 | 25 |
| tongue | 86 | 94 | 100 | 94 |
| eye and tongue | 64 | 74 | 90 | 75 |
| wound penetrating brain | — | 24 | 26 | 24 |
| at umbilicus | 32 | 20 | 31 | 24 |
| at anus | 9 | 4 | 11 | 6 |

also penetrated deep into the brain through the eye socket, although the brain was not eaten and in most cases the lamb was dead before the attack. In only 23% of cases was anything further eaten from the carcass, usually the umbilical cord or small pieces of the intestine removed through a hole in the abdomen.

This behaviour is in marked contrast to the scavenging behaviour of greater black-backed gulls, which can remove up to 500 g of food from a carcass, and usually feed off the muscle and viscera. The crow's stomach is smaller than a gull's, but crows could still obtain more food than they actually take. They can penetrate the skin around the umbilical cord, and remove the whole of the digestive tract, yet they rarely do and usually take an insignificant proportion of their daily food requirements.

DISCUSSION

Most farmers complain about the activity of hooded crows and would like to see their numbers drastically reduced. To decide whether any control is justified we need to consider both the cost of the damage and the cost of effective control measures.

The 'problem' of crow attacks is largely a symptom of the set-stocking system for hill sheep (Eadie 1970). The critical aspects of the problems associated with sheep on hill land are understood chiefly due to the work of the Hill Farming Research Organization. This work has shown that during spring and summer high quality grazing is abundantly available on the hills but that this quality declines towards the end of autumn. During winter the energy requirements of the sheep cannot be met by the grazing and animals rely on body reserves built up during the previous summer. The rams are released onto the hill in late November and lambs are born in late April and May. Pregnant ewes are therefore generally undernourished, and the condition in the last few weeks of pregnancy will be particularly important because this is when energy stores are laid down in the lamb. It is known in other breeds of sheep that the nutritional state of the ewe will influence her survival, the birth weight of the lambs, milk yield of the ewe, strength of the ewe-lamb bond, lamb vigour, rate of lamb growth, possibly the lamb's ability to withstand cooling and lamb survival (Wallace 1948; Alexander & Peterson 1961; Alexander 1961).

Weather conditions can be bad when blackface lambs are born, and shelter is rarely available. Gunn & Robinson (1963) found a lamb mortality of 17% between birth and marking (at about six weeks of age) and College of Agriculture records show lamb mortality of 15–20% in Argyll (A. McLeod, personal communication). Most lamb deaths occur in the first week of life and it is this time when they are also vulnerable to attacks by hooded crows. During the sixteen weeks after marking until the lamb sales there is a mortality of only about 2% (A. McLeod, personal communication).

Still-born lambs and losses within the first week of life are therefore the major cause of wastage in lambs. Still-born lambs were larger in size than those dying after birth and presumably birth was more difficult for the larger animals. Of those which were born satisfactorily, only a small proportion died from disease and about half of the lambs died from uncomplicated starvation.

Most crow attacks on live lambs took place on animals which had reached an extremely weak condition due to starvation or some other cause. We cannot include the loss of these lambs in any estimate of the damage caused by crows because their chances of survival anyway must be considered as negligible. Some of these lambs might have been saved if they had been found by the shepherd and bottle reared or fostered by ewes, but most shepherds are unable or unwilling to take on these extra duties during lambing time. Only about 1.4% of the lambs attacked were viable lambs which might otherwise have been expected to survive. They were presumably attacked shortly after birth when both the ewe and the lamb were weak.

There are therefore probably two conditions in which lambs are vulnerable to crow attacks. All lambs, whether viable or not, may be attacked shortly after birth when both the ewe and the lamb are weak and may not be able to defend themselves. In addition, any lambs which become weak after birth due to disease, exposure or starvation will again become vulnerable to crow attacks when they become weak, shortly before they would have died anyway. An improvement in sheep management, by providing additional winter feeding and better husbandry at lambing, would substantially reduce the number of lambs in this second category, but still leave lambs vulnerable to attack at birth, and attacks at this stage are responsible for losses of the order of 0.12% of lambs per year.

Crows were unlikely to have attacked lambs for food: their food supply was then probably better than at any other time in the year. There was abundant carrion available on the hill from dead ewes, cattle feed was freely available and the insect flush was beginning to appear (Houston 1976).

Other reasons may have provoked these attacks. The eyes and tongues of lambs may be selected because they form a particularly nutritious or tasty food for crows, although this is unlikely. Another explanation is that although crows are not short of food at lambing time, if they kill young animals and leave them uneaten they could return to scavenge from the carcass later, when nesting has started and when large quantities of food are needed to feed the young. This is unlikely because when nesting they feed exclusively on insects (Houston 1976). Another explanation is that this is an innate behaviour pattern which once had a selective value in the past conditions in which crows evolved, but which is no longer relevant today. However, the basic objection remains that if there was some selective advantage in killing lambs, or some other species, then healthy animals would also be attacked. Perhaps a more probable explanation is that it is a consequence of normal predatory behaviour. Kruuk (1972) suggested that predators have a feedback mechanism which prevents them from eating when fully fed, and that while satiation inhibits searching and hunting, it does not affect catching or killing. Normally a predator which is fully fed will not hunt for more food, but if it can kill prey without the need to hunt—as with a fox in a hen house—then it may kill more prey than it can eat. Attacks on lambs by crows may be a similar behaviour mechanism. The head is consistently attacked by crows because this is where they can quickly kill such large animals by stabbing through the eye socket into the brain. Since predation has not been initiated by the need for food, once the attack has been made and the 'kill' achieved, no feeding

occurs. This may be why only weak lambs or dead carcasses are 'at risk' even though little food is taken.

Attacks on helpless ewes give rise to the most venomous of reactions against hooded crows, but this is largely emotional: the crows do not cause significant damage in this way.

This study was undertaken during three mild winters so it is important to consider whether the situation might be different in severe winters. We would then expect a larger proportion of lambs to die from starvation after birth. The food supply for crows is likely to increase during a harsh winter because there will be a larger amount of sheep carrion and cattle feed available. Crows are unlikely to alter their role under these conditions, although there will be a larger proportion of weakly lambs and therefore more attacks on lambs. In a bad winter, however, a larger proportion of ewes might be expected to become trapped on their backs since the ewes would be weaker and weather conditions worse. In this situation attacks on couped ewes might become significant.

This study was confined to a small area in Argyll and we must consider whether these findings apply in other areas. Crow attacks on lambs and sheep has been shown to be a consequence of sheep management and not to features peculiar to the study area. Since the set stocking system of sheep management is widespread throughout the western Highlands the conditions reported here apply to the wider context. Burgess (1963) considered damage caused by Carrion crows in northern England and concluded that half of the lambs attacked were weakly lambs, and that about one in 2000 healthy lambs was attacked. In Australia lamb mortality follows a similar pattern to that in Argyll with crow damage to lambs largely confined to animals weak from starvation (Rowley 1969, 1970).

With damage of 0.12% of lambs per year there is no justification for control of crow numbers. The present management methods on most hill sheep farms leave considerable scope for improvement of lamb yields by the provision of larger areas of in-bye land, some winter feeding and more controlled and intensive husbandry at lambing. By comparison with improvements in lamb survival that can result from these management changes the slight increase in lamb survival that might result from a reduction of hooded crow numbers are insignificant.

ACKNOWLEDGMENTS

I am extremely grateful to many farmers in the Oban area for permission to work on their land and for supplying me with lambs. Mr C. C. Bannatyne and Mr J. G. Maddox, veterinary officers for the West of Scotland College of Agriculture in Oban, gave much assistance, including post mortem examinations to many of the lambs, and kindly allowed their post mortem room to be used for the lamb dissections. I am very grateful to Mr R. Hewson and Mr R. Parsons who kindly helped with the dissections and to Mr A. D. E. Sharp and Mr A. McLeod for their advice on local farming methods. Mr R. I. Currie, Director of the Scottish Marine Biological Association at Dunstaffnage, gave me permission to use the laboratory and I am extremely grateful for this help. Mr M. Bowen gave assistance throughout the study and I am very grateful to Dr J. D. Lockie and Mr J. Cuthbert for their advice and help. The study was financed by a grant from the Department of Agriculture and Fisheries for Scotland.

SUMMARY

(1) Crows are blamed by sheep farmers for killing lambs and, to a lesser extent, for attacking the eyes of trapped ewes.

(2) Crow damage to 'couped' or trapped ewes caused only slight economic damage.

(3) Crow predation on lambs was evaluated in comparison with other causes of lamb mortality. A survey of the causes of death, excluding crow predation, showed that out of 297 lambs found dead on the hill the major causes of death were starvation (48%), still-birth (22%) and disease (9%).

(4) Crows attacked 48% of lambs found dead on the hill. Examination of the wounds showed that only 17% of these lambs were alive when attacked. The body condition of the latter showed that in most cases the lambs had exhausted their fat reserves and were on the point of starvation before being attacked. Crows did not select healthy lambs, and the range of body condition of lambs attacked was similar to lambs dying without being attacked.

(5) In most cases crows killed only lambs that would die anyway. About one in 850 lambs born were healthy lambs which would probably have survived had there not been a crow attack.

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(Received 3 May 1976)