

The Role of Avian Scavengers in locating and exploiting Carcasses in central Saudi Arabia

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ABSTRACT

The order in which different avian scavengers arrive at a carcass, the length of time each species spends feeding, and the methods used to reduce inter-specific competition, were investigated in central Saudi Arabia. Twenty-five observations were made at carcasses placed at sites inside and outside the Mahazat as-Sayd protected area. Observations were also made at a town rubbish dump, where permanent food is available for scavengers. The Brown-necked Raven was the first species to arrive at a carcass, whereas the Lappet-faced Vulture was the last species to find and feed from a carcass. However, the number of vultures increased rapidly once the carcass had been discovered. Competition was reduced by different species attending the carcasses at different times of the day. For example, the small species, such as the eagles and ravens, fed early in the morning and in the late evening, whereas the large species, such as the Lappet-faced Vulture, concentrated their feeding around midday.

INTRODUCTION

The potential for competitive interactions between animals increases greatly where mixed species flocks feed on patchily distributed food resources, and there are many avian examples of this amongst waders and gulls (Goss-Custard 1980; Monaghan 1980). Many field studies of closely related species living in the same area have shown differentiation in feeding habits between species, at least during periods of food shortage (Lack 1954, 1971; Krebs & Davies 1981; Perrins & Birkhead 1983). Carrion represents a resource which is exploited by many bird and mammal species. However, the avian scavengers have a considerable advantage over mammalian competitors in locating these transient, isolated sources of food, through their greater ability to locate carcasses and low energy costs of travel (Houston 1974, 1979).

Among these avian scavengers are vulture species which feed mainly on carrion, and which can locate carcasses quickly even over long distances (Mundy *et al.* 1992). The Old World vultures are known to locate carrion only by sight, whereas among the New World vultures the three species of *Cathartes* also use olfaction (Stager 1964; Houston 1984; Mundy *et al.* 1992). Studies on ecological separation of African vultures have shown that there is considerable specialisation among the avian

scavengers to avoid competition over food (Kruuk 1967; Pennycuick 1972; Houston 1976, 1980; Mundy *et al.* 1992).

However, little is known of the scavenging guild in Arabia. In this study I aim to determine firstly the times at which the avian scavenger species arrive at carcasses; secondly, the length of time each species spends feeding at a carcass; and thirdly, to examine how the numbers and species composition of scavenging birds and mammals feeding at a carcass act to reduce competition among them. I made observations within a reserve, where only wild species were available as a source of food for scavengers, and also outside the reserve where wild animals are scarce but carcasses of domestic animals are abundant (Shobrak 1996).

STUDY AREA

The study was carried out in and around the Mahazat as-Sayd reserve, located on the arid plains of central-western Saudi Arabia, at 22° 00' - 22° 30' N and 41° 28' - 42° 13' E. The reserve (2,244 km²) was fenced in 1989 to exclude stock and nomadic herdsmen, and was the first site for the reintroduction of the Arabian oryx *Oryx leucoryx*, sand gazelles *Gazella subgutturosa*, mountain gazelle *Gazella gazella*, Houbara Bustard *Chlamydotis undulata* and Red-necked Ostrich *Struthio camelus camelus* in Saudi Arabia (Greth & Schwede 1993; Haque & Smith 1994, 1996).

METHODS

Two types of observations were made in this study. The first involved putting out carcasses and monitoring these continuously for 2-3 days. Twenty-five observations were made at sites inside and outside the reserve during most months between April 1993 and January 1995. Inside the reserve three sand gazelles and three Arabian oryx which had died from natural causes were used. Outside the reserve a total of 12 goats and 13 sheep were placed and observed. A total of 20 days were spent monitoring carcasses inside the reserve, and 45 days outside the reserve. The second set of observations was made at a rubbish dump outside the reserve, where butchers' waste was regularly discarded.

In both areas carcasses were provided at dawn (between 04:00 and 05:30 h) or on the previous day after sunset (between 18:00 and 19:30 h). Observations were made from a vehicle, which served as a hide. Carcass sites were selected in open areas where vegetation did not impede visibility. Observations on the dominance hierarchy between the scavenging species were made by recording the maximum number of each species attending the carcass, and the number of aggressive interactions between and within the different species. In addition, a correlation coefficient was calculated between the changes in the number of species with time, to see if the arrival of one species had an effect on the numbers of the other species.

The second set of observations were made at one month intervals at a rubbish dump 40km to the north of the reserve. The observations were started in February 1994 and extended for 11 months. It was possible to watch the behaviour of scavengers at this permanent food source for up to 8 hours per day, and to note the sequence in which different species arrived and the number of birds feeding at any one time. Similar observations were made when natural carcasses were found incidentally. In this study all birds except eagles were identified to species: the field identification of the *Aquila* eagles (Steppe *nipalensis*, Greater Spotted *clanga* and Imperial *heliaca*) is often difficult, and these species are considered collectively.

RESULTS

Locating the carcasses

The avian scavengers inside and outside the reserve can be divided according to their status into three groups: resident species; those species that use the area for feeding; and winter visitors (Newton & Newton 1993; Shobrak 1996). The resident species include the Lappet-faced Vulture *Torgos tracheliotos* and the Brown-necked Raven *Corvus ruficollis*. Species that used the area for feeding

Figure 1. The mean number of scavenging birds present at carcasses placed outside the reserve (bars indicate the standard error)

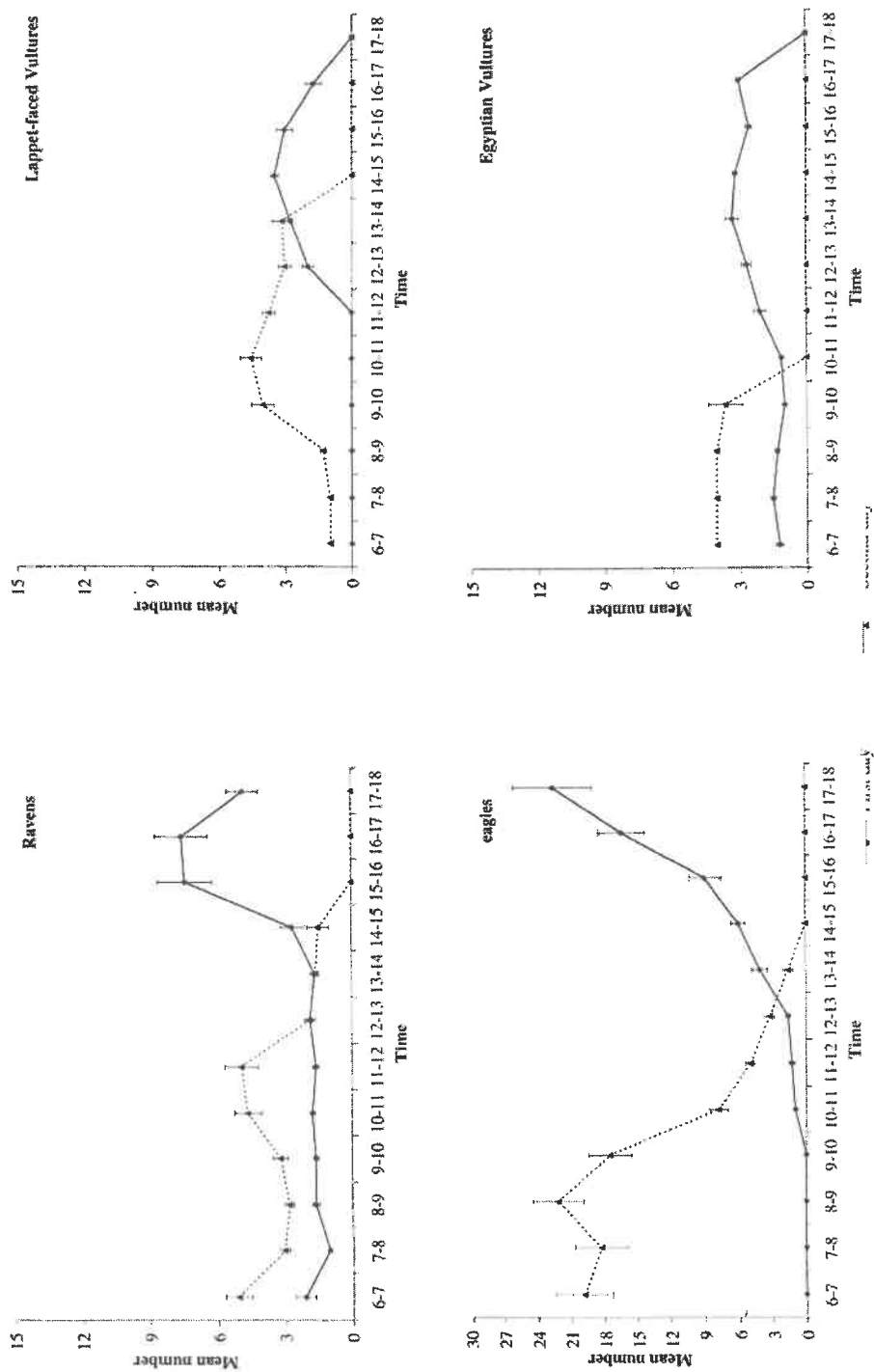


Figure 2. The mean number of scavenging birds present at carcasses placed inside the reserve (bars indicate the standard error)

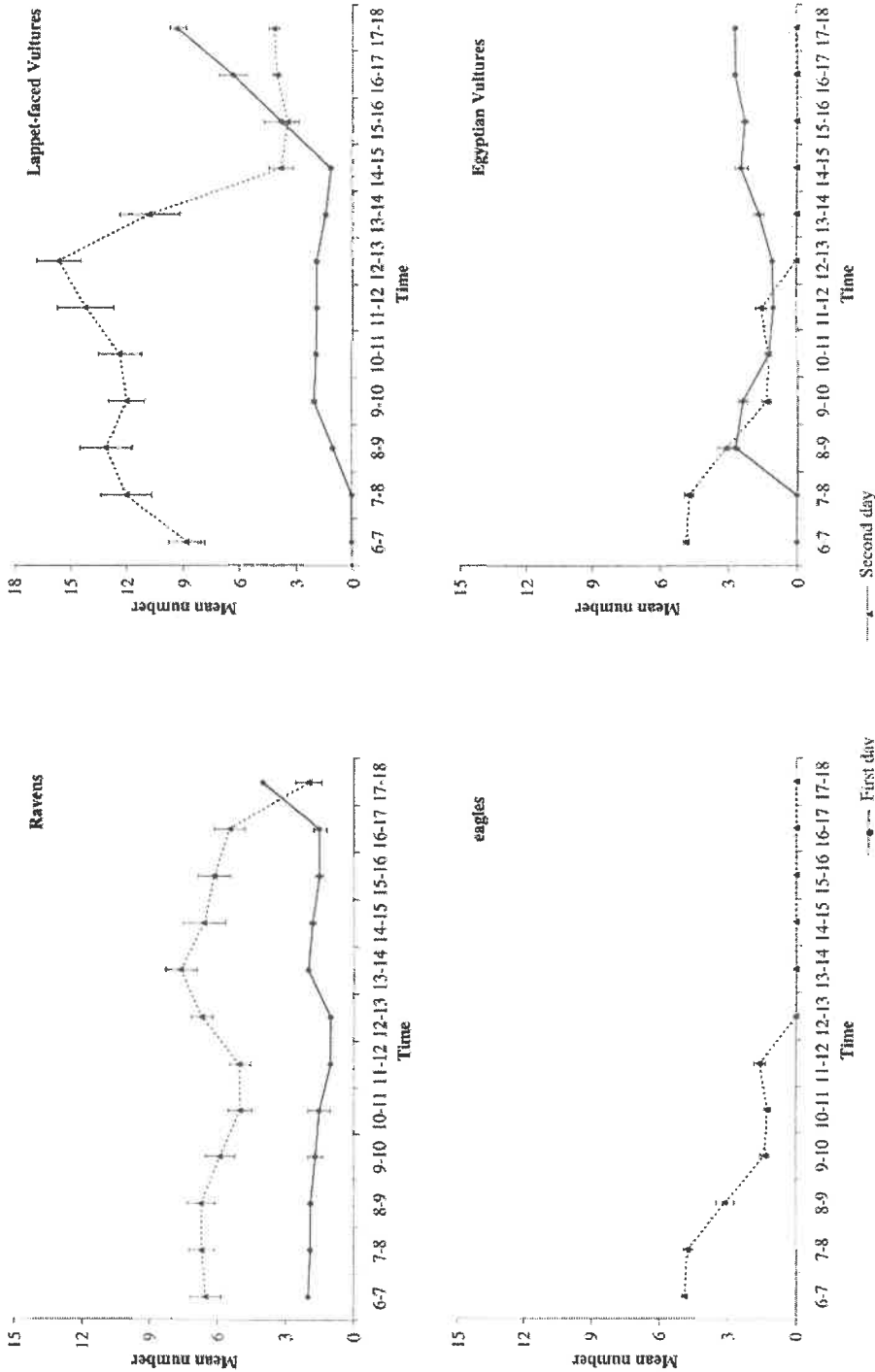
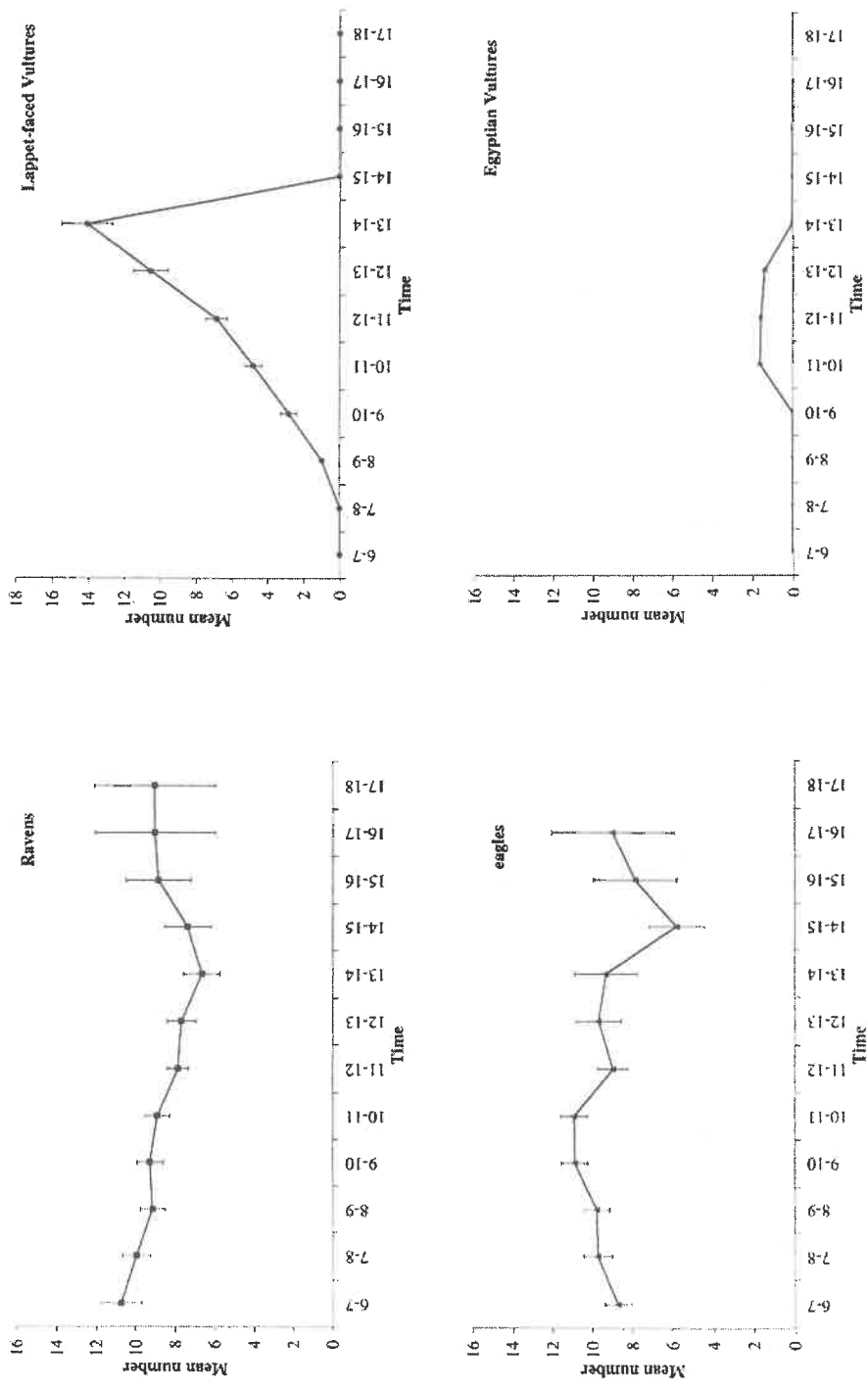


Figure 3. The mean number of scavenging birds at a permanent rubbish dump (bars indicates the standard error)



and roosting include the Griffon Vulture *Gyps fulvus* and the Egyptian Vulture *Neophron percnopterus*. Winter visitors include the Black Kite *Milvus migrans*, Cinereous Vulture *Aegypius monachus*, and Eagles, six species of which have been recorded in the reserve (Newton & Newton 1993): Bonelli's Eagle *Hieraetus fasciatus*, Booted Eagle *H. pennatus*, Golden Eagle *Aquila chrysaetos*, Imperial Eagle *A. heliaca*, Greater Spotted Eagle *A. clanga*, Steppe Eagle *A. nipalensis*. Of the five times in which the Cinereous Vulture was observed during the study, on one occasion one juvenile was seen attending the feeding at the rubbish dump.

Resident species

Lappet-faced Vulture

On the first day Lappet-faced Vultures outside the reserve arrived after 12:00 (Fig. 1), and there were significant differences among the numbers attending the carcasses by time of day (One-way ANOVA, $F_{4,74} = 5.90$, $P < 0.001$). Similarly inside the reserve, the numbers changed with time, and there were significantly more birds attending the carcass later in the day (One-way ANOVA, $F_{9,176} = 34.96$, $P < 0.001$) (Fig. 2). However, on the first day, birds inside the reserve arrived much later than those outside the reserve; 78% of birds coming to carcasses outside the reserve arrived before 15:00, compared with only 5% at carcasses inside the reserve.

On the second day, the birds returned at first light, although they did not start feeding from the carcasses immediately. The number of birds present at carcasses inside the reserve was significantly greater on the second day than on the first day (Mann-Whitney, U -test, $W = 33.5$, $P < 0.01$). Outside the reserve there was no significant difference in the number of birds present at the carcass on the first and second days (Mann-Whitney, U -test, $W = 140$, $P > 0.05$).

At the butchers' rubbish dump, where food was permanently available, the Lappet-faced Vultures arrived between 08:00 and 13:00. The number of feeding birds varied significantly with time of day (One-way ANOVA, $F_{7,263} = 19.90$, $P < 0.005$). The maximum numbers were observed between 13:00 and 14:00 (Fig. 3).

The Lappet-faced Vulture was seen feeding on most types of carcass. In the reserve, these vultures were most abundant at carcasses of medium size (30-60kg) such as those of Arabian oryx (Fig. 4), but overall there was no evidence that the size of carcass affected the number of birds feeding at it (One-way ANOVA, $F_{3,9} = 3.12$, $P > 0.05$). At the carcasses the Lappet-faced Vultures were seen feeding first from the head and from the exposed meat if the carcass was already open. Dominant birds stood on the carcasses before starting to tear the skin. At camel carcasses Lappet-faced Vultures were seen feeding only from the head, part of the neck and the rump, and rarely from the belly. After these parts had been consumed, vultures were not seen at carcasses, even though other edible parts remained.

Brown-necked Raven

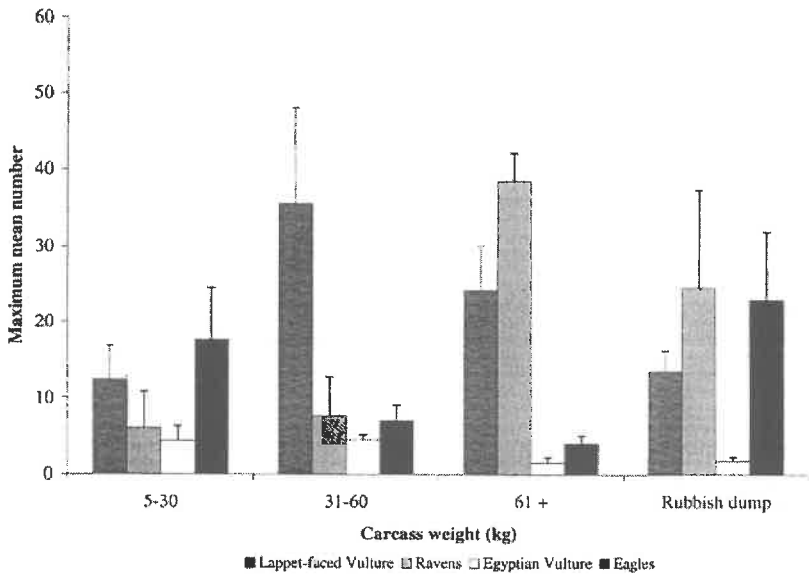
There were no significant differences between the maximum numbers of Brown-necked Ravens attending carcasses on the first and the second days inside and outside the reserve (Wilcoxon Matched-pairs test, $Z = -1.7529$, $P > 0.05$, $n = 8$ "inside"; $Z = -1.2741$, $P > 0.05$, $n = 13$ "outside") (Figs. 1 and 2).

At the rubbish dump, Ravens were seen most of the time. They arrived before 06:00, suggesting that they might roost in the area. There was no evidence that the number of ravens at the dump varied with the time of day (One-way ANOVA, $F_{10,1081} = 1.27$, $P > 0.05$), (Fig. 3). The maximum number observed at the rubbish dump was 54 birds; they were mostly young and non-breeding birds.

The Brown-necked Raven was usually the first species to arrive at the carcass. Out of 17 occasions on which ravens arrived first, on 12 occasions the birds were in pairs, and on three occasions they arrived as trios; on only two occasions did a single bird arrive at the carcass. The first arrival time of ravens at carcasses was normally between 05:30 and 09:30 on the first day. But on one occasion they arrived late in the evening at 17:00. Ravens were observed three times hammering vigorously at bloated carcasses, but succeeded only once in penetrating the skin. The bill structure in this bird is

not adapted to tearing tough skin, but they could succeed in opening small carcasses, such as those of young sheep, goats and gazelles. However, they were seen at all types of carcasses (Fig. 4). There was a highly significant difference in the maximum number of ravens recorded at carcasses of different weight (One-way ANOVA, $F_{3,34} = 20.99$, $P < 0.001$), showing that large carcasses attracted larger numbers of birds

Figure 4. The mean maximum numbers of avian scavengers attending carcasses of different weights (bars represent the standard error)



The species using the area for feeding

Egyptian Vulture

The number of Egyptian Vultures feeding in the study area was low compared to other species, and no more than eight birds were recorded at any one time. Outside the reserve, the number of Egyptian Vultures increased during the day (One-way ANOVA, $F_{10,223} = 11.16$, $P < 0.001$) (Fig 1). Inside the reserve, numbers similarly changed through the day (One-way ANOVA, $F_{9,185} = 20$, $P < 0.05$) (Fig. 2). On the second day the birds were present only in the morning, and had usually left the carcass by midday. Egyptian Vultures were seen only twice at the rubbish dump, and the maximum number was two (Fig. 3).

Similarly to the ravens, the Egyptian Vultures are not adapted for tearing tough skin; they were seen tearing the skin around the skull, but not on other parts of the carcasses. More birds were recorded at small carcasses than at large ones (One-way ANOVA, $F_{3,14} = 5.04$, $P < 0.02$) (Fig. 4).

Griffon Vulture

Only two Griffon Vultures were observed: at two carcasses inside the reserve.

The migratory species

Eagles

The number of eagles at a carcass increased throughout the first day outside the reserve (One-way ANOVA, $F_{7,190} = 13.24$, $P < 0.001$). They were seen roosting near the carcasses, and on the second day they started feeding at first light (Fig. 1); numbers then decreased throughout the day (One-way ANOVA, $F_{7,216} = 14.47$, $P < 0.001$). Comparing the number of eagles which attended the carcasses in the first and second days outside the reserve, there were no significant differences (Mann-Whitney test $W = 95.5$, $P > 0.05$). In the reserve there was one observation of a single bird which arrived on the first day. However, on the second day the number of birds attending the carcass had increased and there was a significant difference in the number of eagles present at different times of the day (One-way ANOVA, $F_{11,226} = 16.55$, $P < 0.001$) (Fig. 2).

At the rubbish dump, eagles arrived before 06:00 indicating that they may roost there. The number of eagles did not vary with the time of day (One-way ANOVA, $F = 1.23$, $P > 0.001$) (Fig. 3).

Similarly to the Egyptian Vultures and ravens, the eagles are not adapted for tearing tough skin, but they could succeed in opening small carcasses. A Steppe Eagle was once seen opening the carcass of an adult gazelle. It started with the soft tissue on the head and back before ripping open the belly area between the back legs. However, there was no significant difference in the maximum numbers of eagles observed at any one time attending carcasses of different weight (One-way ANOVA, $F_{3,12} = 0.482$, $P > 0.05$) (Fig. 4).

Other species

Black Kite and Cinereous Vulture were observed at the carcasses, but their numbers were too small for statistical analysis, and the time they spent at the carcasses was short.

Mammalian scavengers

The mammalian carnivores which could scavenge in the study area are the Arabian red fox *Vulpes vulpes* and Rüppells fox *Vulpes ruppelli*, feral dog *Canis familiaris* and wild cat *Felis silvestris*, sand cat *F. margarita*, and feral cats *F. domesticus*. Most of these species are nocturnal, and were not seen to visit the carcasses during the day. Tracks of foxes and cats were found close to carcasses in 5 of 25 cases, indicating nocturnal feeding. These tracks were found in the late summer and autumn, when the numbers of rodents and insects are known to be low and foxes may then have to seek alternative food (Olfermann 1993, 1996). Additionally, feral dogs were observed feeding on four occasions at the rubbish dump. On all occasions all the avian scavengers were observed to move away as soon as dogs arrived, and there is no doubt that dogs are dominant over the birds. However, these animals are becoming a target for persecution from the shepherds and farmers as they claim that these animals attack their livestock. Two dogs were shot in front of my car in December 1993, and the hunter was then congratulated by local people as they considered he had done them a favour.

The dominance hierarchy among scavenging species

Avian scavengers

Table 1 shows the percentage of interactions among the bird species. The Lappet-faced Vulture was the most aggressive against members of its own species. Other birds often moved aside from carcasses when dominant Lappet-faced Vultures approached. Although the Brown-necked Ravens were often the first species to arrive at carcasses, they also gathered in large numbers at the rubbish dump during summer and autumn. They showed high levels of intraspecific aggression. In groups they would also try to dominate the feeding area, by chasing other larger birds, such as the Lappet-faced Vulture, by pulling their tails and jumping on their backs. There is an excess of food at the site, and ravens rarely took advantage of a food item after it had been abandoned by the bird that they attacked. This area holds large numbers of immature ravens, rather than territorial adults.

Ravens also sometimes attack small birds which come to feed on the insects around the carcasses. Fifteen Brown-necked Ravens were observed at the rubbish dump site chasing a Hoopoe Lark *Alaemon*

alaudipes. At carcasses placed at other sites I have seen the local territorial ravens behave similarly. However, on most occasions the ravens lost fights with larger species.

Table 1 also shows that most of the aggression by scavenging species was directed towards members of the same species. The eagles were the only birds to show strong aggression against the Lappet-faced Vulture. Figures 1 and 2 show that competition among the scavenging birds was reduced through species attending the carcasses at different times. The smaller species fed mainly in the morning and the evening, whereas the Lappet-faced Vultures started at mid-day.

Avian scavengers might avoid competition by leaving a carcass when more dominant species arrive. However, there was no correlation between the changes in the numbers of Lappet-faced Vultures and eagles ($r_{s2} = -0.056$, $P > 0.5$), nor ravens and eagles ($r_{s2} = -0.038$, $P > 0.5$), nor ravens and Lappet-faced Vultures ($r_{s2} = -0.038$, $P > 0.5$). Each species has preferred feeding times, which as a consequence avoids competition with other species, but the arrival of dominant species has no influence on the presence of birds at carcasses.

DISCUSSION

Locating the carcasses

Lappet-faced Vulture

The results showed that the Lappet-faced Vulture was usually the last species to arrive or to approach a carcass. These birds also appeared hesitant near carcasses. Their large size makes it difficult for them to take off and they are therefore more vulnerable to predation than the smaller scavenger species. This shyness at food has been observed in other small and large scavenging birds (Heinrich 1988; Mundy *et al* 1992).

Because the birds roost inside the reserve, they might be expected to locate carcasses within the reserve very quickly. But in fact very few vultures locate carcasses inside the reserve before late afternoon, possibly because there is so little food usually found within the reserve that it is not worth their time to search there and they go immediately outside the reserve as soon as they leave the roost. When birds returned to the reserve to roost later in the day they might then find a carcass located there. At all observations the birds did not start feeding from the carcasses on this first day, but they were seen resting near the carcass and then roosting in nearby trees overnight. Presumably these birds started feeding from the same carcass the next day.

Communal roosts could function as centres for the exchange of information on the location of food (Ward & Zahavi 1973; Weatherhead 1983). Studies on the New World Turkey Vulture *Cathartes aura* in southern Ontario, Canada, show that roosts do not function in this way (Prior & Weatherhead 1991), but there is good evidence that they do for the New World Black Vulture (Rabenold 1987). From my own study, I consider that Lappet-faced Vultures were not roosting communally in order to acquire information about food, but rather this might enable the birds to form a "network" in the sky and thus search effectively for food over a large area. Most birds started foraging singly or in pairs and they moved in different directions (Shobrak 1996) enabling them to cover the area effectively. Prior & Weatherhead (1991) suggested that food patches must persist for at least two days for roosts to function as information centres since most roosting birds only travel to and from the roost once each day. In the study area the majority of Lappet-faced Vultures roost near the carcass in the first day to start feeding at first light of the second day. This is especially true for carcasses placed inside the reserve, as most of these carcasses were placed between 500m and 10km from the roost site, and birds descending to food would be seen easily by the other roosting vultures.

Brown-necked Raven

There may be several reasons why the Brown-necked Raven was most often the first to arrive at a carcass. Firstly, the species is more common in the area than any other scavenging species (Jennings 1995; Newton & Newton 1993). Secondly, this species breeds solitarily and related species are known to occupy large territories (Goodwin 1976; Knight & Call 1980; Marzluff & Heinrich 1991;

Heinrich *et al.* 1994). According to Bossema & Benus (1985), ravens probably form lasting pair bonds and once established in a territory they occupy it for life. In all the sites where carcasses were placed there was a territorial pair of ravens occupying the area, and they usually arrived at the carcasses first. Finally, the ability of ravens to use flapping rather than gliding flight may allow them to start foraging early in the morning before the thermals form, upon which gliding birds such as vultures rely. In agricultural areas in Africa carcasses were also located most often by crows and ravens (Mundy *et al.* 1992).

There may be various reasons why the number of ravens at carcasses inside the reserve varied with the time of day while numbers at carcasses outside the reserve did not. Firstly, this could be due to the different numbers of ravens inside and outside the reserve. Secondly, it could be due to the difference in the size of territories and home ranges, or thirdly it could be related to the availability of food in the two areas. Newton (1979) suggested that the home range size varies depending on the food supply available to a raptor.

Eagles

As a result of hunting and overgrazing in Saudi Arabia the majority of wild prey species, which eagles could feed on during migration, have been depleted or driven to extinction in some areas (Child & Grainger 1990). As a result, the eagles instead take advantage of carrion available in the area. The number of eagles feeding at the rubbish dump was constant through the day. This does not necessarily mean that the same birds remained through the day because new birds may take the opportunity to feed when a satiated bird leaves the patch (Krebs & Davies 1981; Perrins & Birkhead 1983).

Mammalian carnivores

Large carnivores, which used to prey on wild ungulates, have started to feed on the increasing domestic herds, leading to a negative attitude of the local people towards these animals. Predators such as wolf and hyena are now absent from many areas in Saudi Arabia (Child & Grainger 1990). Although there were other mammalian scavengers in the area, such as the foxes, they have alternative food supplies and they mainly feed on insects and small mammals (Olfermann 1993, 1996). The other feral mammals occur only near the small towns and villages where they feed from the garbage dumps, but they were not responsible for removing substantial amounts from the provided carcasses. Shobrak (1996) estimated that the percentage of food utilized by the mammalian scavengers from the carcasses available around the reserve was only 4.4%.

The dominance hierarchy among scavenging species

Avian scavengers are more successful than the mammalian scavengers in utilizing these carcasses. Birds have many advantages in searching for food from the air, because they can cover large areas, and by watching other birds they can collaborate to find food. Pennycuik (1975) estimated the horizontal speed of a vulture in steep dive can reach 70km/h while the running speed of a hyena is about 40 km/h, so vultures can cover large areas with little energy while mammals use considerably more energy to reach food (Schmidt-Nielsen 1972; Pennycuik 1975).

Houston's (1976) studies in the Serengeti implied that vultures do not gain an advantage over mammalian scavengers just because they get to the carcasses first. Their advantage is also that they find carcasses that the mammalian scavengers often never reach at all. In this study the mammalian carnivores are nocturnal, therefore competition at the food source was reduced between this group and the scavenging birds, but it was also found that mammalian scavengers failed to locate most of the sources of food provided. Shobrak (1996) found that the amount of food available to the scavenging species in all areas was more than they could utilize, and there were large proportions of the carcasses (65%) which were uneaten by any of the birds and mammals.

Among the avian scavengers the Lappet-faced Vultures have an advantage over all other scavenging birds, probably due to large body size which allows them to drive away competitors and to survive for longer periods between meals (Kruuk 1967; Lack 1971; Wallace & Temple 1987).

Table 1. Percentage frequency of interactions among avian scavengers at 14 carcasses, (number of aggressive attacks = 1850).

	<i>L.f.V¹</i>	<i>Raven</i>	<i>Eagles</i>	<i>Others²</i>
Intraspecific	71.5	39.7	63.3	
Interspecific	28.5	60.3	36.7	
Interspecific Wins	70.9	25.8	64.8	
Interspecific Losses	29.1	74.2	35.2	
Overall proportion of interactions	41.8	25.3	30.7	2.2

1 Lappet-faced Vulture

2 Griffon Vulture, Black Kite, Egyptian Vulture and Marsh Harrier *Circus aeruginosus*.

They also require less energy per day per unit weight than do smaller birds (König 1983). The small scavenging birds have alternative food sources, and need unspecialised beaks even though carrion may be important as part of their diet for certain periods of the year. By contrast, the Lappet-faced Vulture concentrates on carrion and has a deep powerful beak with a strong hook at the tip adapted for tearing skin and feeding on the meat of mammals (Houston 1979; Mundy *et al.* 1992). This species is clearly the major scavenger on carcasses in the study area. Its ability to open the skin of large carcasses also provides feeding sites for the smaller scavenger species.

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