AN EVALUATION OF PREDATION BY "CROWS" ON YOUNG LAMBS

By IAN ROWLEY*

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Summary

In south-east Australia, *Corvus coronoides* and *Corvus mellori* are slow to reach sexual maturity and spend their immature period in nomadic flocks. Seasonal fluctuations in the numbers of corvids present in any one district correspond to differences in the availability of food and are due largely to the movements of nomadic flocks. Lambing flocks of sheep provide a local abundance of food, mainly in the form of afterbirths and carrion. Few healthy lambs are killed by corvids but many sick animals are finished off by them, a distinction not appreciated by most farmers. Dystocia, twin births, weakness, and desertion are the main circumstances that predispose lambs to serious attacks. Aviary experiments suggest that on the south-east mainland of Australia *C. coronoides* and *C. tasmanicus* are the only species capable of damaging lambs.

A change in sheep management, particularly by providing shelter for lambing flocks, will ensure a greater and more permanent improvement in lambing results than will control of corvids which at best has only a temporary effect.

I. INTRODUCTION

Corvids of one sort or another occur throughout Australia, from the arid interior to the summit of Mt. Kosciusko and from the tip of Cape York to southern Tasmania. All are black birds of medium to large size and are generally called "crows" but more correctly there are five species, two crows and three ravens; all belong to the genus *Corvus*. Four species are confined to Australia while the fifth is shared with New Guinea; the Australian raven (*Corvus coronoides*), the forest raven (*Corvus tasmanicus*,† and the little raven (*Corvus mellori*) occur mainly in the temperate region while the Australian crow (*Corvus orru*) and the little crow (*Corvus bennetti*) occur in the tropics and the arid interior (Fig. 1). The identification, subspeciation, and distribution of these species will be discussed in a subsequent paper.

Since sheep are run under a wide variety of conditions throughout temperate and subtropical Australia and even penetrate deeply into the tropics in northern parts of Queensland and Western Australia, it is not surprising that all five species of *Corvus* come into contact with sheep somewhere in their range as is shown in Figure 1. Frequently two species may occur in the same locality and even breed in sympatry (Rowley 1967); occasionally three species may forage together in mixed flocks but this is exceptional.

* Division of Wildlife Research, CSIRO, Canberra.

† Until recently the author regarded *C. tasmanicus* as a race of *C. mellori*, but he is now convinced that it is a full species with one race occurring in Tasmania, the Otway Ranges, and Wilson's Promontory, and with an isolated race in the New England tablelands.

All five species of *Corvus* are opportunistic scavengers that feed from a succession of sources as the seasons change (insects, seeds, and fruits); carrion feeding and predation on birds, mammals, and reptiles occur as opportunity arises. The birds frequently forage in flocks of from 30 to 300 (some species more so than others) and studies of banded birds have shown that they may move hundreds of miles in the course of their nomadic wanderings.

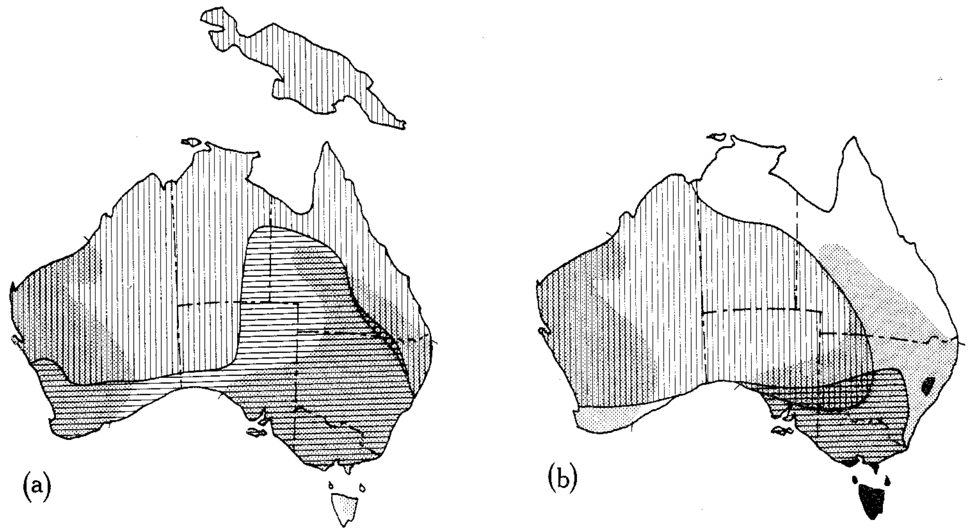


Fig. 1.—(*a*) Distribution of *C. coronoides* (horizontal hatching) and *C. orru* (vertical hatching) compared with that of sheep farming (stippling). (*b*) Distribution of *C. mellori* (horizontal hatching), *C. bennetti* (vertical hatching), and *C. tasmanicus* (black) compared with that of sheep farming (stippling).

Attractive food for corvids is provided by the membranes and placenta (afterbirth) discarded by a ewe shortly after the birth of a lamb. Moreover, since one of every five lambs born dies within a few days, lambing paddocks provide an abundance of food for corvids.* It is inevitable, therefore, that these birds will concentrate on lambing paddocks, just as it is certain that in the farmer's mind corvids and dead lambs are firmly linked as cause and effect.

In the last 15 years a number of surveys have been made of the causes of neonatal lamb mortality (Moule 1954; McHugh and Edwards 1958; Hughes *et al.* 1964; McFarlane 1964; Smith 1964, 1965*a*,*b*; Dennis 1964, 1965, 1969). Almost without exception they have emphasized that neither predation nor disease is the main cause of lamb deaths (although either may sometimes cause deaths in catastrophic numbers on a local scale), and that frequently more than 50% of lambs that die are starving at the time of death (Rowley 1970).

* Throughout this paper the term "corvid" and the phrase "*Corvus* species" refer collectively to all five species of the genus occurring in Australia; no other member of the family Corvidae is found in Australia. Where the term "raven" is used, it means *C. coronoides*, *C. tasmanicus*, and *C. mellori* together; similarly, "crow" refers to both *C. orru* and *C. bennetti*. When a single species is referred to, either the Latin name or the full proper name (e.g. little crow) is used.

The purpose of this investigation was to assess lamb mortality due to *Corvus* spp. and to describe the conditions under which it occurs. The work was concerned mainly with two of the ravens, *C. coronoides* and *C. mellori*; comparative work on the two species of crow and on *C. tasmanicus* was less detailed.

II. Methods

The study of ravens among lambing flocks of sheep in south-eastern Australia was approached in four main ways:

(*a*) Detailed investigation of *Corvus* ecology.

(*b*) Direct observation of lambing flocks.

(*c*) Post-mortem analysis of dead lambs.

(*d*) Experiments carried out in aviaries to compare the relative efficiency, as predators, of the different *Corvus* species.

(*a*) Corvus *Ecology*

This subject has been (Rowley 1967) and will be described in detail in future papers, but a synopsis of the findings relevant to raven movements and predation in general is included here. Three main study areas were used, one at Geary's Gap, N.S.W. (solely *C. coronoides*), one at Kosciusko National Park (solely *C. mellori*), and one at Toganmain Station in the western Riverina of New South Wales, where both species occur together. Since the Kosciusko National Park did not carry sheep it will not be dealt with further here. Less intensive studies on *C. bennetti* near Ivanhoe, N.S.W., and *C. orru* on the Darling Downs, Qld., are being prepared. *C. tasmanicus* was not studied in detail.

Table 1

Comparative climatic data for Canberra* (near Geary's Gap) and Hay (near Toganmain)

	Canberra	Hay
Average maximum temperature (°F), July	51·7	58·7
Average minimum temperature (°F), July	33·3	38·6
Average maximum temperature (°F), Jan.	82·5	89·3
Average minimum temperature (°F), Jan.	56·0	60·9
Average annual rainfall (in.)	22·9	13·6

* As measured at "Westridge". Data from Bureau of Meteorology (1956).

(i) *Geary's Gap, N.S.W.*—This is 20 miles north of Canberra. Thirty square miles of Southern Tablelands sheep country was selected as an intensive study area; some aspects of the climate are shown in Table 1. All the resident pairs of *C. coronoides* within this locality were known, and at least one member of each was trapped and released wearing a combination of colour bands that enabled it to be recognized from a distance of up to a quarter of a mile. Nesting was followed in detail through each of five seasons and many of the young reared were also individually colour-banded. The movements and foraging range of these birds were closely tracked. As opportunity arose, numbers of nomadic non-breeding birds entering the area were trapped, banded, and released in order to study their movements.

All the lambs that died in two flocks in this study area were picked up and examined in each of four successive seasons. Less intensive pick-ups were made on three additional properties. About 100 hours of observations were made on these flocks during other work (Table 2).

TABLE 2

TIME SPENT OBSERVING RAVEN ACTIVITY AMONG LAMBING EWES

Location	Time Watched (hr)
Geary's Gap, N.S.W.	100
Roma, Qld.	9½
Toganmain, N.S.W.	361
Minnipa, S.A.	136
A.C.T., and Monaro, N.S.W.	25

(ii) *Toganmain Station*.—It consists of 100,000 acres carrying about one sheep to three acres and is representative of a well-managed western Riverina sheep property (Table 1). Both *C. coronoides* and *C. mellori* bred there and their ecology was studied in detail, although the continuous observations made at Geary's Gap were not possible. Intensive observations were made throughout the birds' breeding season (July–September) and at lambing time (February–April). At other times brief visits were made each month and all corvids seen on a routine circuit were counted.

On Toganmain 2176 ravens were caught, banded, and released; others were banded by cooperators elsewhere. Subsequent recoveries of some of these birds have led to an understanding of both nomadic and local movements.

(*b*) *Direct Observation of Lambing Flocks*

Lambing flocks were observed through binoculars or telescope from a hide, blind, or observation post. This was done at several locations but in most detail at Toganmain Station and Minnipa Research Centre, S.A. (Table 2). Intensive observations were mainly confined to autumn lambings because of other commitments in spring.

(i) *Toganmain*.—Observations were made on two flocks of stud ewes, each numbering about 400 animals, over four seasons. Lambs were dropped from February until April and the climate during most of this period was hot to very hot; on several days the maximum temperature was more than 100°F. Pasture was usually adequate since the paddocks involved were especially saved for the purpose. The flocks were entirely unshepherded throughout lambing. Since the size of the area over which lambing took place was large (2 by 350 ac), an observation post was established overlooking the only watering place, an earth tank (dam) serving both paddocks. All sheep had to visit this point and many bore their lambs in the immediate vicinity.

(ii) *Minnipa Research Centre*.—In conjunction with the South Australian Department of Agriculture and the CSIRO Division of Animal Physiology, observations were carried out in enclosures for 10 days during the autumn of 1966 and again in 1967 on a selected group of ewes on the point of lambing. As the main object of this study was to investigate fox predation on lambs, a 24-hr watch was maintained. Some of the results of these studies have been reported by Alexander *et al.* (1967) and Mann (1968).

Three species of *Corvus* were present at Minnipa (*C. coronoides*, *C. mellori*, and *C. bennetti*). Since the sheep were confined to small areas they were provided with grain *ad lib.* as supplementary feed. Throughout most of the day more than 50 corvids were present in or around the lambing flocks.

(iii) Less prolonged observations were made near Roma, Qld., Trangie, N.S.W., at Geary's Gap, and at several properties in the Australian Capital Territory and southern Monaro district of New South Wales.

(*c*) *Post-mortem Analysis of Dead Lambs*

Coincident with the start of this study, McFarlane was conducting his early Monaro surveys (McFarlane 1964) and his post-mortem techniques were used in this work. Collections of dead lambs were chilled and forwarded to him in Sydney for analysis; some of this material was lost, and in the final year analysis was performed by the author on the spot. The collections provided comparative data for different years from the same flocks located in the Geary's Gap study area.

The post-mortem technique has been described in detail by McFarlane (1965) and Rowley (1970).

(*d*) *Aviary Experiments*

During the spring of 1967, each of four aviaries averaging 50 sq ft in area was stocked with a pair of *Corvus*. The birds were allowed to adjust to their surroundings and then they were presented with an intact lamb carcass. The time that elapsed before the eyeball of the lamb was removed from its socket was measured by observation through one-way glass from a central room. In this way at least six members from each of the five *Corvus* species present in Australia were tested.

Two birds were tested together because single individuals were easily distracted by the activities in the aviary next door which they could hear but not see. By using two birds together the competitive situation which usually arises in the field was reproduced. It was observed that it was always one bird which removed the eye; therefore, the time measured referred to the work of only one bird. By changing round the partners undergoing test it was possible with one exception to achieve a test measurement for every bird.

A raven or crow starting to feed from an intact lamb selects the uppermost eye for attack. However, in a competitive situation as sometimes developed with the aviary birds, one bird might start probing for the tongue and once this was protruding, the bird attacking the eye would be distracted. In order to avoid such interrupted measurements, the jaws of the dead lamb were wired tightly shut.

As soon as an eye was removed, the observer turned the lamb over and a second test was run with the second eye. A maximum of three tests per bird per day were carried out. At the conclusion of testing, the lamb carcass was removed and the test pair reverted to a grain and fruit diet until the next performance; tests were made every other day. This programme was maintained to ensure the birds did not become satiated with meat, and it was necessary to avoid the complication of hidden food caches, a feature of corvid behaviour.

III. Results

(a) *Synopsis of Raven Ecology*

Most of the present work was carried out in south-eastern Australia and therefore the two common ravens, *C. coronoides* and *C. mellori*, have been most closely studied (Rowley 1967). Aspects of these studies which throw light on predation of lambs are summarized below.

(i) *Geary's Gap*.—Sixty pairs of *C. coronoides* were resident in the study area all year round, each defending territories which averaged 290 acres. These territories, which were defended against trespass by other ravens, provided trees adequate for nesting and roosting in and a sufficient variety of habitat, so that most of the birds' foraging was done within their boundaries. Nesting lasted from July to October. Not until the end of January or February were the young fully independent, then they usually attached themselves to nomadic flocks which passed through the district at that time of year, and fed on grasshoppers or grain stubbles.

Adult ravens seldom left their territory which they patrolled several times a day and they very quickly located any new source of food (e.g. dead or dying animals). These are generally the birds that remove eyes from cast sheep, steal hens' eggs, and take scraps; more usually they feed on carrion, insects, other birds, seeds, and fruit as available. These birds exploit their territory for food in a wide variety of ways depending on weather, season, and the demands of breeding.

They regularly experience the normal pattern of farm operations such as harvesting, cultivation, and the movements of stock and man himself. Any departure from the normal is quickly responded to, whether it is a basket of eggs carelessly left on a gatepost, a "cast" ewe lying upside down, or the fact that the farmer is carrying not a stick but a rifle.

Australian ravens do not occupy a territory or breed until they are three years old. They leave their parents six months after hatching, and for the next two and a half years are not tied to any particular place. Banding shows that these footloose birds, forming a large proportion of the population, may wander extensively during the first year but ultimately tend to settle in the natal district as a member of a local flock, frequently made up of about 30 birds. These flocks wander over a wide area, probably 100 square miles or more, and feed largely on local food gluts such as recently ploughed land, a horde of grasshoppers or pasture grubs, fallen grain after harvesting, or a stock catastrophe as when 70 sheep were killed after being drenched with carbon tetrachloride for liver fluke (Rowley, unpublished data).

Observations of the study area and elsewhere showed that it is these nomadic flocks which make up the bulk of the ravens present among lambing flocks. While the resident pair can repel trespass by from one to four birds a flock of 10 or more is too much, and in such cases the resident birds frequently remain perched in the canopy and do not join the foraging party. These flocks feed in one area as long as food is abundant but move on as soon as a better source is located. This means that ravens are well dispersed over various lambing flocks at the height of lambing in a district, but those properties that lamb either very early or late (by district standards) tend to draw in these nomadic ravens from a considerable area. Property C at Geary's Gap, which regularly lambed in June–July before any of the neighbours, attracted a flock of ravens averaging 50–75 birds. Property B, which lambed in August as did most other properties, rarely had more than 15 birds in the paddock, and these were mainly the neighbouring territorial pairs.

On Trangie Experimental Farm identical flocks were lambed in August and September. Dun and co-workers found that during August relatively little raven predation occurred; most of the neighbouring properties were also lambing (Table 3). In September losses to ravens rose sharply and it would appear that the scarcity of other lambing flocks caused the nomadic birds to concentrate on Trangie.

TABLE 3

LAMBS ATTACKED BY CROWS AT TRANGIE RESEARCH STATION IN 1963

Data from Table 21, Trangie Annual Report 1963/64

Nature of Attack	New-born Lambs Attacked (%)	
	Born August	Born September
Predation of healthy lambs	3	14
Predation of probably dying lambs	10	20
Feeding on lambs already dead	7	19
Total lambs examined	67	169
Percentage attacked	20	53

(ii) *Toganmain*.—*C. mellori* occupy a territory only during the breeding season, and as soon as the young are ready to leave the nest the family leaves the timbered nesting area and joins large foraging flocks on the plain. Thereafter, except when engaged in nesting activities each year (as adults), *C. mellori* live as a flock and may move considerable distances.

(*b*) *Direct Observation*

(i) *Toganmain*.—Although *C. mellori* outnumbered *C. coronoides* by about five to one, the former were never seen to attack lambs but spent most of their time feeding from the ground on insects, seeds, and carrion. *C. coronoides*, the larger species, did occasionally attack lambs that appeared weak but, since in all the cases observed the lambs managed to stand up and the ewes defended the lambs by butting the ravens (Fig. 2(*a*,*b*)), no attack was pressed home sufficiently to wound. Both species of raven avidly ate discarded afterbirth and such carrion as was available; competition between the two species frequently arose over these items, and in all observed cases *C. coronoides* vanquished *C. mellori*. Consequently, *C. coronoides* spent far more time feeding on carcasses than did *C. mellori*.

These two flocks of ewes were observed over a total of 32 days spread over four lambing seasons (1964–67). During the 361 hours involved in these observations, no instance of successful predation was seen. Several approaches were made by *C. coronoides* but no lambs were wounded because they were healthy and the ewes defended them. *C. coronoides* usually approached a sleeping lamb or one very recently born (often in a multiple birth) and pecked hard at the breech or tail area; lambs that were not moribund either ran to their mothers or chased the raven (Fig. 3(*a*)). In two instances the birds persisted in their probing for as long as five minutes; in one case the ewe had a broken leg and was unable to defend the lamb properly. No instance of group or gang attack by ravens was seen.

On most days one or two lost lambs would be left behind at the dam for hours, after the main flock had left to forage or seek shade. Unfortunately, the lambs were unmarked and therefore unrecognizable and it was not known what happened overnight or whether the same lambs were present the next morning. When the weather was hot (over 100°F) these lambs became quite distressed in the absence of shade, and after camping seldom moved again until the evening; no attacks on such lost and prostrate lambs were seen.

Mismothering at the dam resulted largely from the eagerness of the ewe to drink and the tendency for large numbers (*c.* 100) of ewes to arrive together. The ensuing scramble and competition for the best drinking sites resulted in general confusion.

Another situation which might have been expected to expose young lambs to predation was when they became bogged around the dam. It was of the type known as a "turkey's nest" and consisted of a large hole in the ground surrounded by a clay bank. It was filled by a windmill pumping from a subartesian bore. After successive windless days the water level would fall several inches, due both to sheep drinking and to the high evaporation rate. This exposed a margin of soft mud and both ewes and lambs frequently became temporarily bogged. During the observation time, one lamb was bogged for more than 230 min and survived; others were held in the mud for 20, 10, and 5 min, and none of these desperately struggling lambs was attacked by ravens. That they all survived after extricating themselves indicates they were healthy (if stupid!) lambs. One ewe survived a 108-min bogging and one "lost" lamb was seen to pirate-suckle a ewe, definitely not its mother, while she was held firm in the mud, drinking! That all boggings did not end so happily was shown by the occasional carcass lying half in the water.

Under these conditions of minimal interference and the complete absence of any form of shepherding, flocks of Merino ewes of mixed ages averaged 80% of lambs marked to ewes mustered at marking time. Examination of the ewes at marking (as per Dun 1963) suggested that about 17% of the ewes had not borne a lamb recently (as might be expected from a spring mating). Under these circumstances predation seems of little importance, and it is unlikely that any change in management practice would significantly reduce the lamb losses which could be due to a wide range of accidents and to disease.

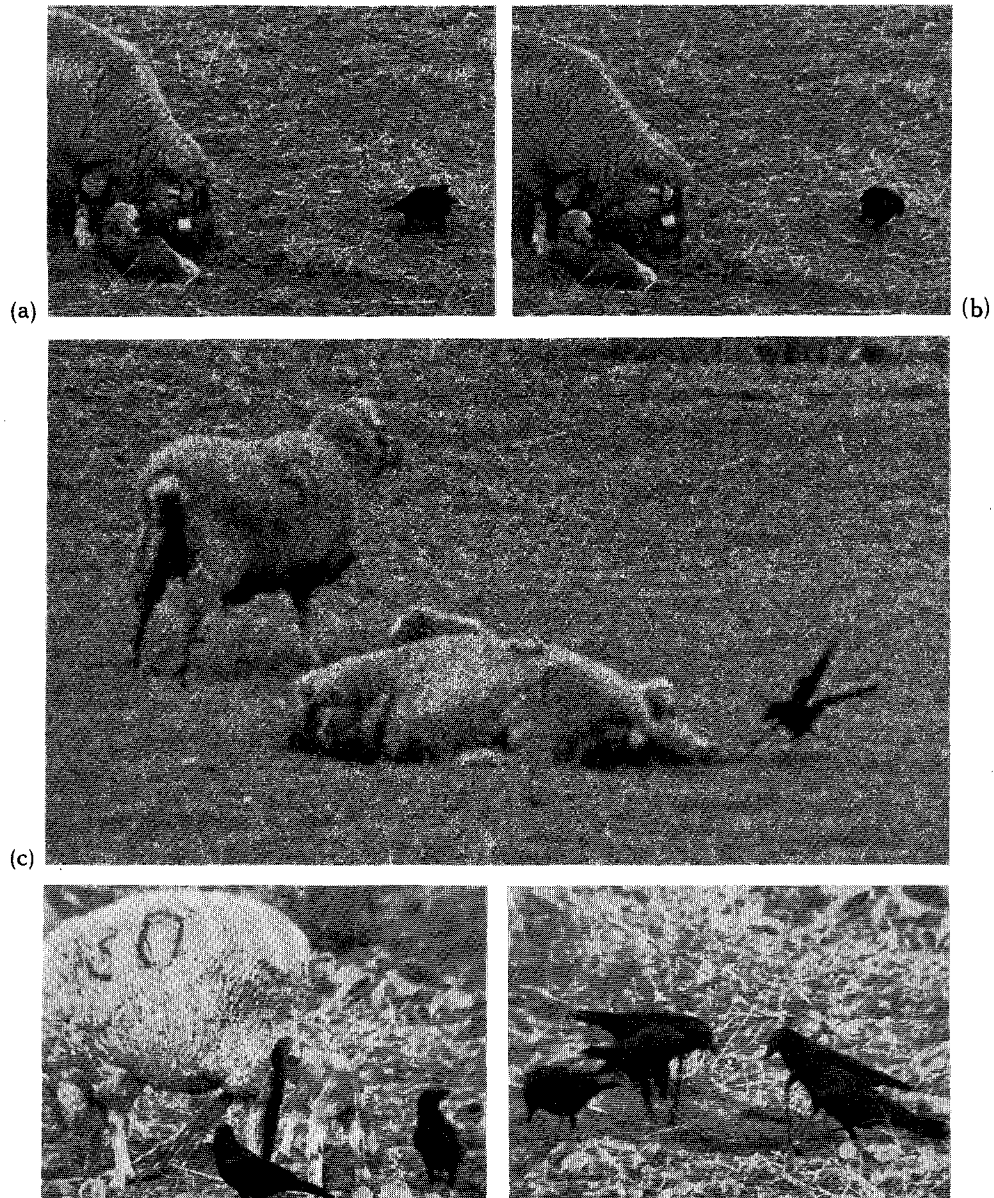
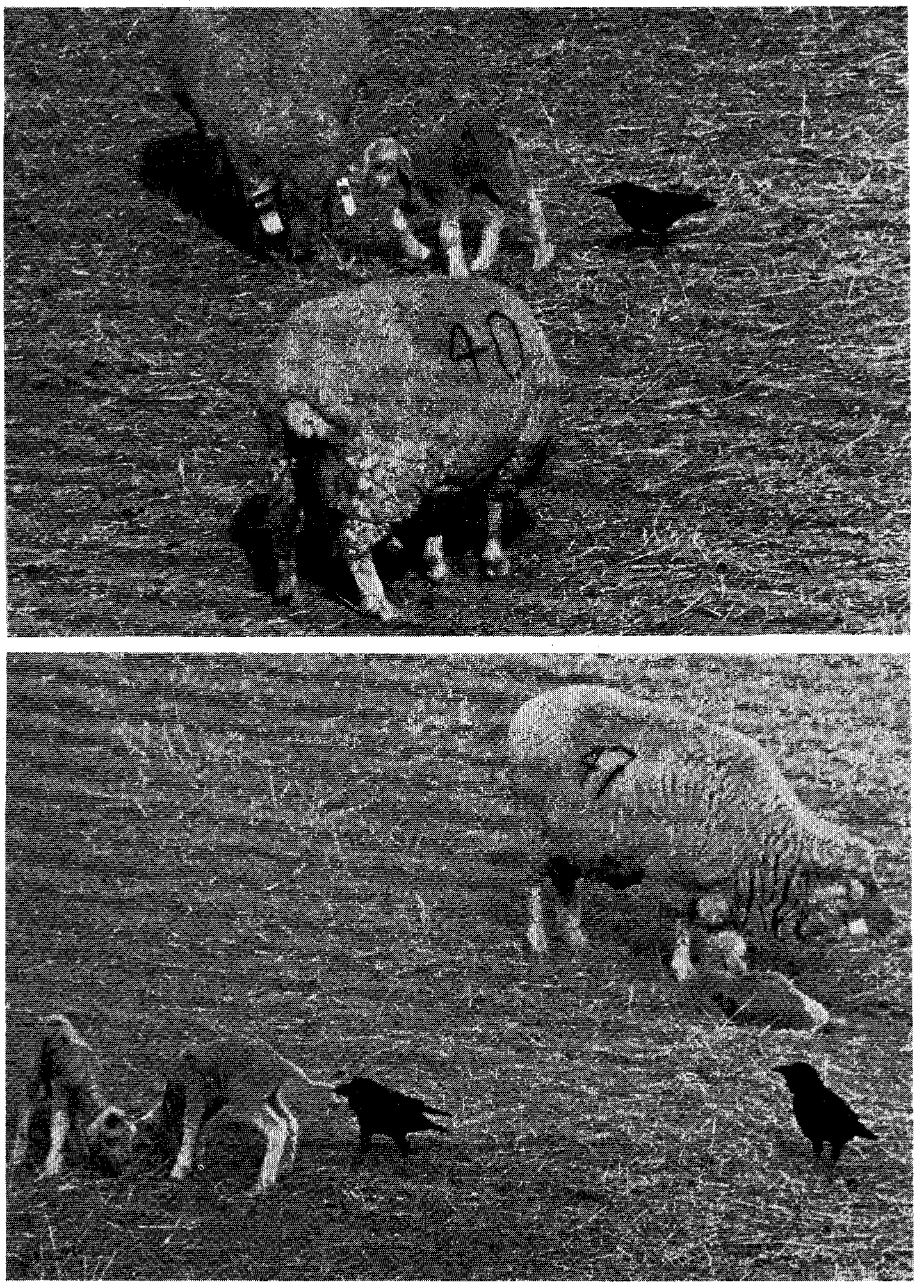


Fig. 2.—(*a*) Raven approaching a lamb guarded by the ewe. (*b*) Ewe repulses raven by a butting movement. (*c*) "Smash-and-grab" raid by raven seeking membranes from a ewe resting just after giving birth to a lamb. The lamb was not attacked. (*d*) Ewe attended by two ravens while her lamb sucks; the ewe is about to shed the afterbirth membranes. (*e*) Same scene after membranes have been shed.



(a)

(b)

Fig. 3.—(*a*) While sleeping, lamb 47 was probed in the anal region by a raven. This healthy lamb jumped up and moved away; a sick lamb might have been attacked further. (*b*) *Corvus coronoides* holding the tail of a lamb in its bill. This lamb appears unconcerned but frequently such a lamb runs off with the raven following, still holding on. As in 3(*a*) this approach probably enables ravens to distinguish between sick and healthy lambs.

(ii) *Minnipa*.—In 1966 and 1967 lamb mortality was not heavy. In 1966, five lambs died from 44 ewes observed to lamb, while in 1967, 49 out of 424 lambs died. Despite the large numbers of corvids present and the absence of any disturbance throughout most of the day, avian predation was not responsible for the loss of one healthy lamb.

These observations provided a unique opportunity to study the progress of lambs from birth until they either died or were gaining weight satisfactorily. As described by Alexander *et al.* (1967), the new-born lambs were weighed and had their body temperatures taken twice a day. Each lamb was individually marked and identifiable from a distance by large numbers (Fig. 3(*a*)), and so it was possible to follow raven attack on individual lambs and to correlate this with the physiological condition of the lambs.

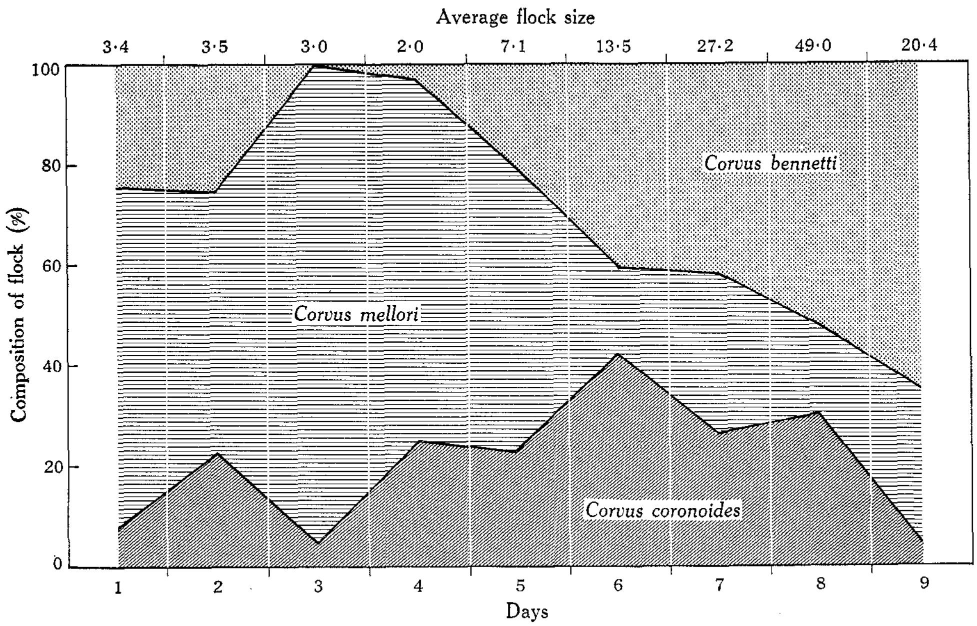


Fig. 4.—Composition of corvid flock feeding in the lambing enclosures at Minnipa, S.A., April 1967.

In 1966 more than 50 corvids were present even before lambing started; they fed on grain provided for the sheep. The next year was quite different since summer rains had provided a wide variety of alternative food for corvids, and it was not until the fifth day after lambing had started that numbers built up to the 1966 level. Figure 4 shows how the composition of the foraging flock varied from day to day. An obvious trend is the increase in both the proportion and numbers of *C. bennetti*. *C. coronoides* shows no such build-up and its irregular fluctuations reflect the nomadic wandering of groups of eight or ten birds, mainly immatures.

The third species, *C. mellori*, occupied a breeding territory covering the enclosures, and the resident pair spent most of their time chasing out intruders during the first few days (hence the high rating of the species in Figure 4 at this time). Once larger groups were attracted by the presence of carrion and afterbirth the resident pair no longer attacked the trespassers. The initial defence of territory by the *C. mellori* pair was directed against members of all three species.

From the high proportion of immature birds among those visiting the enclosures it is clear that the increase was largely due to nomadic flocks of all three species locating this new food source. The fact that the numbers of each species present increased simultaneously suggests a measure of interspecific tolerance when feeding. On dispersal from the feeding area, however, flocks of the different species departed independently and maintained their identity.

(1) *Parturition.*—The lack of effective predation by corvids on the lambs at Minnipa is interesting because ample opportunity for attack existed. Twenty-seven lambs were born in daylight and the whole process was closely studied from the hide; four births were twin deliveries. Each parturition was also watched intently by from 2 to 6 corvids, usually *C. coronoides*, the largest of the three species present. The initial periods of unproductive labour, the scratching of a depression by the ewe in which to lie, and the protrusion and bursting of the "water-bag" all provided visual stimuli to the ravens, at least one of which would have been within 100 ft of any ewe in the paddock. With the protrusion of the membranes the attendant birds became more active and several probes with the beak might have been made. Neither these nor later probes, when a portion of the lamb was visible, caused any damage since the ewes were already restless and circled away from the ravens. After the birth of the lamb, and while the ewe was still resting, single ravens would dash in and grab beakfuls of membranes and attendant fluids adhering to the new-born coat (Fig. 2(*c*)). No particular attention was paid to the lamb's orifices at this time except that the umbilical cord might have been shortened in some instances. Once the ewe had recovered, usually after a few minutes, she faced towards her lamb and butted off the intruding ravens (Fig. 2(*a*,*b*)). The attacks at Minnipa were by fewer birds and were less sustained than those seen at Roma in Queensland.

(2) *Post-parturition.*—The interval between parturition and mothering up was usually very brief for single lambs. With twin births, the interval during which the second lamb was born might leave the first undefended for up to half an hour, and it might be the subject of repeated attacks. In no instance was the attacked lamb damaged in any way.

After parturition the afterbirth membranes hung from the vulva of the ewe for a considerable period until shed (cleansing). The mean interval was 153 min and the time range 116–222 min (10 ewes). During this time the ravens became increasingly impatient (Fig. 2(*d*)) and repeated sorties were made at the pendent membranes. When these were finally shed a general tug-of-war developed, often involving as many as 10 birds (Fig. 2(*e*)). While the birds were escorting an uncleansed ewe they were inevitably in close proximity to her lamb(s) and quick attacks were frequent. Again no lamb damage occurred during these observations.

(3) *Carrion.*—Both crows and ravens are scavengers and feed extensively on any carrion lying around the lambing area. Figure 5 shows that on day 7, the only time that a lamb carcass was available all day, no raven attacks on lambs were recorded.

Since most farmers do not distinguish between the dead and the dying lambs this carrion feeding is often rated as predation, an aspect discussed fully elsewhere (Rowley 1970).

(4) *Faeces-feeding*.—In addition to feeding on carrion, corvids, particularly *C. coronoides*, may feed extensively on the first faeces passed by lambs. In certain circumstances these early faeces may be of a rather treacly consistency and adhere to the breech and tail of the lamb. This material contains 21–44% crude protein, 9–37% fat, and 10–30% carbohydrate (Walker, personal communication) and, therefore, is probably highly nutritious. To acquire this food the raven probed the anal

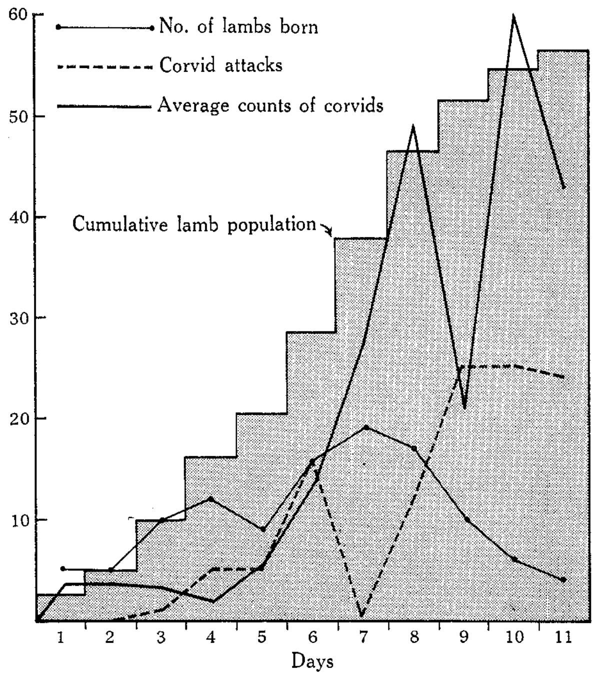


Fig. 5.—The build-up in numbers of the corvid flock feeding in the lambing enclosures at Minnipa, S.A., April 1967. The numbers of lambs born and corvid attacks made are also shown.

region of the lamb with a vigorous peck. Usually the lamb, which was probably sleeping, jumped up, defecated, and either ran off or butted the raven; either alternative ended the encounter (Fig. 3(*a*)). If, however, the lamb happened to be starving and failed to respond, the initial faeces probe might develop into an anal attack and to extensive wounding of a dying lamb.

(5) *Species comparison*.—The frequency with which individuals of the three species of *Corvus* present at Minnipa attacked ewes and lambs is shown in Table 4. Most of the attacks referred to were anal probings.

Table 4 shows that $2\frac{1}{2}$ times more attacks were made on lambs than on ewes. The fact that *C. bennetti* pecked at nearly as many ewes as lambs suggests that this species with a much smaller, finer bill can perhaps locate small seeds and insects in the breech area. More than twice as many lamb attacks were made by *C. coronoides* as by *C. mellori*. The large number of attacks on lambs made by *C. bennetti* were usually probes for faeces directed at sleeping lambs.

TABLE 4

FREQUENCY OF PECKING ATTACKS BY *CORVUS* SPECIES ON EWES AND LAMBS AT MINNIPA, APRIL 1967

Attacking Species	Victim	
	Ewe	Lamb
Corvus coronoides	3	33
C. mellori	4	15
C. bennetti	22	29
Unidentified	3	4
Total	32	81

To be able to observe three closely related species of birds foraging simultaneously highlights the differences between them. At Minnipa the only bird capable of damaging a healthy lamb was the large Australian raven, *C. coronoides*. Not only its greater weight, longer reach, and larger bill enable this species to succeed where others fail, but also its extreme agility. Watching a *C. coronoides* approach a suspicious ewe or lamb, one is inevitably reminded of the footwork of a lightweight boxer; Figure 2(*c*) shows the retreat after a quick attack on a ewe. By comparison, the other species appear clumsy. Often *C. coronoides* will take a lamb's tail in its bill (Fig. 3(*b*)) and, when the lamb runs off, it will follow, still holding onto the tail; members of the other species occasionally try this but cannot keep up and have to let go. Again, *C. coronoides* will sometimes jump onto a lamb's back and when the frightened animal runs off the bird will maintain its balance with wing beats (Fig. 6), pecking viciously. However, the pecks appear surprisingly ineffective, perhaps because of the tough skin and tightly curled birth coat. Neither pattern of attack has resulted in serious damage but they illustrate the agility of *C. coronoides*, since neither *C. mellori* nor *C. bennetti* has been seen to behave like this.

(iii) *Roma, Queensland*.—In August 1964, the author spent five days with I. D. Smith on the property where he reported heavy raven predation on Border Leicester lambs (Smith 1964, 1965*a*). On three mornings it was possible to watch the lambing flock from dawn onwards; later several of the lambs which had been attacked were caught and examined.

(1) *Attacks*.—A feature of these was that the umbilical cord, which is usually 3–5 in. long after separation from the ewe, was almost invariably shortened to less than 1 in. in length. The other main site for attack was the breech, and most of the wounds there appeared to be due to pinching with the entire length of the mandibles,

(a) (b) (c) (d) (e) (f) (g)

Fig. 6.—Successive photographs of ravens attacking two young lambs, both of which survived. (*a–d*) This lamb is a twin, 11½-hr old, left sleeping by its mother when she went to drink along with the other twin. This "ride" lasted 45 sec before the lamb sheltered with a ewe, not its mother; when examined an hour later no wounds could be found. (*e–g*) This is a younger lamb which became temporarily separated from its mother; this attack lasted less than 30 sec before lamb and mother were reunited, and again no wounds were found.

which left an angry red weal. In these Border Leicester lambs the epidermis of the escutcheon may be more tender and more easily penetrated than in other breeds—certainly Merino lambs do not develop these bruises when attacked (cf. attack at Minnipa). With *C. coronoides*, size decreases from east to west as one moves inland from the Dividing Range, but in southern Queensland dimensions (particularly of the bill) tend to remain large far from the coast and those birds shot near Roma were as large as any collected during the study.

(2) *Infection.*—This combination of sensitive skin and large-billed ravens is not lethal by itself, but when infection with *Clostridium* spp. occurs deaths become more frequent. Smith (1965*a*) studied 44 new-born Border Leicester lambs that had been recently pecked by ravens without receiving major wounds. He injected half with antibiotics and left half untreated; seven of the untreated lambs died but none of the treated ones.

TABLE 5

INTENSITIES OF PREDATION AND CARRION FEEDING DURING ONE SEASON IN 1962 ON FOUR PROPERTIES AT GEARY'S GAP

Category of Dead Lamb	Property			
	A	B	C	D
(1) Number examined	114	104	73	85
(2) Number assessable	114	104	70	84
(3) Percentage of (1) wounded	7·0	24·0	46·5	63·5
(4) Percentage of (3) healthy when attacked	1·7	6·7	17·1	7·1
(5) Percentage of (3) dying when attacked	2·5	12·5	21·4	33·3
(6) Percentage of (3) dead when attacked	2·5	4·8	5·7	22·6
Month of lambing	Aug.	Aug.	July	Aug.*
Method of predator control	Poison, scare-gun	Nil	Scare-gun, rifle	Nil

* Property D was stocked at twice the rate of the other properties on very productive sown pastures.

Edgar (1931) showed that *Clostridium* bacteria were commonly carried on the bills of *Corvus* spp. in eastern Australia and were probably responsible for losses of cast sheep due to pecking by crows.

(*c*) *Post-mortem Analysis of Dead Lambs*

In 1962 all dead lambs from four flocks near Geary's Gap were picked up and sent to Sydney for post-mortem examination by McFarlane; data are presented in Table 5.

Each flock consisted of approximately 650 ewes (range 604–721) and so the results are comparable. The flock lambing in July (C) was a full month ahead of others in the district and suffered the most severe losses to predation. Nevertheless, only 12 (17·1%) of the dead lambs were healthy and viable apart from the damage caused by the predator, and this is not a large loss from 700 ewes.

Of the three flocks lambing in August (A, B, and D), flock D was on a very intensively farmed property which, although the dead lambs were picked up twice a day, attracted a large number of ravens, and as a result 63·0% of carcasses were mutilated. The sheep were running at three to the acre in most cases, and this parallels the experience of Davies (1964) at Kojonup, W.A., where lambs at the heaviest stocking rates were mutilated most.

TABLE 6

VARIATION IN PREDATION AND CARRION FEEDING ON PROPERTY C AT GEARY'S GAP OVER FOUR SUCCESSIVE JULY LAMBING SEASONS

	1962	1963	1964	1965
Number of dead lambs examined	73	50	49	206
Percentage of dead lambs fed from	46·5	25·0	65·0	69·4
Percentage of healthy lambs attacked	16·4	2·5	17·7	6·8
Percentage of dying lambs attacked	20·5	12·5	23·5	41·3
Percentage fed from after death (carrion)	5·5	10·0	17·7	18·9
Non-assessable percentage of dead lambs examined	4·1	0	6·1	2·4

Properties A and B were similar in all respects except one. The owner of the former poisoned extensively for foxes and ravens, and used a carbide scare-gun, whereas flock B had none of these protections. It would appear that these measures had little if any effect, as Table 5 shows that approximately the same number of lambs died in each flock. In fact, property A lost two lambs as the direct result of predatory attack while property B lost 7, a saving of 5 lambs out of 500.

TABLE 7

VARIATION IN PREDATION AND CARRION FEEDING ON PROPERTY B AT GEARY'S GAP OVER FOUR SUCCESSIVE AUGUST LAMBING SEASONS

	1962	1963	1964	1965
Number of dead lambs examined	104	80	36*	108
Percentage of dead lambs fed from	24·0	11·1	33·3	38·9
Percentage of healthy lambs attacked	6·7	1·2	11·1	4·6
Percentage of dying lambs attacked	12·5	6·2	11·1	16·7
Percentage fed from after death (carrion)	14·8	3·7	11·1	16·7
Non-assessable percentage of dead lambs examined	0	0	0	0·9

* Data incomplete for this year.

After 1962, comprehensive pick-up of dead lambs was made only on properties B and C. The data are incomplete for reasons stated earlier (Section II), but are presented in Tables 6 and 7. Property C which regularly lambed early, in July, suffered more predation than B, which lambed in August. Each year the number of carcasses fed on from C was double that from B which lambed a month later.

The winter of 1963 was mild and the ewes were well fed prior to lambing; this is reflected in the lower percentage of lambs attacked by predators on both properties—

fewer healthy lambs were killed and fewer dying lambs were finished off. The data are inadequate for 1964. In 1965 the autumn rains failed and feed was very short on property C and a large number of lambs died. As a result, predators were present in large numbers. The lambs were small in size and while they were born without difficulty they were weak and easily chilled. Most of the ewes walked away and left their lambs after parturition without attempting to lick them. At first sight this predation seemed serious, but a substantial number of the lambs killed were weak and because of this would have died eventually, irrespective of predation. In the farmer's own words, "it would have been better never to have joined the ewes that year".

TABLE 8

ANALYSIS OF PREDATION AND CARRION FEEDING ON 314 DEAD LAMBS COLLECTED FROM TWO PROPERTIES AT GEARY'S GAP, JULY/AUGUST 1965

State of Lamb When Attacked	Species of Carnivore Causing Wounds*			
	Fox	Crow	Eagle	Total
Healthy†	14	1	2	17
Questionable health‡	14	42	2	58
Advanced starvation	16	30	1	47
Dead (carrion)	2	55	—	57
Non-assessable	6	—	—	6
Total wounded	52	128	5	185
Total lambs examined				314
Percentage wounded				59

* Rowley (1970).

† These 17 lambs are the only deaths of economic importance to the farmer.

‡ None of these 58 lambs had fed or started to use their fat reserves; 13 had breathed poorly (one, after a difficult birth process), while another 12 had scarcely walked. These are regarded as lambs born with very poor health most of which die anyway.

The problem was really one of management: a dry summer had prevented hay reserves from being replenished; newly sown pastures failed to establish themselves; and established swards failed to grow after poor autumn rainfall. This situation led to a drop of weak lambs. Cases like this pose problems at post-mortem examination. A large number of the lambs are killed when the only sign of starvation is an empty stomach. Their small size and failure to feed strongly suggest they were weak at birth, were chilled, and had probably been deserted by their mothers. Such lambs have walked, and although they have not fed their fat reserves have not been utilized to any appreciable extent. Apathetic and bereft of maternal defence they are easy prey to any predator. The critical question about each lamb is whether it could have survived. From experience, the author considers that the majority would have become "starvers" within about six hours. In other words, they were about to die anyway.

Flock B did not suffer as badly in 1965; in fact it lost only four more lambs than in 1962, but a much greater percentage of dead lambs was mutilated by predators than in any other year. This probably reflected the general shortage of feed available during the drought; predation was at much the same level as in 1962 but carrion feeding was much commoner. Special attention was paid to the detail of predatory attacks in 1965 (Table 8). It will be seen that foxes and crows account for 97% of wounds and wedge-tailed eagles for less than 3%.

Table 9 compares data from 128 lamb carcasses collected from a property in the Australian Capital Territory over one week in April 1962 with data from 160 carcasses collected from Geary's Gap in 1965. The important difference between the two collections was the very high level of mutilation in 1962 (81% of dead lambs) compared with little more than 50% in 1965. This difference largely reflects the time when the carcasses had been picked up; in 1965, carcasses had been retrieved soon after dawn and were less damaged than those collected in 1962, which had been picked up later.

TABLE 9

FREQUENCY AND TYPES OF WOUNDS INFLICTED BY RAVENS BOTH BEFORE AND AFTER DEATH OF LAMBS

Location of Attack*	A.C.T., 1962	Geary's Gap, 1965
One eye	33	98
Two eyes	85	27
Tongue	85	98
Number of lambs examined	128	160

* Some lambs were wounded in more than one position.

That 81% of the 1962 carcasses were mutilated indicates also that there was considerable pressure on the available food supply; this is borne out further by the high proportion of carcasses with *both* eyes removed (Table 9). A dead lamb usually lies on its side, so that removing one eyeball is relatively easy for a raven; to remove the second, the bird (weighing approximately 1 lb) must turn over a lamb averaging about eight times its own weight. In 1962 nearly three-quarters of the lambs that lost eyes lost them both; in 1965 less than one-quarter of the lambs lost both eyes.

(*d*) *Aviary Experiments*

Pilot experiments using dead intact rabbits as test material showed that there was little difference in the time taken to penetrate such carcasses by the five species of *Corvus*. Entry was possible at many more places than in a lamb because the skin is thinner and covered by fur rather than by tightly curled wool. It was obvious that the larger species (*C. coronoides*, *C. tasmanicus*, and *C. orru*) ate more at a sitting than the smaller ones, but exact figures were not obtainable because all species removed flesh and hid it around the aviary in caches.

In later experiments with lamb carcasses, it was possible to show (Table 10) that the large species were much quicker at removing eyes than the small ones. Since all birds had been on a meatless diet for at least 36 hr before testing, and since under the conditions of presentation the eyes were invariably fed from first, these results provide a valid ranking of wounding ability. To attack a live lamb is far more difficult than to feed from a carcass and it is a fair extrapolation to extend this species ranking to the act of lamb predation itself—in fact, the differences would probably be even more marked.

TABLE 10

TIME TAKEN TO REMOVE ONE LAMB'S EYE BY FIVE DIFFERENT SPECIES OF CORVID

Species Tested	Number of Birds	Number of Tests	Mean Eye Removal Time (min)	Range (min)
Corvus coronoides	8	39	2·38	1–6½
C. orru	7	40	9·8	2–22
C. tasmanicus	6	33	3·2	1–7
C. mellori	11	40	7·85	1½–28
C. bennetti	11	35	13·77*	5–27½*

* These figures are too low for this species because a number refused to feed from the carcass and were not included in the calculation.

C. coronoides and *C. tasmanicus* were extremely competent at removing lambs' eyes; both species have long and massive bills and relatively long tarsi which enable a very powerful thrust to be delivered. Thrusts were rated as picking, pecking, or beaking, in order of descending severity. Picking is usually performed with one foot firmly anchoring the head of the target, the bill is lowered at right angles to the neck (hence resemblance to a pick-axe), then raised about 4–6 in. and driven into the target with considerable force (Fig. 7). Pecking is delivered from any position without special preparation and lacks the purposefulness and strength of picking. Beaking is usually an exploratory action which, while initially quite gentle, may lead to the pinching of a piece of flesh in the mandibles and its removal by pulling (Fig. 2(*e*)). A fourth category of approach, most frequently used by the smaller birds to explore orifices, is spreading. The beak is inserted closed and the mandibles are parted *in situ* to expand the aperture; spreading is used particularly prior to the removal of a tongue or anal evisceration (Fig. 8).

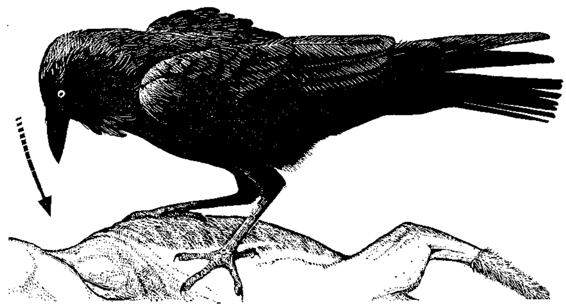


Fig. 7.—Raven "picking" at a carcass; note bill at right angles to neck and the firm stance.

The picking attack generally bursts the eyeball and the deflated tissues are then easily removed. A large part of the difficulty experienced by the smaller *Corvus* species is due to their failure to burst the eye and the consequent need for extensive delving to break the connective tissue at the rear, before the eyeball can be removed intact. The large species can swallow an intact eyeball easily; the smaller birds have considerable difficulty.

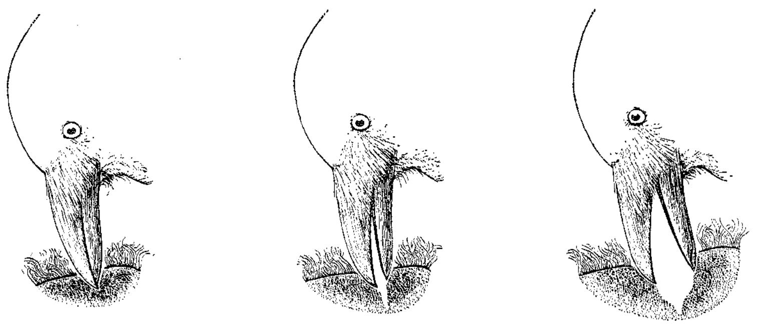


Fig. 8.—Raven "spreading" a small opening in a carcass.

The little raven (*C. mellori*) is a much smaller bird than *C. coronoides* or *C. tasmanicus* and, not surprisingly, is slower at removing eyes. This and field observations indicate that it is extremely doubtful whether the little raven is ever a serious predator of healthy lambs.

The large crows (*C. orru*) which were trapped in Queensland had bills very nearly as large as *C. coronoides* and *C. tasmanicus*, and yet were slower than the smaller *C. mellori* in removing a lamb's eye. With both *C. orru* and *C. mellori* there was some improvement in performance with experience; this did not occur with either *C. tasmanicus* or *C. coronoides*, which were consistently proficient, or with *C. bennetti* which not only failed to improve but also, in the case of several individuals, never achieved the removal of an eye during more than an hour's opportunity. The first 13 tests with *C. orru* averaged 13·5 min; the remainder, run a month later when the birds were familiar with lambs as food, averaged only 8 min but still lacked the skilled technique of *C. coronoides* or *C. tasmanicus*.

The slowest of all the corvids to achieve penetration of a lamb is *C. bennetti*; its very small bill lacks the terminal hook of the larger species. Not only is the bill a less fearsome weapon but also the shorter tarsi seem to make it harder for the bird to steady its prey and attack at the same time. The smaller weight of the bird also reduces the power available behind a peck. In the field, short tarsi mean that progress over the ground is relatively slow and certainly *C. bennetti* cannot keep up with a running lamb, as *C. coronoides* can easily. As a lamb predator *C. bennetti* is very unlikely to be effective; as a carrion eater it will feed last after the other larger species have finished, the fine bill enabling it to penetrate crevices unavailable to the others and to manipulate small items ignored by them.

IV. Discussion

The results presented in this paper show that the majority of corvids that visit lambing paddocks are members of nomadic flocks and are primarily scavenging for afterbirths and other carrion waste. Normally these flocks are distributed over several neighbouring properties lambing at the same time. When a farmer lambs out of phase with his neighbours he may attract abnormal numbers of birds; the available supply of carrion may be inadequate to satisfy all, and some may turn to predation on live lambs instead of the afterbirth which originally drew them.

Mismanagement by over- or under-feeding pregnant ewes, inadequate provision of shelter, or insufficient supervision may result in large numbers of starving lambs. Ravens can easily finish these off but such attacks do not represent a further financial loss to the farmer as these lambs would die anyway.

The activities of man and corvids conflict when both compete for the same agricultural product, whether it is crop or stock. In order to decide how important this conflict is, it is necessary to assess the magnitude of the competition and then to compare it with the cost and efficiency of any contemplated control measure.

Table 11

Summary of Australian predation losses from lamb-mortality survey data*

(1) Number of dead lambs examined	12,443
(2) Maximum number of healthy lambs killed by predators	842
(3) (2) as percentage of (1)	6·75
(4) Maximum percentage of lambs born, killed by predators, that might otherwise have survived†	1·14

* Dennis (1969); Hughes *et al.* (1964); McFarlane (1964); Moule (1954); Smith (1964).

† Based on estimation that 20% of lambs born in Australia fail to survive.

(*a*) *Losses of Lambs due to Predation by Corvids*

Surveys on a large-scale regional basis have been carried out in Queensland (Moule 1954; Smith 1964), New South Wales (McFarlane 1964; Hughes *et al.* 1964), and Western Australia (Dennis 1969). Predation of lambs is discussed fully elsewhere

Table 12

Sheep damage by the pied crow, *Corvus albus*, and the Cape raven, *Corvus albicollis*, in the Great Karroo, South Africa*

Number of sheep on farms surveyed	413,383
Number of lambs† lost to corvids annually	2625
Number of adult sheep† lost to corvids annually	737

* Data from Siegfried (1963).

† No attempt was made to separate sick from healthy animals in this questionnaire survey.

(Rowley 1970); the summarized figures are presented in Table 11 and show that predation is not a great cause of mortality. Comparable data are available for different species of *Corvus* from the Great Karroo, South Africa (Siegfried 1963), and from northern England (Burgess 1963) and are presented in Tables 12 and 13. South Africa's losses are on a similar scale to Australia's; the fact that English losses are less than one-tenth of these figures probably reflects the intensive husbandry practices which are practical with small flocks run at heavy stocking rates.

TABLE 13

SHEEP DAMAGE BY CARRION CROWS, *CORVUS CORONE*, ON 214 SELECTED FARMS IN NORTHERN ENGLAND DURING 1962*

	Number of Animals	
	Ewes	Lambs
Total present	82,000	77,000
Total attacked by crows	16	69

* Data from Burgess (1963).

In the case of crows and ravens in Australia, it is not sufficient to prove that these birds eat lambs, which few would dispute, because they are by nature scavengers. It is necessary to survey lamb mortality in all its aspects; to separate lamb carcasses that have been attacked by crows from those which are unmutilated and then to subdivide the mutilated cases into three classes:

Carrion—lambs that were dead before feeding started.

Dying lambs—lambs already dying from some other cause before being attacked by crows.

Healthy lambs—those which if they had not been attacked might have been expected to survive.

The criteria and techniques for this classification have been fully described elsewhere (Rowley 1970) together with descriptions of the wounds typical of corvids and other predators. The analysis is neither difficult nor time-consuming and is essential to any evaluation of the importance of predation at the flock level.

Corvids and dead lambs are closely linked as cause and effect in the minds of most farmers. Dead lambs represent both personal failure and financial loss; the crow or raven presents a logical and clearly visible scapegoat. Since careful post-mortem examination shows the real cause of death to stem usually from mismanagement, no matter how intensively corvids are eliminated the lamb mortality rate will be little affected. The real causes demand more fundamental remedies. An example of this is shown in Table 5 for properties A and B; in one, control measures were taken while in the other they were not.

The surveys quoted above, the work of Alexander and colleagues on lamb physiology and sheep behaviour (Alexander 1968), and the data presented in this paper suggest that there are two periods of a lamb's life when it is particularly vulnerable to corvid attack.

(i) *During or Immediately after Parturition.*—Birth is quick for a single lamb of average weight (*c.* 8 lb), normally presented; an experienced mother recovers rapidly and actively defends her offspring until it stands and suckles. This leaves little opportunity for corvid interference and most fed lambs progress satisfactorily.

However, (*a*) large lambs may take a considerable time to be expelled from the ewe's vulva; not only are they exposed in a defenceless position during this time but also physical damage to the lamb frequently occurs, leading to weakness if nothing worse. Over-feeding of the ewe during pregnancy is usually responsible for large lambs. (*b*) Maiden ewes, lambing for the first time, sometimes appear to be severely shocked during parturition and this may lead to physical exhaustion or active desertion of the young lamb. Both events leave the new-born lamb defenceless. Desertion among experienced ewes is much less frequent. (*c*) Twins are not common among most strains of Merinos but where they occur the first-born lamb is inevitably left defenceless while the second twin is born; the interval between the two births is rarely sufficient for the first-born to mother up before the second arrives. Not only are twins temporarily defenceless but they are always smaller than other lambs and may be weak.

(ii) *During the Moribund State preceding Death from Other Causes.*—Death is seldom a sudden process and is usually preceded by a period of decline when the victim becomes increasingly listless and defenceless and eventually moribund. A few lambs are born with energy reserves inadequate to enable them to stand and suck the ewe. This effect is magnified under severe climatic conditions and when shelter is inadequate. Starvation is the commonest single cause of lamb mortality in Australia and may proceed for three or four days before the lamb dies, if the weather is mild. The process is generally irreversible, because once the decline has started the lamb becomes increasingly comatose and even less likely to suck. Moribund lambs offer little resistance to corvid attack; they are usually deserted by the ewe when they fail to respond, if not before.

To summarize, dystocia, twin births, weakness, and desertion are the main circumstances that will expose lambs to attack by corvids. Observations reported in this paper suggest that the great majority of normal healthy lambs are not in danger of serious wounding by corvids due to their agility and tough skin, to vigorous maternal defence, and to the size disparity between victim and attacker.

(*b*) *Methods of Control*

Five main methods of controlling corvids have been used: shooting, blasting of roosts, scaring, trapping, and poisoning.

(i) *Shooting.*—To shoot a crow or raven is notoriously difficult and a lot of time can be wasted this way. The birds will seldom permit approach within shotgun range, and where it is necessary to remove a rogue individual the .222 rifle with telescopic sights is the best weapon. A member of a breeding pair is replaced remarkably quickly—in a matter of hours sometimes—so that shooting, except to remove a bird with criminal habits, is inefficient.

(ii) *Blasting of Roosts.*—Several of the species of *Corvus* occurring on other continents roost at night in enormous assemblies (Table 14). Such roosts may cause a nuisance when in or near towns (Murbach 1962), but they provide an opportunity for slaughter on a large scale either by spraying (as for *Quelia*, in South Africa, James 1961) or by blasting with explosives at night after the birds are in residence (Bent 1946, p. 252). Such techniques are not practical with any of the Australian corvids, for although the nomadic flocks do roost together these assemblies are not large (seldom more than 30–40) and are usually sited conveniently to the current (temporary) food source rather than at some traditional, long-used roost. Expense, in terms of both time and materials, makes this approach practical only where large kills are obtained; even then public opinion is likely to react adversely because many of the birds are maimed or wounded.

TABLE 14

CORVUS SPECIES ROOSTING IN LARGE ASSEMBLIES

Country	Species	Number of Birds at Roost	Reference
England	*C. corax* *C. frugilegus* *C. monedula* *C. corone*	10,000 15,000	Burns (1957) Coombs (1960)
Switzerland	*C. corone*	> 2000	Murbach (1962)
India	*C. splendens*	10,000	Ali (1961)
U.S.A.	*C. brachyrhynchos* *C. brachyrhynchos*	20,000 200,000	Haase (1963) Bent (1946)
Japan	*C. levaillantii* *C. corone*	3000 2700	Yamagishi (1962) Hirabayashi (1962)

(iii) *Scaring*.—This method has been used for centuries and the term "scare-crow" is part of our everyday vocabulary. Various automatically triggered guns, strings of Chinese crackers, strips of bright metal strung on wires, rows of conspecific corpses, and broadcast distress calls have all been tried at one time or another. While most of these devices afford immediate relief from bird depredations the effect is short-lived, especially with corvids, since the birds soon learn that the alarm is harmless and adjust their reactions accordingly. In one case the resident pair, in whose territory sheep were lambing and a carbide gun was firing regularly, perched in a tree 50 ft above the routine detonation and took no notice of the explosions.

Unfortunately, most crops and lambing flocks are vulnerable for a far longer period than the effective scare duration of these devices if used on their own.

(iv) *Trapping*.—This method had been widely used to catch crows. Rabbit traps, while effective, have limited use because many birds escape minus one leg, and there are dangers to dogs and to sheep and lambs. Cage traps of various sizes and shapes have been developed and they and their operation are described in detail elsewhere (Rowley 1968); sometimes these are very successful, at other times they are avoided for weeks for no obvious reason.

Despite the unreliability of cage traps and their cost if bought ready-made, they can be prepared before the rush of lambing and require relatively little servicing when in operation. They can also be built quite cheaply by the farmer.

(v) *Poisoning*.—Under the extensive and relatively unsupervised system of lambing practised widely in Australia, lambing paddocks are frequently very large and several traps/scare-guns would be necessary to have any overall effect. Poisoning is much more easily extended over such large areas and although in the past relatively few birds have been killed (largely using S.A.P.), a significant scaring effect has been claimed. More recently, the introduction of organic insecticides has provided some readily available chemicals very toxic to birds which are readily accepted by corvids (Johnston 1965). They die in such a way that other birds are not alarmed and so large kills can result.

Although poisoning may kill a lot of crows it may also kill dogs just as readily; baits remain toxic for many weeks and could be transported by birds beyond the poisoner's property, so neighbours should be warned.

In the case of persistent egg stealing the poisoning of fowl eggs can eliminate the culprit, selectively.

While there is no doubt that under certain rare circumstances ravens may kill numbers of lambs that might otherwise have survived, relatively few lambs are susceptible to raven predation and the large majority of flocks lose lambs chiefly through other causes. With efficient and easily obtainable poisons such as are now available destruction of ravens is simple. Therefore, there is considerable danger that the traditional destruction of ravens by the farming community could lead to widespread slaughter of these birds and thus to a drastic reduction of the main natural removers of carrion, since the Australian avifauna has few other scavenging species. This could lead to greater outbreaks of fly-strike, since flies would have more carrion in which to breed, and thus to more stock losses than are caused by the present infrequent raven predation.

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