Factors influencing the use of winter-burnt grassland by foraging bald ibises *Geronticus calvus*

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Use of winter-burnt grassland by foraging bald ibises, *Geronticus calvus*, and the abundance of invertebrates in winter-burnt grassland were investigated in relation to the time elapsed after burning in Natal high grassland. Bald ibises were recorded feeding in dormant, winter-burnt grassland from less than 4 h after burning up to 35 days after burning. Insects and other potential prey items were significantly more abundant 0 – 7 days than 14 – 37 days after burning: most specimens consisted of fire-killed arthropods. Live insects increased in abundance soon after the appearance of new growth 46 – 82 days after burning. Possible factors influencing the use of winter-burnt grassland by foraging bald ibises are discussed with emphasis on changes in the relative abundance of living and dead arthropods in relation to the time elapsed after burning.

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Die benutting van winter-gebrande grasveld deur kossoekende kalkoenibisse, *Geronticus calvus*, en die talrykheid van ongewerwelde diere in winter-gebrande grasveld, is in die Natalse hoë-grasveld met betrekking tot tydsverloop na 'n brand ondersoek. Kalkoenibisse wat kos soek in rustende winter-gebrande grasveld, is vanaf minder as 24 h na 'n brand tot solank as 35 dae daarna, aangeteken. Insekte en ander moontlike prooi was 0 – 7 dae na die brand beduidend meer volop as 14 – 37 dae daarna: die meeste voorbeelde het uit doodgebrande geleedpotige diere bestaan. Lewende insekte het kort na die verskyning van die nabrandse uitloop (46 – 82 dae na die brand) in getalle toegeneem. Die moontlike faktore wat die benutting van winter-gebrande grasveld deur kossoekende kalkoenibisse beïnvloed, word met beklemtoning van veranderings in die relatiewe talrykheid van lewende en dooie geleedpotige diere in verhouding met tydsverloop na die brand, bespreek.

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The bald ibis *Geronticus calvus* (Aves: Threskiornithidae) is a rare species endemic to the south-eastern highlands of southern Africa. It is highly gregarious, usually feeding in flocks and roosting communally on cliffs and in trees. The bald ibis forages in open grassland areas primarily on arthropods, earthworms and other small invertebrates obtained in grassland and cultivated lands (Vincent & Symons 1948; Siegfried 1971; McLachlan & Liversidge 1978; Manry 1982).

The grassland inhabited by *G. calvus* is burnt annually by landowners, usually between May and November, and the bald ibis feeds extensively in burnt grassland and in short, post-burn regrowth (Manry 1982). I investigated the use of winter-burnt grassland by foraging bald ibises, and changes in arthropod abundance in winter-burnt grassland, in relation to the time elapsed after burning.

Study area and grass burning

The study area (Manry 1982) is in western Natal, South Africa, between 950 and 1 950 m above sea level with ambient temperatures from – 13,3 to 45,0 °C and mean annual rainfall of 600 to 1 000 mm. About 48% of the total annual rainfall occurs in summer (December – February), and only 5 – 6% in winter (June – August). Winter frosts are severe, but snowfalls are extremely rare (Edwards 1967; Manry 1982).

About 74% of the study area consists of indigenous grassland and savanna-woodland vegetation (Manry 1982). In its natural condition, the grassland is treeless, but plantations of conifers, eucalypts and other exotic trees are now commonplace since the arrival of European settlers in the mid-19th century (Edwards 1967). About 26% of the study area is under cultivation, silviculture and non-agricultural forms of land-use (Manry 1982).

During autumn (March-May) grass in the study area becomes dry and highly flammable. Landowners burn strips of grassland (usually between 10 and 100 m wide) from May to July to create a network of firebreaks for protection against runaway grass fires. Firebreaks burnt during June – July, and large areas of grassland burnt inadvertently when firebreaks are prepared, are herein referred to collectively as 'winter-burnt grassland'. Grassland burnt during this period remains dormant with no sustained aerial regrowth, until rain and/or rising soil temperature stimulate the resumption of aerial growth sometime between mid-July and mid-August (Edwards 1967; Manry 1982).

Methods

From June 1978 to November 1980 I recorded all sightings

of bald ibises foraging in the study area. At each sighting I noted the date, time of day, locality, the number of ibises present and habitat type (Manry 1982). Where ibises were observed feeding in dormant burnt grassland an attempt was made to contact the property owner to ascertain the date of burning.

Invertebrates were sampled on four different firebreaks burnt between 2 June and 6 July 1980 on the farm 'Durleigh' (29°15'S/29°55'E; 1 450 m above sea level) in *Themeda-Trachypogon* Highlands Grassland (Edwards 1967), approximately 10 km S.W. of Mooi River, Natal. *Themeda-Trachypogon* Highlands Grassland is dominated by *Themeda trianda, Apochaete hispida, Trachypogon spicatus* and *Heteropogon contortus*, and achieves a height of 1,0 m under favourable conditions (Edwards 1967). Samples were collected systematically during June – August 1980 using a bottomless cardboard carton (580 × 380 × 380 mm wide) with a removable top. The sampling box was suspended on the end of a 2-m pole, carried along the midline of the firebreak and dropped to the ground suddenly at *ca* 10-m intervals. The top was then removed and all living or dead macrofauna specimens with a combined head-abdomen length of ⩾ 5,0 mm were collected and deposited in glass vials (the minimum size criterion eliminated micro-invertebrates such as collembolans and formicids from the samples). Ash and other detritus were dislodged and removed by gentle blowing and sweeping with a small paintbrush, and all invertebrates were collected.

Thirty samples were collected from each firebreak in each sampling trial, and each sampling trial required *ca* 2,9 h to complete.

Use of winter-burnt grassland by foraging bald ibises

Bald ibises feeding in dormant burnt grassland during winter were encountered singly or in groups of 2 to 52 birds (mean ± S.D.: 9,17 ± 12,12; n = 30).

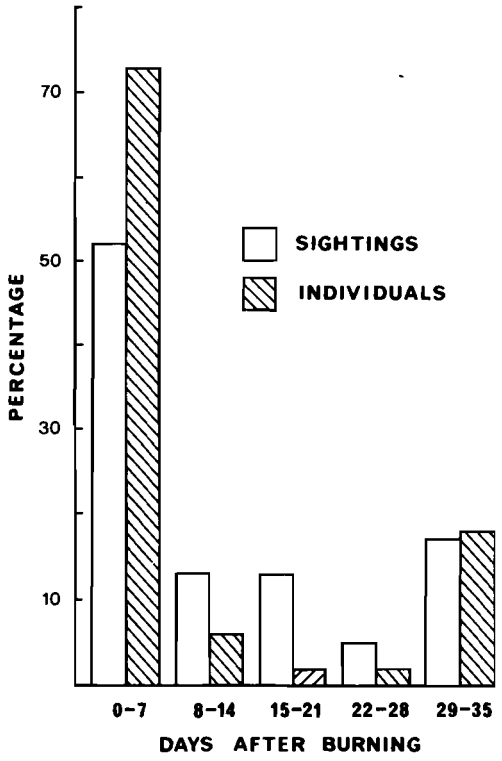

Figure 1 Relative frequency of bald ibises recorded feeding in dormant, winter-burnt grassland during June – August in 1978, 1979 and 1980, in relation to the time elapsed after burning, based on 23 sightings and 180 total individuals.

Of a total of 30 sightings of bald ibises feeding in dormant burnt grassland during June – August in 1978, 1979 and 1980, the age of the burn was determined in 23 separate cases, involving a total of 180 individuals (Figure 1). A majority of these sightings (52%) and total individuals (73%) was recorded during the initial seven days after burning, including six sightings (involving a total of 43 individuals) recorded in dormant burnt grassland 2 – 24 h after burning. The remaining records were made between one and 35 days after burning (Figure 1). The observed distribution of sightings among the five age-groups of winter-burnt grassland (Figure 1) departed significantly from a hypothetical equitable distribution (χ^2 = 15,913; d.f. = 4, $P < 0{,}005$).

Arthropods in winter-burnt grassland

A total of 360 samples was collected in 12 sampling trials on four different firebreaks. All macrofauna collected were arthropods — acridids, blattids, lepidopteran larvae and spiders being the most numerous (Table 1). Acridids, blattids, and scarabaeids were recorded in 42 – 75% of all sampling trials (Table 1).

Samples were assigned to three different groups, *viz.* those collected 0 – 7 days after burning, those collected > 7 days after burning but before the resumption of sustained aerial growth (i.e. 14 – 37 days after burning), and those collected in the early

Table 1 Numbers of living and dead arthropods collected in 12 sampling trials on four different firebreaks on the farm 'Durleigh' during June – August 1980. Total specimens = 164

Taxon	Total number of each taxon collected		Percent total specimens	Frequency in sampling trials (%)
	Alive	Dead		
Class Arachnida				
Order Araneae (spiders)	18	0	10,97	33,3
Order Acarina (ticks)	0	1	0,61	8,3
Class Chilopoda (centipedes)	0	1	0,61	8,3
Class Insecta				
Order Orthoptera				
Acrididae	53	39	56,10	75,0
Blattidae	8	1	5,49	66,7
Tetrigidae	0	1	0,61	8,3
Tettigoniidae	2	1	1,83	16,7
Order Isoptera (termites)	0	1	0,61	8,3
Order Hemiptera				
Coreidae	0	1	0,61	8,3
Pentatomidae	4	1	3,05	25,0
Reduviidae	0	1	0,61	8,3
Order Homoptera				
Cicadellidae	1	1	1,22	16,7
Order Lepidoptera				
larvae	5	8	7,92	33,3
pupae	0	1	0,61	8,3
Order Coleoptera				
Curculionidae	2	3	3,05	33,3
Scarabaeidae	0	8	4,88	41,7
Tenebrionidae	0	1	0,61	8,3
Order Hymenoptera (wasps)	0	1	0,61	8,3

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stages of renewed aerial growth (46 – 82 days after burning) (Table 2). These data indicate some possible trends in the availability of potential food items for bald ibises in winter-burnt grassland. Living (χ^2 = 8,395; d.f. = 1; $P < 0{,}005$) and dead (χ^2 = 45,150; d.f. = 1, $P < 0{,}005$) arthropods were significantly more abundant in dormant burnt grassland during the initial week after burning, compared to 14 – 37 days after burning. The abundance of live arthropods increased significantly (χ^2 = 23,290; d.f. = 1; $P < 0{,}005$) after the appearance of renewed grass growth on winter-burnt areas, while the number of dead arthropods continued to decline (Table 2).

In 1980, sustained aerial growth appeared on all four firebreaks in mid-August, *ca* 36 – 70 days after burning. Samples collected after the resumption of sustained aerial growth (46 – 82 days after burning) indicate a concomitant increase in the abundance of live invertebrates in winter-burnt grassland to levels exceeding those obtained during the initial week after burning (Table 2).

Table 2 Numbers of living and dead arthropods collected in 360 samples in winter-burnt grassland in relation to time elapsed after burning

Days elapsed after burning	Total number of samples	Number of arthropods collected	
		Alive	Dead
dormant grassland			
0 – 7	120	31	61
14 – 37	120	12	6
post-burn regrowth			
46 – 82	120	50	4

Discussion

The feeding habits of *G. calvus* are poorly known and no systematic study of its diet has been made, although insects, earthworms, snails and small vertebrates probably form the bulk of the food (Layard & Sharpe 1875 – 1884; Start & Sclater 1906; Roberts 1940; Vincent & Symons 1948), reflecting a dietary range similar to that recorded for the closely related waldrapp or red-cheeked ibis *G. eremita* of Turkey and Morocco (Smith 1970; Cramp & Simmons 1977; Hirsch 1979). Although no observations were made on the selectivity of bald ibises for particular prey items, the results of sampling macrofauna in winter-burnt grassland suggests that acridids, blattids, coleopterans, lepidopterous larvae and spiders compose the bulk of food items consumed by *G. calvus* during winter, when most sightings of foraging bald ibises were recorded in burnt grassland (Manry 1982).

Observations on bald ibises foraging in dormant, winter-burnt grassland for which the date of burning was determined indicate that the birds feed in such habitat mainly during the initial week after burning, but continue to visit burnt areas for at least five weeks after burning. Sampling of macrofauna indicates that living and dead arthropods are most abundant in dormant, winter-burnt grassland 0 – 7 days after burning, but occur in reduced numbers 14 – 37 days after burning, although dead arthropods in particular are substantially less abundant following the initial week after burning.

The primary advantage to bald ibises feeding in recently burnt grassland, compared to older burnt areas, may be the abundance of prey items killed by the fire. Arthropods killed in grass fires are little damaged except for scorching of extremities. Living and dead arthropods are easier to locate in burnt grassland, where most vegetation has been removed by the fire, and once located, dead prey items require no further pursuit. Moreover, invertebrates fleeing ahead of the fire may accumulate in front of the advancing flame front and be overtaken, leaving rich concentrations of dead prey items which are dispersed patchily on the firebreak. After landing on a firebreak, bald ibises usually move uni-directionally across the burnt area as a bunched flock, or in a row, with each bird maintining a regular distance of *ca* 0,4 – 1,5 m from its nearest neighbour on either side. Bald ibises walk rapidly over burnt grassland picking up food items from the surface and occasionally probing the ground on both sides of the search patch. Birds that lag behind the formation to feed where prey items are concentrated soon attract other ibises to their vicinity. In these circumstances bald ibises seemed tolerant of conspecifics feeding close by, and occasionally two of three birds probed simultaneously in an area of less than 0,01 m^2 without showing signs of aggression. The bald ibis's group-foraging behaviour, involving systematic ground-search formations and mutual tolerance of conspecifics feeding very close by, seems well suited to locating and exploiting localized concentrations of food in burnt areas.

An additional advantage of foraging in burnt grassland is the conspicuous appearance of burnt areas compared to the surrounding unburnt grass, so that they can be located easily from an aerial vantage point. Bald ibises use rising air currents to gain altitude, ascending in thermals or updraughts, usually in compact flocks, and after attaining a certain height the birds glide in a shallow descent to intercept the ground several kilometres away.

Bald ibises can apparently distinguish recently burnt ($\leqslant 7$ days) from older (>7 days) areas of winter-burnt grassland. How they do this is not known, but two methods seem plausible. First, ibises may detect a grass fire some considerable distance away by noticing the rising smoke column and flying toward it. After locating a burnt area, an ibis may return to it to feed on subsequent days, perhaps accompanied by other ibises that were previously unaware of its position. Secondly, bald ibises may use colour as an indicator of a burnt area's age. Recently burnt grassland is dark black, but its colour fades gradually as the ash is dispersed by wind. Human investigators estimate the ages of burnt areas appearing in satellite imagery by referring to a grey scale (Jarman 1973). Similarly, *G. calvus* may also distinguish recently from older burnt areas by their degree of blackness.

The abundance of living and dead arthropods on a firebreak immediately after the fire will depend partly on the numbers present at the time of burning, the nature of the vegetation and terrain, as well as the type, intensity and rate of spread of the fire. Highly mobile invertebrates flee into the surrounding unburnt vegetation, while others take refuge in rocks, termitaria, burrows, cracks in the ground and islands of unburnt vegetation, and may re-occupy the burnt area later. Subterranean forms are generally unaffected by fire *per se*, but may be adversely affected by the post-fire environment (Rice 1932; Cancelado & Yonke 1970; Gillon 1972; Lamotte 1975; Frost in press). The rate at which the numbers of living and fire-killed invertebrates diminish on a firebreak after burning will depend partly on local decomposition rates, and the presence of predators and scavengers.

Shortly after the renewal of aerial growth in burnt grassland between mid-July and mid-August, *G. calvus* adjusts its winter

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foraging strategy, which emphasizes feeding in recently burnt grassland, to include older burnt areas supporting short, post-burn regrowth (Manry 1982). Several studies conducted in grassland and savanna areas in North America and tropical Africa show that invertebrates begin to increase in numbers in burnt vegetation shortly after the renewal of aerial growth, and that the abundance of invertebrates in post-burn regrowth may exceed that obtained in adjacent, unburnt vegetation (Rice 1932; Tester & Marshall 1961; Cancelado & Yonke 1970; Gillon 1972; Lamotte 1975). In the present study an increase in arthropod numbers was apparent *ca* 10 – 14 days after the appearance of new growth. Thus, old winter-burnt grassland may become a highly profitable habitat type for foraging bald ibises shortly after the renewal of aerial growth in late winter.

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