in Quelea quelea - Africa's Bird Pest, Richard L. Bruggers and Clive C. H. Elliott, eds. 1989. pp 262-280.

19

Assessment of bird-repellent chemicals in Africa

RICHARD L. BRUGGERS

Introduction

Chemical repellents have been used to protect crops since the onset of agriculture. Wright (1981) reviewed chemical repellents and gave a brief history of their use, derivation from natural plant substances, and an account of the sensory mechanisms by which birds perceive chemical stimuli. Repellents began receiving attention in Africa in the mid-1970s. This chapter reviews and summarizes the results of research evaluating chemical repellents for protecting crops from pest birds in Africa and suggests possible directions for future research.

Phenomenon of repellency

Rogers (1978*a*) defined a repellent as 'a compound or combination of compounds that, when added to a food source, acts through the taste system to produce a marked decrease in the utilization of that food by the target species'. Schafer (1981) characterized repellents as 'tactile (chemical modification of surfaces), taste (chemical modification of flavours), physiological (chemical-induced illness), and other (primarily chemically caused behavioural changes over large areas not directly treated)'. Rogers (1978*a*) stated that, historically, no consistently effective chemical repellents have been developed for use against vertebrate pests, primarily because, until recently, efforts were directed towards finding 'bad-tasting' chemicals. This search was predicated on an anthropomorphic-based assumption that the human taste experience was directly transferable to birds. Although birds possess the same basic sensory mechanisms as mammals, it is naive to assume that their perception of stimuli corresponds to that of humans (Wright 1981). This approach led to laboratory screening efforts that resulted in many candidate chemicals for field testing.

Most researchers believe that a co-ordinated effort among chemists, biologists, behaviourists, physiologists, and other disciplines is needed if chemical repellents are to function effectively (Rogers 1978*a*). Understanding a chemical's mode of action, the sensory physiology of the bird, and its subsequent behaviour has become important to demonstrating efficacy data to obtain Environmental Protection Agency (EPA) registration. Registering chemicals is such a lengthy and costly process—estimated at US $15 million (Weidner 1983)—that it is impractical to develop new chemicals for minor uses on specific avian species (Schafer 1981).

Using repellents to protect crops from highly gregarious, grain-eating birds in Africa is based on the premise that not all individuals in feeding flocks must be affected to inhibit feeding. Because birds will learn to avoid food that makes them ill (Wright 1981), in some cases for 4 weeks or longer (Rogers 1978*b*), chemicals that cause a conditioned taste aversion would seem to show more promise as repellents than chemicals that simply taste bad (Rogers 1980). Conspecifics in feeding flocks also can learn to avoid treated food by observing affected birds (Mason and Reidinger 1981).

Repellents tested in Africa

Chemical repellents have been evaluated in more than 40 demonstrations or replicated trials in 15 African countries between 1975 and 1984. The principal repellents tested in Africa included one that apparently affects the taste sense, Curb^R (synergized aluminium ammonium sulphate, SAAS), and two that apparently cause an illness-induced, adverse physiological reaction, methiocarb [3,5-dimethyl-4-(methylthio)phenyl methylcarbamate, Mesurol^R] and trimethacarb (80 per cent 3,4,5-trimethylphenyl methylcarbamate and 20 per cent 2,3,5-trimethylphenyl methylcarbamate). These studies determined the susceptibility of different pest species to the repellents and the effective application rates for seed dressings and ripening panicles. Application procedures were also improved and made more economical and residue degradation patterns were determined.

General species sensitivity

Considerable variation exists in the sensitivity of African bird species to the repellent and toxic effects of the three chemicals (Table 19.1). All species were more sensitive to methiocarb than the other chemicals in R_{50} tests—the concentration at which 50 per cent of the birds are repelled in a single-choice test. Sensitivity data paralleled field experience, for higher application rates of Curb and trimethacarb were needed to obtain field efficacy than for

Table 19.1. Comparison of chemical repellent LD_{50} (mg/kg) and R_{50} (%) for several pest bird species. Sensitivities for all species not denoted with superscripts were determined in Bruggers *et al.* (1984*b*).

Chemical	*Quelea quelea*	*Passer domesticus*	*Psittacula krameri*	*Ploceus cucullatus*	*Agelaius phoeniceus*	*Passer luteus*	*Euplectes orix*
Methiocarb (Mesurol®)							
LD_{50}	4.2[a]	14.1	7.1	7.5[b]	4.7[c]	5.62[b]	5.62[b]
R_{50}	0.02[d]	0.11	0.18	0.06[e]	0.08[c]	0.18[b]	0.13[b]
Trimethacarb							
LD_{50}	50.9	33.6	11.9	11.3	13.3[f]	ND[g]	ND
R_{50}	0.24	0.22	0.34	0.14	0.12[f]	ND	ND
Aluminium ammonium sulphate (Curb®)							
LD_{50}	ND	ND	ND	ND	> 100[f]	ND	ND
R_{50}	ND	ND	ND	ND	> 1.0[f]	ND	ND

[a] Schafer *et al.* (1973).
[b] Shefte *et al.* (1982).
[c] Schafer and Brunton (1971).
[d] Shumake *et al.* (1976).
[e] Garrison and Libay (1982).
[f] E. Schafer, unpubl. data.
[g] ND, not determined.

methiocarb. Quelea are 4.2–11.8 times more sensitive to methiocarb (R_{50} = 0.015 per cent) than Black-headed Weavers *Ploceus cucullatus*, Golden Sparrows *Passer luteus*, or Red Bishops *Euplectes orix*. Garrison and Libay (1982) determined R_{50} values for methiocarb of between 0.036 and 0.057 per cent for three species of mannikins (*Lonchura malacca*, *L. punctulata*, *L. leucogaster*) that are pests to rice in the Philippines. The R_{50} for *P. cucullatus*, an occasional pest to rice in African countries, is most likely in the same general range. Sultana *et al.* (1986) also determined an R_{50} = 0.18 per cent for methiocarb for Rose-ringed Parakeets *Psittacula krameri* in Bangladesh where the species is an important pest of maize, as it is in some African countries.

Trimethacarb

Trimethacarb is a carbamate mixture registered with the EPA as an insecticide. DWRC originally screened trimethacarb in 1967 on Red-winged Blackbirds *Agelaius phoeniceus* and European Starlings *Sturnus vulgaris* and determined LD_{50} levels of about 10 mg/kg and > 100 mg/kg, respectively (D. Cunningham and E. Schafer, unpubl. data). In R_{50} tests, the compound was rated as marginal but designated for possible reconsideration (R. Brunton, D. Cunningham and E. Schafer, unpubl. data). Since then, promising results from studies showing conditioned aversion by common crows to treated eggs (Nicolaus *et al.* 1983) reduced damage to newly sown corn seed by Ring-necked Pheasants *Phasianus colchicus* and reduced damage following topical applications to cherries (P. Kleyla, unpubl. data). Additional laboratory studies with technical grade material of better quality have generated renewed interest in the compound.

Trimethacarb has been evaluated only twice in Africa: on ripening rice in Mali in June 1983 and on ripening wheat in Zimbabwe in July 1984. These initial demonstrations and other studies conducted in Haiti, Bangladesh, the Philippines, and India suggest that it has potential both as a seed treatment at levels between 0.125 and 0.25 per cent (by seed weight) and as a head spray at application rates > 4.0 kg/ha (Bruggers *et al.* 1984*b*). However, germination of wheat, millet, rice, and sorghum seeds treated at levels > 1 per cent was significantly retarded compared to untreated seeds.

Degradation No studies have yet been conducted on trimethacarb degradation in Africa. However, in Haiti, following 4- and 8-kg (a.i.)/ha application rates in rice, average residues of 9.4 p.p.m. and 465 p.p.m., respectively, declined to 0.1 p.p.m. on the seed (both application levels) at harvest (Bruggers *et al.* 1984*b*). Half-life was 5.2 days for the 4-kg a.i./ha application and 4.2 days for the 8-kg a.i./ha application. Residues exceeding the R_{50} of most bird pests remained on the seeds-glume sample and the seeds-only sample for 21 days after spraying. Chemical on seeds at harvest was less than the amount shown to inhibit germination, which suggests that sprayed seeds could be used as seed stock.

In the Philippines, trimethacarb residues on grain sorghum seed were 0.18 p.p.m. about 4 weeks after a 3-kg a.i./ha application and 0.68 p.p.m. after a 4-kg a.i./ha application. Comparable residues at harvest were found on seed sprayed either once (0.68 p.p.m.) or twice (0.42 p.p.m.) at 4 kg a.i./ha (Bruggers *et al.* 1984*b*). If more detailed and comprehensive repellency studies demonstrate efficacy, trimethacarb could presumably become more widely available and be marketed competitively (P. Kleyla, pers. comm.).

Curb Curb is a relatively non-toxic formulation with reported repellent properties to rodents, deer, and many species of birds (Stone 1976). In Europe, Curb occasionally has been used successfully against birds when applied as a seed dressing to corn (Leinati 1968) or as a spray to fruit buds (Stone 1976) and vegetables (Dar 1974) at application rates of 20–40 kg/ha. Alum-based formulations are bitter, highly astringent, and taste bad (Schafer 1981). In the United States, it has not been registered for use, nor do those North American bird species tested show much sensitivity to Curb.

Curb has been evaluated during the wet and dry seasons in Sahelian and wet coastal Guinean ecosystems, on several types of ripening cereals, and under varying levels of attack from at least 10 species of birds other than quelea that were resident during the trials (Bruggers 1979*a*). In studies at Bambey, Senegal, and Mitro, Benin, Curb provided some protection for between 7–14 days when applied at 8–10 kg/ha in one or two applications. At Sinthiou Maleme, Senegal, weights of treated sorghum heads at harvest were greater than weights of untreated sorghum heads ($P < 0.05$). All trials in Chad and Cameroon in which Curb was applied against quelea at rates of 4, 8, and 16 kg/ha have resulted in very little, if any, protection (Park and Adam 1976; Park *et al.* 1975; Park and Assegninou 1973). In laboratory and limited short-term tests in the United States, a solution of 0.5 kg Curb in 2 l water provided some protection to grapes from House Finches *Carpodacus mexicanus* (Ewing *et al.* 1976).

Methiocarb

Seed treatment Methiocarb has proved to be a consistently effective broad-spectrum repellent when applied as a seed dressing and head spray in many countries worldwide (Besser 1973; Calvi *et al.* 1976; Crase and DeHaven 1976; Dhindsa and Toor 1980; Duncan 1980; Guarino 1972; Holler *et al.* 1982; Mott *et al.* 1976; Poché *et al.* 1980; Rogers 1974, 1978*a*,*b*). In Africa, most seed treatment trials were conducted on rice in Senegal in the Senegal

River Valley, where Ruffs *Philomachus pugnax* were the main pests. Their numbers annually swell from about 10 000 in September to more than 100 000 during December and January (Treca 1976). White-faced Tree-ducks *Dendrocygna viduata* and Black-tailed Godwits *Limosa limosa* also eat newly sown rice. Seed treatment applications of methiocarb at 0.25–0.83 per cent (by seed weight) have resulted in more rice plants and fewer birds in treated than in untreated plots in all trials (Bruggers 1979*b*). The number of plants and the yield at harvest in plots sown with treated rice seed also were greater ($P < 0.05$) than those in plots sown with untreated seed (Ruelle and Bruggers 1979). At rates of 0.25–0.50 per cent, no sick or dying birds were found; dead birds were found when methiocarb was applied at 0.83 per cent (Bruggers and Ruelle 1977). In another rice trial in Sudan, seed losses to crested larks and sparrow larks were 3.8 times greater in untreated plots than in treated plots (Hamza *et al.* 1982). Methiocarb residues from the dried samples of seeds and seedlings were all < 1 p.p.m. (the level of detectability of the analytical method used) after 15 days, a 99.9 per cent decrease from pre-sowing level of 1100 p.p.m. Holler *et al.* (1982) also found rapid degradation with only 16 per cent remaining after 3 days and 6 per cent after 21 days.

Ripening cereals Initial studies in West Africa of methiocarb as a head spray to ripening crops at research stations were erratic yet encouraging (Table 19.2; Fig. 19.1). The results demonstrated how the success of a repellent is affected by the application rate, the type of crop, its location and maturation process, the bird species and their numbers, and the season of the year.

Protecting crops during the dry season at agricultural research stations is difficult. These stations are in effect oases that provide a predictable supply of water and food, and therefore attract large numbers of birds from the surrounding countryside. Although one application of 6.5 kg a.i./ha to millet in Senegal early in the 1975 dry season resulted in treated heads (4.0 g) weighing nearly twice as much as untreated (2.2 g) heads, some damage occurred to almost all heads in the field. Two applications of 1, 2, and 3 kg a.i./ha applied at the end of the 1976 dry season to ripening millet at the same location were completely ineffective. Three days post-application, 50–100 per cent of the heads in all plots were completely denuded and most of the crop was devoured before it reached the early milk stage. Such acute damage is characteristic of the end of the dry season, a period in the Sahel when natural food supplies are scarce (Ward 1965*a*).

During the normal growing season in Senegal, 2.5 kg/ha of methiocarb applied over the entire field protected ripening sorghum at Darou and ripening rice in the Senegal River Valley in 1975 (Table 19.2). However, applying methiocarb to rice in alternate bands was unsuccessful in the Senegal River Valley in 1977, owing to abundant weed seed in the rice fields,

Table 19.2. Summary of methiocarb studies to protect ripening crops from bird pests in Senegal from 1975 to 1977 (source: Bruggers 1979*b*).

Crop, location, (date), trial[a]	Applications		Yields or % damage	Main pest species
	No.	kg a.i./ha		
Millet				
Bambey (Feb. 1975)				
Treated	1	6.5	4.61 g/head	*Passer luteus*, *Passer griseus*, *Euplectes orix*; 200–300 total in small resident feeding flocks
Untreated	–	–	2.19 g/head	
Bambey (Apr. 1976)				
Treated	2	1.0, 2.0, 3.0	93–100%	*Quelea quelea* (30%), *Passer luteus* (33%), *Euplectes orix* (23%); roost population of 1000–3000 birds
Untreated	–	–	100%	
Sorghum				
Darou (Nov. 1975)				
Treated	2	2.5	4%; 49.4 g/head	*Ploceus cucullatus*, *Ploceus melanocephalus*, *Lamprotornis chalybaeta*, *Vinago waalia*, *Bubalornis albirostris*, *Ploceus* spp.; from breeding colony of 500–1000 birds
Untreated	–	–	67%; 15.8 g/head	

Rice				
Richard Toll (Sept. 1975)				
Treated	2	2.0, 2.5	2.05 g/head 206 ± 8 g/0.5 m^2	*Euplectes orix*, *Quelea quelea*, *Ploceus* spp.
Untreated	–	–	1.91 g/head 149 ± 50 g/0.5 m^2	
Richard Toll (Sept. 1977)				
Treated	3	2.0	38%, 63%, 75%	*Quelea quelea* (80%), *Ploceus* spp. (5%), *Euplectes orix* (15%); 600–2000 birds each period all from pre-nesting or nesting colonies
Untreated	–	–	93%, 100%, 100%	

[a] Trials were conducted on 1–3 treated and untreated plots of between 0.04 and 0.80 ha.

Fig. 19.1. Mesurol can be sprayed onto ripening sorghum heads to repel quelea (photo: R. Bruggers).

extended maturation period, and drought that simulated dry-season conditions. Both rice studies demonstrated the influence of differences in feeding behaviour of pest species and crop maturation on repellent effectiveness (Bruggers 1979*b*).

The initial field experiments with methiocarb in West Africa (Bruggers 1979*b*) and in eastern Africa (De Grazio and Shumake 1982) involved application rates of 3–6 kg/ha applied over entire fields and again gave variable, yet encouraging results. From these early field experiments, it was evident that in many situations bird damage was localized in fields along the borders or sheltered bush areas and often never reached the interior. Subsequent studies in eastern Africa employed economical application techniques such as edge, band, or spot-spraying (Bruggers *et al.* 1981*b*). Results from these studies also were encouraging (Table 19.3). Protection of rice at the Libya–Somalia (LIBSOMA) scheme in Somalia, sorghum in Ethiopia, and wheat at West Kilimanjaro, Tanzania, was particularly good. In these locations, the crop was either the only one in the area or was in the vulnerable stage at the onset of the trial. Inconsistent, although less satisfactory results occurred in a rice trial at the Agricultural Research Centre in Afgoi, Somalia, and a wheat trial at the Arusha Foundation Seed Farm (AFSF) in Arusha, Tanzania, primarily because untreated fields were immediately adjacent to treated fields and held birds that might otherwise be repelled.

Cost:benefit analysis In the eastern African trials, birds usually began attacking crops along field borders or in spots and then moved into the fields, making edge or spot applications appropriate and economical (see Bruggers *et al.* 1981*b* for detailed cost explanations for each trial). The cost of applying methiocarb to bands at the 3-ha rice field at the LIBSOMA scheme was approximately US \$45/ha. Using bird scarers raised the cost an additional \$50/ha. With a harvest value of approximately \$375/ha and a 5 per cent loss to birds, LIBSOMA still showed a benefit of nearly \$200/ha, this is particularly good when compared with \$7.50/ha benefit from a 36-ha field that was 90 per cent damaged just before the trial, when bird scarer costs totalled \$143/ha. Crop protection using bird scarers accounted for 15–43 per cent of total rice production costs at LIBSOMA (Bruggers 1980).

At the AFSF in Tanzania in 1979, the yield for the treated field of variety Trophy averaged \$53/ha more than the untreated field, and the number of bird scarers in all trial fields was reduced by 50 per cent. In 1979, bird scaring costs for 60 ha of trial fields were between \$650 and \$820, compared to approximately \$1250 in 1978 when the AFSF lost 60 per cent of its crop (M. Mmari, pers. comm.).

At West Kilimanjaro in 1979, spot-spraying areas where birds were seen feeding cost only \$176 for the entire 1012-ha farm. The value of the yield was approximately \$70 000. The value of yields in 1976 and 1977 when methiocarb was also used and 5 per cent was lost to birds was \$267 000 and \$317 000, respectively, greatly exceeding the \$47 000 value of the 1978 crop when methiocarb was not used.

Degradation Using repellents on food crops requires an understanding of their degradation patterns to ensure permissible residue levels at harvest. Methiocarb degradation patterns have been determined on sorghum in Senegal and on wheat in Tanzania. In Senegal, a 2-kg a.i./ha application rate (with 60 ml of Triton AE adhesive per 100 l water) resulted in residues of <3.5 p.p.m. on seed after 20 days and a half-life of 6–7 days (Gras *et al.* 1981). Initial degradation was very rapid, and metabolic effects began to appear on the second day. The methiocarb $R_{50} = 0.015$ per cent or 150 p.p.m. for quelea (Shumake *et al.* 1976), an amount equivalent to that remaining on grain 3 days after spraying. The time to treatment inhibition was 20–23 days (Gras *et al.* 1981). This time period corresponded to actual field application methods. Second applications usually are applied within 7–10 days of the first, leaving approximately 3 weeks until harvest in a normal 4- to 5-week maturation period.

Table 19.3 Harvest results from methiocarb studies in eastern Africa between 1974 NS 1980 (sources: Bruggers *et al.* 1981*b*; De Grazio and Shumake 1982; Hamaza *et al.* 1982)

Location, crop, (date), trial	Fields		Application technique				
	No.	Area (ha)	kg a.i./ha	No. applications	Method	Yield or % damage	Pest species
Somalia							
ARC—rice (July–Aug. 1979)							
Treated	1	0.15	1	2	Applied to 1/3 area in edge and centre bands	1600 kg/ha	70% *Quelea quelea*; 25% *Ploceus cucullatus*; 5% *Euplectes* spp.
Untreated	1	0.15	–	–		1700 kg/ha	
LIBSOMA—rice (Aug.–Sept. 1979)							
Treated	1	3	1	2	Applied to 1/3 area in edge and centre bands	5%; 1500 kg/ha	90% *Quelea quelea*; 10% *Euplectes* spp., and *Ploceus cucullatus*
Untreated	1	36	–	–		90%; 160 kg/ha	
Tanzania							
AFSF—wheat (June–Sept. 1979)							
Treated	2	12, 15	1	2	Applied to 1/3 area in edge and centre bands	291 and 316 g/m² 1072 and 1125 kg/ha	95% *Quelea quelea*; 5% *Ploceus rubiginosus*
Untreated	2	18, 12	–	–		280 and 200 g/m² 1293 and 639 kg/ha	

Simba/Poverty Gulch—wheat							
Treated (July–Sept. 1979)	25	1125	0.005	As required	Spot application	<5%; 556 kg/ha	95% *Quelea quelea*; 5%
				As required	only to areas being		*Passer domesticus*, and
(1977)	25	1125	0.005	As required	attacked	<5%; 1938 kg/ha	*Ploceus rubiginosus*
(1976)	25	1125	0.005			<5%; 993 kg/ha	
Untreated (1978)	25	1125	–	–		86%; 311 kg/ha	
Rujewa—wheat (Feb. 1974)							
Treated	1	0.05	3	1	Complete	5%	*Quelea quelea*
Untreated	1	0.05	–	–	coverage	51%	
Ethiopia							
IAR, Melkassa—sorghum							
Treated (Sept.–Oct. 1980)	1	12	5.3 and 1.2	2	Alternate row	14.2%	99% *Quelea quelea* all
(1979)	1	12	5.3 and 1.2	2	(5 m) application	22.1%	years; 1% *Ploceus*
(1978)	1	12	5.3 and 1.2	2	to heads of ½ area	5.7%	*melanocephalus*,
(1977)	1	12	5.3 and 1.2	2		<2–3% after treatment; 23% before treatment	*Streptopelia* spp., and *Euplectes orix*
Untreated (1976)	1	12	–	–		42%	
Kenya							
Nanyuki—wheat (Jan. 1974)							
Treated	1	0.012	3	1	Complete	6%	*Quelea quelea*, *Ploceus*
Untreated	1	0.012	–	–	coverage	50%	*rubiginosus*, *Euplectes progne*
Sudan							
ARC, Shambat—wheat (1980)							
Treated	2	0.25	1	1	Edge; (⅓ of the	8.4%	*Passer domesticus*, *Ploceus*
Untreated	2	0.25	–	–	area)	16.2%	spp., *Euplectes orix*

Residue degradation following a 1.8-kg a.i./ha application to ripening wheat at elevations of 1500–2000 m in Tanzania (Ndege 1982) followed a similar pattern to that observed in Senegal. Much of the chemical and its metabolites (sulphoxides and sulphones) was deposited on glumes, and very little was found on the seed itself. Methiocarb residues in glumes decreased rapidly to about one-seventh of initial levels within 2 days. Chemical levels sufficient to induce repellency to quelea (R_{50} = 150 p.p.m.; Shumake *et al.* 1976) were estimated to remain on the glumes for about 3 days after the first application but then fell to less than 15 per cent of the R_{50} level 5 days post-treatment. The half-life was calculated as 4 days. Methiocarb is registered federally with the EPA as a seed treatment for corn (maize) (Schafer 1979). Registration with EPA of a 0.25 per cent a.i. Mesurol 75 per cent Seed Treater on aerially sown rice seed is pending.

Additional investigations

Foliar and lure crop sprays, impregnated string, and baits

Several innovative uses have been suggested for employing chemical repellents (methiocarb in particular) to protect crops from birds in Africa. These include: spraying roost vegetation or nests, spraying lure crops that ripen before the main crop, impregnating string with methiocarb and aerially applying it in nesting areas, distributing methiocarb-impregnated baits in crop fields, and enhancing repellent sprays with sensory cues.

Some of these ideas have been tried on quelea and other avian pest species. Because quelea will avoid white ($CaCO_3$)-coated seeds in the laboratory (Elmahdi 1982), consideration has been given to moving birds from day roosts near crops by spraying roost vegetation with this material. Ruelle (1983) has shown that damage to rice in Senegal and The Gambia can be reduced by spraying carbofuran on early maturing varieties in bordering plots; repellents could also be tried. S. Shumake (pers. comm.) has demonstrated that caged quelea will weave nests with string and he has established application rates for several chemicals that will impregnate the string and kill quelea constructing nests with it. A dispenser that attaches to aircraft and cuts string into desired lengths is used in insect control. Jaeger *et al.* (1983) found that methiocarb-impregnated sunflower seed baits would not stop Red-winged Blackbirds from damaging maturing sunflower; it seems unlikely that the technique would be any more effective on quelea.

Sensory-cue enhancement

Of those speculative uses for repellents in Africa, enhancing the effectiveness of head sprays (particularly methiocarb) with sensory cues, has received the most attention. No primary repellent, including wattle tannin (Zeinelabdin 1980; Zeinelabdin *et al.* 1983), has provided consistent, economical protection when topically applied to ripening cereal crops. Apparently the toxic, emetic, or nauseating effects associated with a secondary repellent, like methiocarb, are necessary stimuli consistently to reduce feeding by birds (Bullard *et al.* 1983*a*). However, the conditioned aversion formed in response to the adverse effects of secondary repellents can be enhanced with the addition of inexpensive, tactile, visual, or olfactory sensory cues that are, or can become, primary repellents because of subsequent association with methiocarb.

Most research to enhance repellent effectiveness with sensory cues has been laboratory work. Quelea will avoid seed treated with methiocarb and taste cues of citric-acid (Shumake *et al.* 1976), wattle tannin (Bullard *et al.* 1983*b*,*c*) and colour cues of calcium carbonate (Bullard *et al.* 1983a). In fact, visual cues may be more important than taste cues in forming conditioned aversion (Capretta 1961; Gillette *et al.* 1980; Mason and Reidinger 1982). Starlings and many other species readily learn to associate visual cues with illness (Czaplicki *et al.* 1976; Rooke 1983; Schuler 1980). Red-winged Blackbirds display food aversion that lasts about 2 weeks (Mason and Reidinger 1982) as a consequence of observational learning (Mason and Reidinger 1981). Because opportunistic feeders such as Red-winged Blackbirds (Dolbeer 1980) readily learn to avoid foods associated with aversive consequences (Klopfer 1958), it is possible that quelea, as highly gregarious, opportunistic foragers, would exhibit similar response patterns.

Initial attempts to investigate sensory-cue enhancement of methiocarb to protect ripening cereals have been encouraging (Table 19.4; Bullard *et al.* 1983*c*). In field enclosure studies conducted in the Sudan in 1979, the median percentage damage to ripening heads of sorghum and millet treated with 1.0 per cent methiocarb or 0.5 per cent methiocarb/1.0 per cent wattle-tannin combinations was minimal and significantly less ($P < 0.001$) for both grains than damage to untreated heads. For both sorghum and millet, there was no significant difference in damage between the methiocarb and the methiocarb/wattle-tannin treatments. Methiocarb and methiocarb/wattle-tannin also provided comparable protection to wheat from bird damage in the Sudan. The methiocarb treatment reduced damage by 80.3 per cent and 82.9 per cent at the milk and dough stages of the wheat crop, respectively; the methiocarb/wattle-tannin formulation reduced damage by 85.1 per cent and 97.8 per cent at the milk stage and dough stage, respectively. At Babougon Seed Farm in the Office du Niger, Mali, methiocarb/wattle-tannin suspension provided some protection to milk-stage sorghum from quelea. Bird damage at harvest was 75 per cent in a 250-m^2 untreated plot and <25 per cent in a 100-m^2 treated plot.

Table 19.4. Summary of field trials[a] comparing 0.5% methiocarb/1.0% wattle tannin and 1.0% methiocarb topical applications (both applied at the rate of 3 kg a.i. methiocarb/ha to ripening cereal in developing countries. Both repellent formulations contained 0.05% Rhoplex AC-33 adhesive (source: Bullard *et al.* 1983*c*).

Crop, location, (date)	Area (ha or m^3)		Application technique	No. applications	% damage			Main bird pests
	Treated	Untreated			Methiocarb/tannin	Methiocarb	Untreated	
Sorghum								
Mali (Mar. 1981)	0.001 ha	0.025 ha	Applied over entire field	2	<25	NA[b]	75	*Quelea quelea*
Philippines								
IRRI (Mar. 1982)	0.012 ha	0.012 ha	Applied to damaged heads	2	<2	NA	28	*Passer montanus*
UPBL (Apr. 1982)								
Site 1	0.03 ha	0.03 ha	Applied over entire field	2	6	10	32	*Passer montanus*
Site 2	0.03 ha	0.03 ha	Applied over entire field	2	4	34	10	*Passer montanus*
Sudan								
ARC (Nov. 1979)	8 m^3	8 m^3	Enclosure test	1	1	4	100	*Quelea quelea*
Wheat								
Sudan								
ARC (Mar. 1980)	0.008 ha	0.008 ha	Applied to heads on one side of plot	2	0.7	4.5	26.4	*Euplectes orix*, *Passer luteus*, *Passer domesticus*, *Ploceus* spp., *Quelea quelea*
Millet								
Sudan								
ARC (Nov. 1979)	8 m^3	8 m^3	Enclosure test	2	20	10	100	*Quelea quelea*
ARC (Nov. 1979)	0.1 ha	0.1 ha	Applied to heads on one side of field	2	2	NA	15	*Euplectes orix*, *Passer luteus*, *Passer domesticus*, *Ploceus* spp., *Quelea quelea*

[a] Trials conducted on one treated and one untreated plot at each site.

[b] NA, not applicable.

Although additional field studies and analyses of chemical breakdown are needed before recommending a methiocarb/wattle-tannin combination, initial work indicates that it shows promise for economically protecting ripening cereals from birds. The addition of cues that are detectable by the olfactory, visual, or tactile senses of a bird apparently enhances the effect of methiocarb. Dimethyl anthranilate (DMA), an inexpensive human food flavouring agent, is apparently unpalatable to birds (Mason *et al.* 1985) and may be another such cue that could be used with a chemical repellent or perhaps alone. By finding ways to lower the costs of chemical repellents without losing efficacy (for example, reducing the amount of methiocarb in the spray formulation and adding inexpensive sensory cues) and employing economical field application techniques (for example, edge, alternate row, or spot spray), traditional farmers in developing countries may be able to consider using repellents in some situations to protect their crops from birds.

Recommendations for use

Using repellents successfully necessitates a thorough knowledge of the specific bird problem and actual treatment timing and procedures. Adhering to certain guidelines should improve the effectiveness of chemical repellents.

(1) Some damage must be expected during the conditioning period of the pest population; 100 per cent protection is not a reasonable expectation (Rogers 1980).
(2) The likelihood of successfully protecting a crop decreases as the dry season progresses and natural food becomes scarce.
(3) Effective repellents are not necessarily bad tasting; a pest learns to associate a particular taste with an adverse physiological reaction (Rogers 1980).
(4) Because of differences among crops, repellents will not be uniformly effective. Better protection can be expected when treating millet or grain sorghum than when treating rice, because it is easier to deliver the chemical to the exposed grains of these crops. Because rice panicles often are surrounded by leaves, much of the repellent does not land on the panicle. Likewise, the seeds are protected by glumes that are not ingested by feeding birds, further diminishing the amount of repellent to which a bird is exposed.
(5) With most cereals, at least two applications (one during the early milk stage and one during the soft-dough stage) will usually be necessary.
(6) For a successful spray application, one must consider the physical characteristics of the plant (height, pubescence, panicle type), agronomic practices (row spacing, flooded or dry field), the climatic conditions

of the area (temperature, evaporation rate, rainfall, wind), and then choose and prepare the spray system and apply the chemical accordingly. Martin and Jackson (1977) have discussed these procedures and related practical application problems.

(7) Considerable attention should be given to the timing of the application relative to the intensity of bird attack. Delays of only 1 week may be critical.

(8) A particular repellent is unlikely to be effective against all species. Better success seems to be achieved with bishops, Golden Sparrows, and Black-headed Weavers, which despite being less sensitive to repellents than quelea, are still gregarious, yet feed in smaller flocks and inflict less damage before being repelled.

(9) The repellent principle of learned aversion will work better in the presence of resident rather than transient species.

(10) The possible effect of adhesives in masking repellency (Hermann and Kolbe 1971) has not yet been satisfactorily evaluated. Evidence suggests that this may, indeed, occur when a high ratio of adhesive to repellent, for example 1:3, is used at low application rates to protect ripening cereal grains (J. Besser and D. Elias, unpubl. data). Conversely, adhesive to repellent ratios of 1:1 have provided protection to seeded rice in flooded paddies at repellent application rates (Besser 1973). The results of the trials in Senegal confirm that repellency can occur when adhesives are used, and that they probably are necessary under conditions of heavy rainfall or aerial irrigation.

(11) Trial designs in fields having untreated plots adjacent to treated plots seemed to retain birds that might otherwise be repelled, with additional resulting damage. Small, closely associated treated and untreated plots are unsatisfactory for the most effective repellent use. Additional considerations of test design and efficacy evaluations in developing countries are discussed by Martin and Jackson (1977) and Bruggers and Jackson (1981).

(12) Birds often begin attacking crops along field borders or in patches along borders and later damage areas further into the field. Economical application techniques employing edge, alternate band, or spot sprays applied at the onset of damage often can protect the field.

(13) Repellents can be more effective in fields free of insects and weeds. Insecticidal properties of methiocarb apparently play an important role in reducing crop damage by birds, at least in maize (Woronecki and Dolbeer 1980; Woronecki *et al.* 1981). An insect-free field would presumably be less attractive to pest species that sometimes eat insects or rely heavily on them to feed their nestlings. A shift by the adults from insects to grain and the subsequent use of the field by fledglings would seem to be quite easy and not unexpected. Likewise, damage is less

(Luder 1985*a*) and methiocarb protection is better (Bruggers 1979*b*) in properly managed weed-free fields than in weedy fields.

Implications for use in Africa

Despite the encouraging results, research on and use of repellents in Africa have only been localized. Since 1979, a time when advances were being made to use methiocarb economically (Bruggers *et al.* 1981*b*), little additional work has been undertaken. There seem to be several reasons for this lack of interest.

First, the priority of the two UNDP/FAO grain-eating bird projects in eastern and western Africa has been to assist and strengthen regional lethal control operations. Although both projects stressed the need to look into 'alternative methods of control' (FAO 1980*c*), neither project has recently advocated using repellents. In West Africa, repellents have been dismissed as 'too costly', and efforts have been directed towards poisoning crops, employing ground sprays, destroying nests, baiting with poisons, and trapping birds (FAO 1982*b*).

Second, the inconsistent results that characterized the initial field screening trials in West Africa have impeded the acceptance of repellents, despite evidence from later trials in eastern Africa demonstrating more consistent protection.

Third, the feeling persists that repellents, when they work, only redistribute damage so that overall losses in an area remain constant. However, in many of the studies conducted in eastern Africa (Bruggers *et al.* 1981*b*), the protected crop was the only one in the area or in a vulnerable stage at the onset of the trials. Under these conditions, it can be assumed that 'repelled' birds shifted to wild seeds and perhaps insects, the only other available foods. In perhaps the only damage situation in which behaviour of 'repelled' birds has been systematically monitored, flocks of radio-equipped Red-winged Blackbirds frightened from vulnerable sunflower fields in North Dakota fed next, on 43 per cent of 56 occasions, in stubble fields, weed patches, non-vulnerable sunflower fields, corn fields, and swathed wheat; 27 per cent of the flocks visited cornfields but inflicted only negligible damage. The remaining 30 per cent of the flocks visited vulnerable sunflower fields usually within 19.3 km of the roost (Besser 1978; Besser *et al.* 1979). Similar studies need to be conducted in Africa to understand better the movements of 'repelled' birds and the relationships of alternate food sources and adjacent cropping areas to crop protection efforts.

Redistributing damage may have merit. Farmers are more likely to produce annually or even expand a particular crop if damage levels are tolerable. Similarly, it has been shown that many crops such as grain sorghum (Beesley 1978), maize (Woronecki *et al.* 1980), and sunflower (J. Sedgwick *et al.*, unpubl. data) may compensate through increased weight of remaining seeds for minimal amounts of damage at early periods in maturation. Finally, a reduction in sprouting does not necessarily infer similar yield reductions because many small-grain crops can compensate for stand reduction by increased tillering. Reduction in yield of both barley and oats is not proportional to the number of grains removed (Feare 1974). Given that growth compensation is apparently common, it probably occurs in other cereals that quelea damage.

Irrespective of arguments supporting continued evaluation of repellents, individuals and organizations best able to promote their use seem to feel that because repellents will not protect crops in all situations, crop protection efforts should be directed towards improving lethal control methods. Because of this attitude, most farmers are unaware that repellents exist. This is unfortunate because repellents can be cost-effective. Those who have been instrumental in evaluating them recognize that they are not a panacea and that they will probably not supplant lethal control to reduce crop damage by quelea in Africa. Many situations exist in Africa where repellents can be used alone or with lethal control to protect crops (Bruggers and Jaeger 1982; Erickson *et al.* 1980). Repellents could also be especially useful to individual farmers, agronomists at research stations, and individuals at seed multiplication or production schemes when facing damage by small populations of quelea or other pest species for which lethal control may be impractical, uneconomical, or unwarranted. The importance of having both lethal and non-lethal methods available to protect crops from bird pests in Africa cannot be overstated.

References

Abifarin, A. D. (1984). The importance of rice awns in the reduction of bird damage. *West Afr. Rice Dev. Assoc. Tech. Newsl.*, **5**, 27–8.

Abramson, M. (1979). Vigilance as a factor influencing flock formation among curlews *Numenius arquata*. *Ibis*, **121**, 213–6.

Adesiyun, A. A. (1973). Bird damage to cereals grown in the dry season in some parts of northern Nigeria. *Samaru Agric. Newsl.*, **15**, 34–7.

Agren, G. and Gibson, R. (1968). *Food composition table for use in Ethiopia*. Swedish Int. Dev. Auth./Ethiopian Ministry of Health, Addis Ababa.

Alcock, J. (1973). Cues used in searching for food by red-winged blackbirds (*Agelaius phoeniceus*). *Behaviour*, **46**, 174–87.

Ali, S. and Ripley, S. D. (1969). *Handbook of the birds of India and Pakistan*, Vol. 3. Oxford University Press, Bombay.

Allan, R. (1983). The strategy for protecting crops from the depredations of quelea birds in Kenya. *Proc. 9th Bird Control Semin.*, Bowling Green, Ohio, **9**, 307–16.

Allan, R. G. (1975). Assessment of bird damage to irrigated wheat in Sudan. Unpubl. Internal Rep., FAO/UNDP Quelea Project RAF/73/055, FAO, Rome.

Allan, R. G. (1980). Quantitative and qualitative assessment of bird damage. *Proc. 2nd Annu. Tech. Meet.*, FAO/UNDP Regional Quelea Project RAF/77/042.

Alsager, D. E. (1976). The role of private consultants in vertebrate pest problems in Canada. *Proc. 7th Vertebr. Pest Conf.*, Monterey, California, **7**, 26–34.

Ankney, C. D. and Scott, D. M. (1980). Changes in nutrient reserves and diet of breeding brown-headed cowbirds. *Auk*, **97**, 684–96.

Anonymous (Undated). Report of a preliminary survey of vertebrate pest damage in the Northwest Frontier Province, Pakistan. Unpubl. Rep.

Anonymous (1954). La lutte contre les oiseaux granivores au Sénégal et en Mauritanie. *Protection des Végétaux*, Dakar.

Anonymous (1979). FAO crop protection manual, African grain-eating birds. Unpubl. Internal Rep., FAO/UNDP, Rome, Italy.

Armstrong, W. D., Rogler, J. C., and Featherston, W. R. (1974). Effect of tannin extraction on the performance of chicks fed bird resistant sorghum grain diets. *Poult. Sci.*, **53**, 714–20.

Ash, J. S. (1981). Qualitative and quantitative assessment of bird pests in Eastern Africa: Somalia. *Proc. 3rd Annu. Tech. Meet.*, FAO/UNDP Regional Quelea Project RAF/77/042.

Ash, J. S. and Miskell, J. E. (1983). Birds of Somalia their habitat status and distribution. *Scopus Special Suppl.*, No. 1.

Ashton, H. (1957). Sixth ringing report. *Ostrich*, **28**, 98–115.

Asquith, T. N., Izuno, C. C., and Butler, L. G. (1983). Characterization of the condensed tannin (proanthocyanidin) from a group II sorghum. *J. Agric. Food Chem.*, **31**, 1299–303.

Attwell, R.I.G. (1954). Crocodiles feeding on weaver birds. *Ibis*, **96**, 485–6.

Avery, M. L. (1979). Food preferences and damage levels of some avian rice field pests in Malaysia. *Proc. 8th Bird Control Semin.*, Bowling Green, Ohio, **8**, 161–6.

Barnard, C. J. (1980). Flock feeding and time budgets in the house sparrow (*Passer domesticus* L.) *Anim. Behav.*, **28**, 295–309.

Barré, M. H. (1983). Quelea movement patterns in Somalia (April 1982– April 1983). *Proc. 4th Annu. Tech. Meet.*, FAO/UNDP Regional Quelea Project RAF/81/023, pp. 40–4.

Barré, N. (1973). Incidence de la suppression d'un des parents sur le devenir de la couvée chez *Quelea quelea* (L.). Efficacité de la lutte chimique. Unpubl. Internal Rep., FAO/UNDP Quelea Project RAF/73/055, FAO, Rome.

Bashir, E. A. (1978). Review of parakeet damage in Pakistan and suggested control methods. *Proc. Semin. Bird Pest Problems in Agric.*, July 5–6, 1978, Karachi, Pakistan, pp. 22–7.

Bashir, E. A. (1979). A new 'parotrap' adapted from the MAC trap for capturing live parakeets in the field. *Proc. 8th Bird Control Semin.*, Bowling Green, Ohio, **8**, 167–71.

Bashir, E. A. (1983). An assessment of bird pest problems to rice in Liberia. Unpubl. Internal Rep., FAO/UNDP Project RAF/81/022, Dakar, Senegal.

Bashir, E. A. (1984). The ecology of birds and their damage to rice in Liberia. *West Afr. Rice Dev. Assoc. Tech. Newsl.*, 5, 9–12.

Bayer, R. D. (1982). How important are bird colonies as information centers? *Auk*, **99**, 31–40.

Beesley, J.S.S. (1978). Extension of Botswana bird pest research project 1976–1978. Ministry of Overseas Dev./Govt. of Botswana ODM Research Scheme R.2664.

Benson, C. W. and Benson, F. M. (1977). *The birds of Malawi*. Montfort Press, Limbe.

Benson, C. W., Brooke, R. K., Dowsett, R. J., and Irwin, M.P.S. (1973). *The birds of Zambia*, 2nd edn. Collins, London.

Beri, Y. P., Jotwani, M. G., Misra, S. S., and Chander, D. (1969). Studies on relative bird damage to different experimental hybrids of bajara. *Indian J. Entomol.*, 30, 69–71.

Bertram, B. C. (1978). Living in groups: predators and prey. In *Behavioural ecology* (eds. J. R. Krebs and N. B. Davies). Blackwell Scientific Publishers, Oxford.

Besser, J. (1971). Syllabus. Unpubl. Rep., Denver Wildlife Research Center, Denver, Colorado.

Besser, J. (1973). Protecting seeded rice from blackbirds with methiocarb. *Int. Rice Comm. Newsl.*, **22**, 9–14.

Besser, J. (1978). Improvements in the use of 4-aminopyridine for protecting agricultural crops from birds. *Proc. 8th Vertebr. Pest Conf.*, Sacramento, California, **8**, 51–3.

Besser, J. F., Berg, W. J., and Knittle, C. E. (1979). Late-summer feeding patterns of red-winged blackbirds in a sunflower-growing area of North Dakota. *Proc. 8th Bird Control Semin.*, Bowling Green, Ohio, **8**, 209–14.

Bille, J.-C. (1976). Etude de la production primaire nette d'un écosystème sahélien. Travaux et documents de l'ORSTOM, Nr. 65, ORSTOM, Paris.

Blem, A. R., Ames, R. B., Liew, C. S., and Pryzbylek, J. M. (1983). Effect of preharvest application of Dimethipin on grain moisture, milling quality and yield of rice. *Proc. 10th Annu. Meet. Plant Growth Regul. Soc. America*, pp. 241–7.

Blessin, C. W., Anderson, R. A., Deatherage, W. L., and Inglett, G. E. (1971). Effect of alkali dehulling on composition and wet-milling characteristics of sorghum grain. *Cereal Chem.*, 40, 528–32.

Bocquet, C. and Roy, J. (1953). Lutte antiaviaire rapport de mission. *Protection des Végétaux*, Dakar.

Bortoli, L. (1970). Rapport de campagne-nidification 1970. Unpubl. Internal Rep., FAO/UNDP Quelea Project RAF/73/055, FAO, Rome.

Bortoli, L. (1974*a*). Mission en Haute Volta—du 4 au 11 juin 1974. Unpubl. Internal Rep., FAO/UNDP Quelea Project RAF/73/055, FAO, Rome.

Bortoli, L. (1974*b*). Nidification des principales espèces d'oiseaux granivores au Mali en 1974. Unpubl. Internal Rep., FAO/UNDP Quelea Project RAF/73/055, FAO, Rome.

Bortoli, L. (1975). Rapport sur la nidification de *Quelea quelea* dans le delta interieur du Niger et les regions adjacentes en 1975. Unpubl. Internal Rep., FAO/UNDP Quelea Project RAF/73/055, FAO, Rome.

Bortoli, L. (1978). Traditional crop protection methods. Unpubl. Internal Rep., FAO/UNDP Quelea Project RAF/73/055, FAO, Rome.

Bortoli, L. and Bruggers, R. L. (1976). Degats d'oiseaux sur sorgho de decrue dans La Vallée du Sénégal. Unpubl. Internal Rep., FAO/UNDP Quelea Project RAF/73/055, FAO, Rome.

Bortoli, L. and Jackson, J. (1972). The distribution of races of *Quelea quelea* in the project area. Unpubl. Internal Rep., FAO/UNDP Quelea Project RAF/73/055, FAO, Rome.

Bouchardeau, A. and Lefevre, L. (1965). Monographie du Lac Tchad. ORSTOM, Paris.

Boudet, G. (1975). Manuel sur les paturages tropicaux et les cultures fourragères. Ministère de la Coopération, Paris, IEMVT, Maisons-Alfort.

Boudreau, G. W. (1975). *How to win the war with pest birds*. Wildlife Technology, Hollister, California.

Bray, O. E. (1973). Radiotelemetry for studying problem birds. *Proc. 6th Bird Control Semin.*, Bowling Green, Ohio, **6**, 198–200.

Bray, O. E., Knittle, C. E., Jack, J. R., and Bowman, R. L. (1978). Locating and identifying blackbird-starling roosts by multispectral remote sensing. *Sci. Tech. Ser. Natn. Wildl. Fed.* **3**, 194–6.

Bray, O. E., Larsen, K. H., and Mott, D. F. (1975). Winter movements and activities of radio-equipped starlings. *J. Wildl. Manage.*, **39**, 795–801.

Breman, H., Cisse, A. M., Djiteye, M. A., and Elberse, W. Th. (1982). Le potentiel botanique des paturages. In *La productivité des paturages saheliens* (eds. F.W.T. Penning De Vries and M. A. Djiteye). Centre for Agricultural Publishing and Documentation, Wageningen, pp. 98–132.

Brooke, C. (1967). The heritage of famine in central Tanzania. *Tanzania Notes Rec.*, 67, 15–22.

Brown, L. H. and Britton, P. L. (1980). *The breeding seasons of East African birds*. East African Natural History Society, Nairobi.

Brown, L. H., Urban, E. K., and Newman, K. (1982). *The birds of Africa*, Vol. 1. Academic Press, London, UK.

Bruggers, R., Ellis, J., Sedgwick, J. and Bourassa, J. (1981*a*). A radio transmitter for monitoring the movements of small passerine birds. *Proc. 3rd Int. Conf. Wildl. Biotelem.*, Laramie, Wyoming, **3**, 69–79.

Bruggers, R., Matee, J., Miskell, J., Erickson, W., Jaeger, M., Jackson, W. B., and Juimale, Y. (1981*b*). Reduction of bird damage to field crops in eastern Africa with methiocarb. *Trop. Pest Manage.*, **27**, 230–41.

Bruggers, R. L. (1979*a*). Evaluating Curb as a crop repellent to West African bird pests. In *Vertebrate pest control and management materials, ASTM STP 680* (ed. J. R. Beck). Am. Soc. for Testing and Materials, pp. 188–97.

Bruggers, R. L. (1979*b*). Summary of methiocarb trials against pest birds in Senegal. *Proc. 8th Bird Control Semin.*, Bowling Green, Ohio, **8**, 172–84.

Bruggers, R. L. (1980). The situation of grain-eating birds in Somalia. *Proc. 9th Vertebr. Pest Conf.*, Fresno, California, **9**, 5–16.

Bruggers, R. L. (1982). The exportation of cage birds from Senegal. *Traffic Bull.* IV, 12–22. Wildlife Trade Monitoring Unit, IUCN Conservation Monitoring Centre, Cambridge, UK.

Bruggers, R. L., Bohl, W. H., Bashir, S. El, Hamza, M., Ali, B., Besser, J. F., De Grazio, J. W., and Jackson, J. J. (1984*a*). Bird damage to agriculture and crop protection efforts in the Sudan. *FAO Plant Protect. Bull.*, **32**, 2–16.

Bruggers, R. L. and Bortoli, L. (1979). Laboratory trials using fluorescent dyes and paints as marking agents for quelea studies. In *Vertebrate pest control and management materials, ASTM STP 680* (ed. J. R. Beck). Am. Soc. for Testing and Materials, pp. 231–6.

Bruggers, R. L. and Jackson, W. B. (1981). Suggested methods for determining the efficacy of vertebrate control agents in developing countries. In *Vertebrate pest control and management materials, ASTM STP 752* (eds. E. W. Schafer, Jr. and C. R. Walker). Am. Soc. for Testing and Materials, pp. 15–28.

Bruggers, R. L., Jaeger, M. E., and Jaeger, M. M. (1985). Tisserins gendarmes (*Ploceus cucullatus abyssinicus*) et tisserins masqués (*Ploceus intermedius intermedius*) munis d'émetteurs radio et de rubans dans une colonie de nidification du sud de l'Ethiopie. *Oiseau Rev. Fr. Ornithol.*, **55**, 81-92.

Bruggers, R. L. and Jaeger, M. M. (1982). Bird pests and crop protection strategies for cereals of the semi-arid African tropics. In *Sorghum in the Eighties: Proc. Int. Symp. on Sorghum* (ed. J. Mertin). ICRISAT, Patancheru, A. P., India, pp. 303–12.

Bruggers, R. L., Jaeger, M. M., and Bourassa, J. B. (1983). The application of radiotelemetry for locating and controlling concentrations of red-billed quelea in Africa. *Trop. Pest Manage.*, **29**, 27–32.

Bruggers, R. L., Jaeger, M. M., Keith, J. O., Hegdal, P. L., Bourassa, J. B., Latigo, A. A., and Gillis, J. N. (In press). Impact of fenthion sprays on nontarget birds during quelea control in Kenya. *Wildl. Soc. Bull.*,

Bruggers, R. L., Murshid, A. A., and Miskell, J. (1981*c*). Accidental death of red-billed queleas roosting in lemon trees in Somalia. *Ostrich* **52**, 60–2.

Bruggers, R. L. and Ruelle, P. (1977). Bird losses in Senegal rice significantly cut. *Rice J.*, Nov/Dec, pp. 10–4.

Bruggers, R. L. and Ruelle, P. (1981). Economic impact of pest birds on ripening cereals in Senegal. *Protect. Ecol.*, **3**, 7–16.

Bruggers, R. L. and Ruelle, P. (1982). Efficacy of nets and fibres for protecting crops from grain-eating birds in Africa. *Crop Protect.*, **1**, 55–65.

Bruggers, R. L., Sultana, P., Brooks, J. E., Fiedler, L. A., Rimpel, M., Manikowski, S., Shivanarayan, N., Santhaiah, N., and Okuno, I. (1984*b*). Preliminary investigations of the effectiveness of trimethacarb as a bird repellent in developing countries. *Proc. 11th Vertebr. Pest Conf.*, Sacramento, California, **11**, 192–203.

Brunel, J. and Thiollay, J. M. (1969). Liste préliminaire des oiseaux de Côte-d'Ivoire. *Alauda*, **37**, 230–54.

Bullard, R. W. (1979). New developments in bird resistant sorghums. *Proc. 8th Bird Control Semin.*, Bowling Green, Ohio, **8**, 229–34.

Bullard, R. W., Bruggers, R. L., Kilburn, S. R., and Fiedler, L. A. (1983*c*.) Sensory-cue enhancement of the bird repellency of methiocarb. *Crop Protect.*, **2**, 387–9.

Bullard, R. W. and Elias, D. J. (1980). Sorghum polyphenols and bird resistance. In *Polyphenols in cereals and legumes, Proc. 36th Annu. Meet. Inst. Food Technol.* (ed. J. H. Hulse). Ottawa, Canada, Int. Dev. Res. Centre Publ. IDRC-145e, pp. 43–9.

Bullard, R. W., Garrison, M. V., Kilburn, S. R., and York, J. O. (1980). Laboratory comparisons of polyphenols and their repellent characteristics in bird-resistant sorghum grains. *J. Agric. Food Chem.* **28**, 1006–11.

Bullard, R. W., Schafer, E. W., Jr., and Bruggers, R. L. (1983*a*). Tests of the enhancement of avian repellent chemicals with sensory cues. In *Vertebrate pest control and management materials, ASTM STP 817* (ed. D. E. Kaukeinen). Am. Soc. for Testing and Materials, pp. 66–75.

Bullard, R. W. and Shumake, S. A. (1979). Two-choice preference testing of taste repellency in *Quelea quelea*. In *Vertebrate pest control and management materials, ASTM STP 680* (ed. J. R. Beck). Am. Soc. for Testing and Materials, pp. 178–87.

Bullard, R. W. and York, J. O. (1985). Breeding for bird resistance in sorghum and maize. In *Plant breeding progress reviews* (ed. G. E. Russell). Butterworths, Surrey, England, pp. 193–222.

Bullard, R. W., York, J. O., and Kilburn, S. R. (1981). Polyphenolic changes in ripening bird-resistant sorghums. *J. Agric. Food Chem.*, **29**, 973–81.

Bullard, R. W., Zeinelabdin, M. H., and Jackson, W. B. (1983b). Repellent potential of vegetable tannins on *Quelea quelea*. *Proc. 9th Bird Control Semin.*, Bowling Green, Ohio, **9**, 233–9.

Busnel, R. G. and Grosmaire, P. (1958). Enquête auprès des populations du fleuve Sénégal sur leur méthode acoustique de lutte traditionnelle contre le Quelea. *Bull. I.F.A.N.*, **20**, 623–33.

Calvi, C., Besser, J. F., De Grazio, J. W., and Mott, D. F. (1976). Protecting Uruguayan crops from bird damage with methiocarb and 4-aminopyridine. *Proc. 7th Bird Control Semin.*, Bowling Green, Ohio, **7**, 255–8.

Campbell, B. and Lack, E. (eds.) (1985). *A dictionary of birds*. BOU/Poyser, Calton, England.

Capretta, P. J. (1961). An experimental modification of food preferences in chicks. *J. Comp. Physiol. Psychol.*, **54**, 238–42.
Caraco, T. (1979). Time budgeting and group size: a theory. *Ecology*, **60**, 611–7.
Caraco, T., Martindale, S., and Pulliam, H. R. (1980). Avian flocking in the presence of a predator. *Nature*, **285**, 400–1.
Caughley, G. (1977). *Analysis of vertebrate populations*. Wiley, Chichester.
Cheke, R. A. and Walsh, J. F. (1980). Bird records from the Republic of Togo. *Malimbus*, **2**, 112–20.
Chen, P. Y. and Li, Y. (1980). The effect of wheat awns on grain weight and their physiological function. *Acta Agron.*, **7**, 279–82.
Chibber, B. A. K., Mertz, E. T., and Axtell, J. D. (1978). Effects of dehulling on tannin content, protein distribution, and quality of high and low tannin sorghum. *J. Agric. Food Chem.*, **26**, 679–83.
Church, B. M. (1971). The place of sample survey in crop loss estimation. In *Crop loss assessment methods, FAO manual on the evaluation and prevention of losses by pests, disease and weeds* (ed. L. Chiarappa), pp. 2.2/1–2.2/8.
Cisse, A. M. and Breman, H. (1982). La phytoécologie de Sahel et du terrain d'etude. In *La productivité des pâturages Sahéliens* (eds. F.W.T. Penning De Vries and M. A. Djiteye). Centre for Agricultural Publishing and Documentation, Wageningen, pp. 71–83.
Cisse, B. (1981). Lutte chimique contre le quelea (mange-mil) en Afrique de l'Ouest. Unpubl. Ph.D. Thesis, Univ. of Dakar, Faculty of Medicine and Pharmacy, Dakar, Senegal.
Clancey, P. A. (1960). A new race of red-billed quelea from southeastern Africa. *Bull. Br. Ornithol. Club*, **80**, 67–8.
Clancey, P. A. (1968). Subspeciation in some birds from Rhodesia II. *Durban Mus. Novit.*, **8**, 153–82.
Clancey, P. A. (1973). The subspecies of the *lathamii*-group of *Quelea quelea* (Linnaeus). *Durban Mus. Novit.*, **10**, 13–22.
Cochran, W. G. (1977). *Sampling techniques*, 3rd edn. Wiley, New York.
Collias, N. E. and Collias, E. C. (1970). The behaviour of the west African village weaverbird. *Ibis*, **112**, 457–80.
Collias, N. E. and Collias, E. C. (1971). Ecology and behaviour of the spotted-backed weaverbird in the Kruger National Park. *Koedoe*, **14**, 1–27.
Collar, N. J. and Stuart, S. N. (1985). *Threatened birds of Africa and related islands*. Int. Council for Bird Preservation and Int. Union for Conservation of Nature and Natural Resources, Cambridge, UK.
COPR. (1975). The problem of damage to sorghum by doves in Botswana, 1972–1974 Report. Unpubl. Int. Rep., Centre for Overseas Pest Research, London, UK.
COPR. (1976). Bird pest research project, Botswana. Final Rep. 1972-1975. Centre for Overseas Pest Research, London, UK.
COPR. (1977). Quelea investigations project, Nigeria. Final Rep. 1972–1975. Ministry of Overseas Dev./Fed. Military Govt., Nigeria.
Crase, F. T. and DeHaven, R. W. (1976). Methiocarb: its current status as a bird repellent. *Proc. 7th Vertebr. Pest Conf.*, Monterey, California, 7, 46–50.
Crase, F. T. and DeHaven, R. W. (1978). Food selection by five sympatric California blackbird species. *Calif. Fish Game*, **64**, 255–67.

Crocker, J. (1984). How to build a better scarecrow. *New Scientist*, **1403**, 10–2.
Crook, J. H. (1960). Studies on the social behaviour of *Quelea q. quelea* (Linn.) in French West Africa. *Behaviour*, **16**, 1–55.
Crook, J. H. (1962). The adaptive significance of pair formation types in weaver birds. *Symp. Zool. Soc. Lond.*, **8**, 57–70.
Crook, J. H. (1964). The evolution of social organization and visual communication in the weaver birds (Ploceinae). *Behaviour [Suppl.]*, **10**, 1–178.
Crook, J. H. and Butterfield, P. A. (1970). Gender role in the social system of quelea. In *Social behaviour in birds and mammals* (ed. J. H. Crook). Academic Press, London, pp. 211–48.
Crook, J. H. and Ward, P. (1968). The quelea problem in Africa. In *The problems of birds as pests* (eds. R. K. Murton and E. N. Wright). Academic Press, London, pp. 211–29.
Curtis, D. L. (1965). Sorghum in West Africa. *Samaru Res. Bull.*, **59**. Nigeria.
Curtis, D. L. (1968). The relation between the date of heading of Nigerian sorghums and the duration of the growing season. *J. Appl. Ecol.*, **5**, 215–26.
Czaplicki, J. A., Borrebach, D. E., and Wilcoxin, H. C. (1976). Stimulus generalization of an illness-induced aversion to different intensities of colored water in Japanese Quail. *Anim. Learn. Behav.*, **4**, 45–8.
Da Camara-Smeets, M. (1977). Les dégâts d'oiseaux au berbéré au Tchad et au Nord-Cameroun. *Agron. Trop.*, **XXXII 3**, 262–78.
Da Camara-Smeets, M. and Affoyon, D. (1980). Mission de reconnaissance des oiseaux granivores depredateurs au sud-Cameroun II. Unpubl. Internal Rep., FAO/UNDP Project RAF/77/047, FAO, Rome.
Da Camara-Smeets, M. and Manikowski, S. (1979). Repères visuels utilisés par *Quelea quelea* et *Ploceus cucullatus* dans leurs choix alimentaires. *Malimbus*, **1**, 127–34.
Dar, C. (1974). *Summary of trials with CURB on cultivated vegetables and fruit from sowing to harvest*. Assiamaabarot Ltd., Israel.
Davies, N. B. (1977). Prey selection and the search strategy of the spotted flycatcher (*Muscicapa striata*): a field study on optimal foraging. *Anim. Behav.*, **25**, 1016–33.
Dawson, D. G. (1970). Estimation of grain loss to sparrows (*Passer domesticus*) in New Zealand. *N.Z. J. Agric. Res.*, **13**, 681–8.
De Grazio, J. W. (1978). World bird damage problems. *Proc. 8th Vertebr. Pest Conf.*, Sacramento, California, **8**, 9–24.
De Grazio, J. W. (Compiler) (1984). Progress of vertebrate pest management in agriculture, 1966–1982. Unpubl. USAID/DWRC Rep., Denver Wildlife Research Center, Denver, Colorado.
De Grazio, J. W. and Besser, J. F. (1970). Bird damage problems in Latin America. *Proc. 4th Vertebr. Pest Conf.*, Davis, California, **4**, 162–7.
De Grazio, J. W., Besser, J., and Schafer, E., Jr. (1971). Unpubl. Annu. Rep., Denver Wildlife Research Center, Denver, Colorado.
De Grazio, J. W. and Shumake, S. A. (1982). Controlling quelea damage to small grains in Africa with methiocarb. In *Alternative strategies for desert development and management*, Vol. 2. Proc. UNITAR Int. Conf., Sacramento, California, 1977. Pergamon Press, New York, pp. 452–6.

De Groot, P. (1980). Information transfer in a socially roosting weaver bird (*Quelea quelea*; Ploceinae): an experimental study. *Anim. Behav.*, **28**, 1249–54.

Dekeyser, P. L. (1958). Recherches sur la biologie du travailleur a bec rouge (*Quelea quelea* Latham). In *Reunion de specialistes sur les Quelea*, Dakar, 31 October–6 November 1955. CCTA/CSA Joint Secretariat, London, pp. 1–8.

Devine, T. and Peterle, T. J. (1968). Possible differentiation of natal areas of North American waterfowl by neutron activation analysis. *J. Wildl. Manage.*, **32**, 274–9.

Dhindsa, M. S. and Toor, H. S. (1980). Extent of bird damage to rice nurseries in the Punjab and its control. *India J. Agric. Sci.*, **50**, 715–9.

Disney, H. J. de S. (1957). *Quelea quelea* in Tanganyika. Cage experiments. CCTA/CSA Africa (57)QB13. *CSA Symposium on Quelea*, Livingston, 1957. CCTA/CSA Joint Secretariat, Bukavu.

Disney, H. J. de S. (1960). Ringing and marking of quelea in Tanganyika. CCTA/CSA Quelea (60)9. *CCTA/FAO Symposia on Quelea*, Bamako. CCTA/CSA Publ. **58**, 143–9.

Disney, H. J. de S. (1964). Quelea control. In *A new dictionary of birds* (ed. A. Landsborough Thomson). Nelson, London and Edinburgh, pp. 673–4.

Disney, H. J. de S. and Haylock, J. W. (1956). The distribution and breeding behaviour of the Sudan dioch (*Quelea q. aethiopica*) in Tanganyika. *East Afr. Agric. J.*, **21**, 141–7.

Disney, H. J. de S., Lofts, B., and Marshall, A. J. (1959). Duration of the regeneration period of the internal reproductive rhythm in a xerophilous equatorial bird *Quelea quelea*. *Nature (Lond.)*, **184**, 1659–60.

Disney, H. J. de S., Lofts, B., and Marshall, A. J. (1961). An experimental study of the internal rhythm of reproduction in the red-billed dioch *Quelea quelea* by means of photo-stimulation, with a note on melanism induced in captivity. *Proc. Zool. Soc. Lond.*, **136**, 123–9.

Disney, H. J. de S. and Marshall, A. J. (1956). A contribution to the breeding biology of the weaver-finch *Quelea quelea* (Linnaeus) in East Africa. *Proc. Zool. Soc. Lond.*, **127**, 379–87.

Doggett, H. (1957). Bird-resistance in sorghum and the quelea problem. *Field Crop Abstracts*, **10**, 153–6.

Doggett, H. (1970). *Sorghum*. Longmans Green and Co. Ltd., London, UK.

Doggett, H. (1982). Factors reducing sorghum yields *Striga* and birds. In *Sorghum in the Eighties: Proc. Int. Symp. on Sorghum* (ed. J. Mertin). ICRISAT, Patancheru, A. P., India, pp. 313–16.

Doggett, H., Curtis, D. L., Laubscher, F. X., and Webster, O. J. (1970). Sorghum in Africa. In *Sorghum production and utilization* (eds. J. S. Wall and W. M. Ross). AVI Publishing Company, Inc., Westport, Connecticut, pp. 288–326.

Dolbeer, R. A. (1980). Blackbirds and corn in Ohio. *U.S. Fish Wildl. Serv. Resour. Publ.*, **136**.

Dolbeer, R. A., Stickley, A. R., and Woronecki, P. P. (1978). Starling *Sturnus vulgaris* damage to sprouting wheat in Tennessee and Kentucky, U.S.A. *Protect. Ecol.*, **1**, 159–69.

Dolbeer, R. A., Woronecki, P. P., and Stehn, R. A. (1984). Blackbird (*Agelaius phoeniceus*) damage to maize: crop phenology and hybrid resistance. *Protect. Ecol.*, **7**, 43–63.

Dorow, E. (1973). Grunddaten und Ueberlegungen zum Einsatz einer wirkungsvollen Spruchausruestung für die Altvogelbekaempfung im Nistplatz. Unpubl. Internal Rep., GAWI, Frankfurt, West Germany.

Drees, E. M. (1980). Bird pests in agriculture in West Africa and their control. Unpubl. Internal Rep., Wageningen Agric. Univ. Natuurbeheer.

Dunbar, R.I.M. and Crook, J. H. (1975). Aggression and dominance in the weaver bird, *Quelea quelea*. *Anim. Behav.*, **23**, 450–9.

Duncan, R. R. (1980). Methiocarb as a bird repellent on ripening grain sorghum. *Can. J. Plant Sci.*, **60**, 1129–33.

Dunnet, G. M. and Patterson, I. J. (1968). The rook problem in North-east Scotland. In *The problems of birds as pests* (eds. R. K. Murton and E. N. Wright) Academic Press, London, pp. 119–39.

DWRC. (1978). Vertebrate damage control research in agriculture. Unpubl. Annu. Rep., Denver Wildlife Research Center.

Dyer, M. I. and Ward, P. (1977). Management of pest situations. In *Granivorous birds in ecosystems* (eds. J. Pinowski and S.C. Kendeigh). Cambridge University Press, Cambridge, pp. 267–300.

Eastman, P. (1980). An end to pounding: a new mechanical flour milling system in use in Africa. Monograph, IDRC-152e, Int. Dev. Res. Centre, Ottawa, Canada.

Edwards, W. R. and Smith, K. E. (1984) Exploratory experiments on the stability of mineral profiles of feathers. *J. Wildl. Manage.*, **48**, 853–66.

Elgood, J. H., Fry, C. H., and Dowsett, R. J. (1973). African migrants in Nigeria. *Ibis*, **115**, 375–411.

Elias, D. (1977). Vertebrate pests in Latin American agriculture. Unpubl. Internal Rep., Denver Wildlife Research Center, Denver, Colorado.

Elliott, C.C.H. (1979). The harvest time method as a means of avoiding quelea damage to irrigated rice in Chad/Cameroun. *J. Appl. Ecol.*, **16**, 23–35.

Elliott, C.C.H. (1980*a*). Monitoring and research in *Quelea quelea intermedia*. *Min. 2nd Annu. Tech. Meet.*, FAO/UNDP Regional Quelea Project RAF/77/042.

Elliott, C.C.H. (1980*b*). Sex ratio in two ploceids. *Acta 17th Congr. Int. Ornithol. Berlin*, (ed. R. Nöhring), pp. 1359–60.

Elliott, C.C.H. (1980*c*). A regional quelea survey/spray helicopter service for Eastern Africa. *Min. 2nd Annu. Tech. Meet.*, FAO/UNDP Regional Quelea Project RAF/77/042, pp. 184–93.

Elliott, C.C.H. (1981*a*). Monitoring of *Quelea quelea* in eastern Africa - Part II. The relationship between quelea breeding and rainfall. Quelea moult studies. *Proc. 3rd Annu. Tech. Meet.*, FAO/UNDP Regional Quelea Project RAF/77/042, pp. 35–42.

Elliott, C.C.H. (1981*b*). Methods for assessing the efficiency of aerial spraying control operations on quelea colonies and roosts. In *Vertebrate pest control and management materials, ASTM STP 752* (eds. E. W. Schafer, Jr. and C. R. Walker). Am. Soc. for Testing and Materials, pp. 62–73.

Elliott, C.C.H. (1981*c*). Overview of bird pest problems in Eastern Africa. *Proc. 3rd Annu. Tech. Meet.*, FAO/UNDP Regional Quelea Project RAF/77/042.

Elliott, C.C.H. (1983*a*). The quelea bird as a pest of wheat in eastern and southern

Africa. *Proc. Regional Wheat Workshop East, Central and Southern Africa*, Arusha, Tanzania. Nakuru Press, Kenya, pp. 140–6.
Elliott, C.C.H. (1983*b*). Quelea movement patterns at the national level – Tanzania. *Proc. 4th Annu. Tech. Meet.*, FAO/UNDP Regional Quelea Project RAF/81/023.
Elliott, C.C.H. (In press). The quelea as a major problem in a food-deficient continent. In *The quelea problem in southern Africa* (eds. P. J. Mundy and M.J.F. Jarvis). Baobab Books, Zimbabwe.
Elliott, C.C.H. and Beesley, J.S.S. (1980). Bird damage to cereal crops— Tanzania 1980. *Proc. 2nd Annu. Tech. Meet.*, FAO/UNDP Regional Quelea Project RAF/77/042.
Elliott, C.C.H. and Jarvis, M.J.F. (1970). Fourteenth ringing report. *Ostrich*, **41**, 1–117.
Elliott, C.C.H. and Jarvis, M.J.F. (1972–1973). Fifteenth ringing report. *Ostrich*, **43**, 236–95; **44**, 34–78.
Elliott, C.C.H. and Manikowski, S. (1976). A review of scouting methods used during the 1976 bird-control campaign in Chad/Cameroun and proposals for their improvement. Unpubl. Internal Rep., FAO/UNDP Quelea Project RAF/73/055, FAO, Rome.
Elmahdi, E. M. (1982). Sensory cue enhancement of methiocarb repellency to the African weaver-finch (*Quelea quelea*). Unpubl. M.S. thesis, Bowling Green State University, Bowling Green, Ohio.
Elmahdi, E. M., Bullard, R. W., and Jackson, W. B. (1985). Calcium carbonate enhancement of methiocarb repellency for quelea. *Trop. Pest Manage.*, **31**, 67–72.
Emlen, S. T. and Demong, N. J. (1975). Adaptive significance of synchronized breeding in a colonial bird. *Science*, **188**, 1029–31.
Endler, J. A. (1977). *Geographic variation, speciation, and clines*. Princeton University Press, Princeton.
Erickson, W. A. (1979). Diets of the red-billed quelea (*Quelea quelea*) in the Awash River Basin of Ethiopia. *Proc. 8th Bird Control Semin.*, Bowling Green, Ohio, **8**, 185–200.
Erickson, W. A. (1984). Diets of five weaverbird species (Ploceidae) in the Awash River Valley of Ethiopia. Unpubl. M.S. thesis, Bowling Green State University, Bowling Green, Ohio.
Erickson, W. A. and Damena, A. (1982). Breeding of red-billed queleas (*Quelea quelea*) in relation to rainfall patterns in Ethiopia. Unpubl. Internal Rep., FAO/UNDP Quelea Project ETH/77/022, FAO, Rome.
Erickson, W. A., Jaeger, M. M., and Bruggers, R. L. (1980). The development of methiocarb for protecting sorghum from birds in Ethiopia. *Ethiop. J. Agric. Sci.*, **2**, 91–100.
Evans, J. and Griffith, R. E., Jr. (1973). A fluorescent tracer and marker for animal studies. *J. Wildl. Manage.*, **37**,73–81.
Ewing, K., Crabb, A. C., Martin, L. R., and Moitoso, R. (1976). Preliminary laboratory and field trials of Curb, a possible avian repellent. *Proc. 7th Bird Control Semin.*, Bowling Green, Ohio, **7**, 239–41.
Fahlund, L. A. (1965). Report of the United States observer to the Food and Agriculture Organization of the United Nations. *Conf. on Quelea, Bird and Water Hyacinth Control in Africa*, Duala, Cameroon, V, 1–118.

FAO. (1978). *Bird scout's handbook*. United Nations Dev. Prog./Food and Agricultural Organization.
FAO. (1979*a*). *Min. 1st Annu. Tech. Meet.*, FAO/UNDP Regional Quelea Project RAF/77/042.
FAO. (1979*b*). Crop protection manual—African grain-eating birds. FAO/UNDP Publ. AGOA, RAF/73/055.
FAO. (1980*a*). Cereal crop pests in Africa, with particular reference to birds. Unpubl. Internal Rep., FAO/UNDP, Rome, Italy.
FAO. (1980*b*). *Min. 2nd Annu. Tech. Meet.*, FAO/UNDP Regional Quelea Project RAF/77/042.
FAO. (1980*c*). Coordination of cooperative action to reduce bird damage to crops in eastern Africa. *Min. 2nd Annu. Tech. Meet.*, FAO/UNDP Regional Quelea Project RAF/77/042.
FAO. (1981*a*). An assessment of the bird pest problem in Sudan, Ethiopia, Somalia, Kenya, Tanzania. Unpubl. Internal Rep., FAO/UNDP, Rome, Italy.
FAO. (1981*b*). The infrastructure for monitoring quelea in eastern Africa. Unpubl. Internal Rep., FAO/UNDP, Rome, Italy.
FAO. (1982*a*). FAO Month. Bull. Stat., **5**, 1–68, Food and Agriculture Organization of the United Nations, Rome, Italy.
FAO. (1982*b*). Regional technical assistance to OCLALAV for crop protection against grain-eating birds: conclusions and recommendations of the project. Final Report AG:DP/RAF/77/047. FAO/UNDP, Rome.
FAO. (1984*a*). Agroclimatological data for Africa. Unpubl. Internal Rep., FAO/UNDP, Rome, Italy.
FAO. (1984b). *Proc. 5th Annu. Tech. Meet.*, FAO/UNDP Regional Quelea Project RAF/81/023.
FAO/WHO. (1980). Pesticide residues in food—1980; evaluations 1980. Food and Agriculture Organization/World Health Organization, *FAO Plant Prod. Protect.*, **26**, 218–34.
Farris, M. A. E. (1975). The general bird problem in grain sorghum. *Proc. Int. Sorghum Workshop* (ed. Publication Staff). U.S. Agency for International Development, Washington, D.C., pp. 289–304.
Feare, C. (1984). *The starling*. Oxford University Press, Oxford and New York.
Feare, C. J. (1974). Ecological studies of the rook (*Corvus frigilegus* L.) in North-East Scotland. Damage and its control. *J. Appl. Ecol.*, **11**, 897–914.
Federer, W. T. (1955). *Experimental design: Theory and application*. Oxford and IBH Publ. Co., Calcutta.
Fitzwater, W. D. (1971). The weaver finch of Hispaniola. *Pest Control*, **39**, 19–20; 56–9.
Fitzwater, W. D. (1973). Madam Saga—an approach to an animal damage problem. *Proc. 6th Bird Control Semin.*, Bowling Green, Ohio, **6**, 47–52.
Fleming, T. H. (1981). Winter roosting and feeding behaviour of pied wagtails *Motacilla alba* near Oxford, England. *Ibis*, **123**, 463–76.
Fogden, M.P.L. (1972). The seasonality and population dynamics of equatorial forest birds in Sarawak. *Ibis*, **114**, 307–43.
Fogden, M.P.L. and Fogden, P. M. (1979). The role of fat and protein reserves in the annual cycle of the Grey-backed camaroptera in Uganda (Aves: Sylviidae). *J. Zool. (Lond.)*, **189**, 233–58.

Froman, B. and Persson, S. (1974). *An illustrated guide to the grasses of Ethiopia.* Chilalo Agricultural Development Unit, Asella, Ethiopia.

Funmilayo, O. and Akande, M. (1977). Vertebrate pests of rice in southwestern Nigeria. *PANS*, **23**, 38–48.

Fuggles-Couchman, N. R. (1952). The destruction of rice-eating birds. *East Afr. Agric. J.*, **19**, 77–8.

Gadgil, M. (1972). The function of communal roosts: relevance of mixed roosts. *Ibis*, **114**, 531–3.

Garrison, M. V. and Libay, J. L. (1982). Potential of methiocarb seed treatment for protection of sprouting rice from Philippine bird pests, *Lonchura* spp. *Philipp. Agric.*, **65**, 363–6.

Gaston, A. (1973). Equisse de reconnaissance des groupements vegetaux de la zone de recherches écologiques intensives du projet *Quelea quelea* (Region de N'Djamena). Unpubl. Internal Rep., FAO/UNDP Quelea Project RAF/67/087, FAO, Rome.

Gaston, A. and Lamarque, G. (1976). Travaux phytoécologiques en relation avec la lutte contre *Quelea quelea*—Bilan de quatre années. Rapport final, FAO/UNDP Regional Quelea Project RAF/67/087. Inst. Elev. Med. Vet. Pays Trop. Maisons Alfort.

Gaudchau, M. D. (1967). Report on control of the red-billed weaver bird (*Quelea quelea aethiopica*) in the Republic of the Sudan during 1964/65/66/67. Unpubl. Rep., Khartoum, Ministry of Agriculture, Plant Protection Division.

Ghosh, B. (1945). Efficiency of rectangular plots of different shapes and sizes in field experiments or sample surveys. *Proc. 32nd Indian Sci. Congr.*, Sec. XII, No. 48.

Gillet, H. (1974). Tapis végétal et paturages du Sahel. In *UNESCO Le Sahel: bases écologiques de l'aménagement.* Notes techniques MAB UNESCO, Paris, pp. 21–7.

Gillette, K., Irwin, J. D., Thomas, D. K., and Bellingham, W. P. (1980). Transfer of coloured food and water aversions in domestic chicks. *Bird Behav.*, **2**, 37–47.

Ginn, H. B. and Melville, D. S. (1983). *Moult in birds.* British Trust for Ornithology, Guide No. 19.

Goldstein, J. L. and Swain, T. (1963). Changes in tannins in ripening fruit. *Phytochemistry*, **2**, 371–83.

Goss-Custard, J. D. (1977). Optimal foraging and the size selection of worms by redshank, *Tringa totanus*, in the field. *Anim. Behav.*, **25**, 10–29.

Gramet, Ph. (1974). Rapport de mission en République du Mali et du Sénégal du 24/9 au 14/10/74. Unpubl. Internal Rep., FAO/UNDP Quelea Project RAF/73/055, FAO, Rome.

Grant, C. L. (1953). Spectrographic analysis of ashes of feathers and bones of ruffed grouse. Unpubl. Internal Rep., New Hampshire Fish and Game Department, Concord, New Hampshire.

Gras, G., Hasselman, C., Pellissier, C., and Bruggers, R. (1981). Residue analysis of methiocarb applied to ripening sorghum as a bird repellent in Senegal. *Bull. Environ. Contam. Toxicol.*, **26**, 393–400.

Grist, D. H. and Lever, R.J.A.W. (1969). *Pests of rice.* Longmans, London, UK.

Grosmaire, P. (1955). Essai sur l'evolution de la population de *Quelea* dans la vallée du fleuve Sénégal. Variation de cette population depuis Mai 1953 jusqu'au 15 Octobre 1955. Efficacité de la lutte entreprise par l'Organisme de Lutte Antiaviaire (OLA) du Sénégal. CSA Reunion des Specialistes du Quelea, Dakar, 1955. Bukavu, Secretariat Conjoint CCTA/CSA.

Grue, C. E., Fleming, W. J., Busby, D. G., and Hill, E. F. (1983). Assessing hazards of organophosphate pesticides to wildlife. *Proc. North Am. Wildl. Conf.*, **48**, 200.

Grue, C. E., Powell, G.V.N., and McChesney, M. J. (1982). Care of nestlings by wild female starlings exposed to an organophosphate pesticide. *J. Appl. Ecol.*, **19**, 327–35.

GTZ. (1979). Pesticide residue problems in the Third World. Unpubl. Rep., Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), Eschborn, West Germany.

GTZ. (1982). Die Oekologie and Bekaempfung des Blutschnabelwebervogels [*Quelea quelea* (L.)] in Nordostnigeria. Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ). Eschborn, West Germany.

GTZ. (1986). Rotations-Driftspruehanlage. Einsatz- und Bedienungshandbuch. Spec. Publ. No. 186, Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), Eschborn, West Germany.

GTZ. (1987). The ecology and control of the Red-billed Weaver Bird (*Quelea quelea* L.) in Northeast Nigeria. Spec. Publ. No. 199, Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), Eschborn, West Germany.

Guarino, J. L. (1972). Methiocarb, a chemical bird repellent: a review of its effectiveness on crops. *Proc. 5th Vertebr. Pest Conf.*, Fresno, California, **5**, 211–6.

Gupta, R. K. and Haslam, F. (1980). Vegetable tannins—Structure and biosynthesis. In *Polyphenols in cereals and legumes, Proc. 36th Annu. Meet. Inst. Food Technol.* (ed. J. H. Hulse). Ottawa, Canada, Int. Dev. Res. Centre Publ. **IDRC-145e**, pp. 15–24.

Hagerman, A. E. and Butler, L. G. (1980). Condensed tannin purification and characterization of tannin-associated proteins. *J. Agric. Food Chem.*, **28**, 947–52.

Hailu, K. (1984). Lethal control of red-billed quelea (*Quelea quelea*) in the southern and central Rift Valleys during 1983 and 1984 control seasons. *Proc. 5th Annu. Tech. Meet.*, FAO/UNDP Regional Quelea Project RAF/81/023, pp. 102–7.

Haldane, J.B.S. (1955). The calculation of mortality rates from ringing data. *Proc. Int. Ornithol. Congr.*, **11**, 454–8.

Hall, B. P. and Moreau, R. E. (1970). *An atlas of speciation in African Passerine birds.* British Museum (Natural History), London, UK.

Hamza, M., Ali, B., El Haig, I., Bohl, W., Besser, J., De Grazio, J., and Bruggers, R. L. (1982). Evaluating the bird repellency of methiocarb. *Malimbus*, **4**, 33–41.

Hanson, H. C. and Jones, R. L. (1968). Use of feather minerals as biological tracers to determine the breeding and molting grounds of wild geese. *Ill. Nat. Hist. Surv. Biol. Notes* **60**.

Hanson, H. C. and Jones, R. L. (1976). The biogeochemistry of blue, snow and Ross' geese. *Ill. Nat. Hist. Surv. Spec. Publ.*, **1**.

Harrel, C. G. and Dirks, B. M. (1955). Cereals and cereal products. In *Handbook of food and agriculture* (ed. F. C. Blanck). Reinhold, New York, N.Y., pp. 411–52.

Harris, H. B. (1969). Bird resistance in grain sorghum. *Proc. 24th Annu. Corn Sorghum Res. Conf.* (eds. J. I. Sutherland and R. J. Falasca). American Seed Trade Association, Washington, D.C., pp. 113–22.

Hartigan, R. (1979). Sorghum tannins: inheritance, seasonal development, and biological value. Unpubl. M.S. thesis, Purdue Univ., Lafayette, Indiana.
Haylock, J. W. (1955). *Quelea quelea*—movements. Unpubl. Rep.: Moshi 25.1.55.
Haylock, J. W. (1957). Preliminary notes on the Sudan dioch (*Quelea quelea aethiopica*) and its control by the Department of Agriculture in Kenya Colony. CCTA/CSA Africa (57) QB 12. *CSA Symp. Quelea*, Livingstone, 1957. CCTA/CSA Joint Secretariat, Bukavu.
Haylock, J. W. (1959). *Investigations on the habits of quelea birds and their control.* Nairobi, Government Printers.
Heckel, J.-U. (1983). GTZ—bird control activities in the Republic of Niger during 1981/82 and future goals. *Proc. 4th Annu. Tech. Meet.*, FAO/UNDP Regional Quelea Project RAF/81/023.
Heisterberg, J. F., Knittle, C. E., Bray, O. E., Mott, D. F., and Besser, J. F. (1984). Movements of radio-instrumented blackbirds and European starlings among winter roosts. *J. Wildl. Manage.*, **48**, 203–9.
Hermann, G. and Kolbe, W. (1971). L'enrobage de la semence avec le Mesurol pour la lutte contre les oiseaux dans les cultures de mais, compte tenu de la tolérance des variétés et des effets secondaires. *Pflanzenschutz-Nachrichten Bayer*, **24**, 290–331.
Holler, N. R., Naquin, H. P., Lefebvre, P. W., Otis, D. L., and Cunningham, D. J. (1982). Mesurol® for protecting sprouting rice from blackbird damage in Louisiana. *Wildl. Soc. Bull.*, **10**, 165–70.
Holyoak, D. T. (1970). Sex-differences in feeding behaviour and size in the carrion crow. *Ibis*, **112**, 397–400.
Hoogland, J. L. and Sherman, P. W. (1976). Advantages and disadvantages of bank swallows (*Riparia riparia*) coloniality. *Ecol. Monogr.*, **46**, 33–58.
Horn, H. S. (1968). The adaptive significance of colonial nesting in the Brewer's blackbird (*Euphagus cyanocephalus*). *Ecology*, **49**, 682–94.
Hoshino, T. and Duncan, R. R. (1981). Bird damage and tannin content in grain sorghum hybrids under different environments. *Jpn. J. Crop Sci.*, **50**, 332–7.
Howard, W. E., Park, J. S., Shin, Y. M., and Cho, W. S. (1975). Rodent control in Republic of Korea. Inst. Agric. Sci. Office of Rural Development.
Hudson, R. H., Tucker, R. K., and Haegele, M. A. (1984). Handbook of toxicity of pesticides to wildlife. *USFWS Resour. Publ.* **153**.
Huffnagel, H. P. (1961). *Agriculture in Ethiopia.* Food and Agriculture Organization of the United Nations, Rome, Italy.
Hulse, J. H., Laing, E. M., and Pearson, O. E. (1980). *Sorghum and the millets: their composition and nutritive value.* Academic Press, London, UK.
Humphries, D. A. and Driver, P. M. (1970). Protean defence by prey animals. *Oecologia*, **5**, 285–302.
Inglis, I. R. (1980). Visual bird scarers: an ethological approach. *Proc. Bird Problems in Agric. Symp.* (eds. E. N. Wright, I. R. Inglis, and C. J. Feare). University of London, BCPC Publ., pp. 121–43.
Irwin, M.P.S. (1981). *The birds of Zimbabwe.* Quest Publishing, Harare.
Jackson, J. (1973). Summary of data on distribution and migration of quelea in the Lake Tchad Basin and the Benoue Watershed in Tchad and Cameroon. Unpubl. Internal Rep., FAO/UNDP Quelea Project RAF/73/055, FAO, Rome.

Jackson, J. and Park, P. O. (1973). The toxic effects of fenthion on a nesting population of queleas during experimental control by aerial spraying. *Proc. 6th Bird Control Semin.*, Bowling Green, Ohio, **6**, 53–73.
Jackson, J. J. (1971). A bird resistant millet from South Chad. Unpubl. Internal Rep., FAO/UNDP Quelea Project RAF/73/055, FAO, Rome.
Jackson, J. J. (1974*a*). Nesting success of *Quelea quelea* with one parent removed and observations on roosting behavior, with implications for control. *Proc. 6th Vertebr. Pest Conf.*, Anaheim, California, **6**, 242–5.
Jackson, J. J. (1974*b*). A trap for fledgling *Quelea quelea.* Unpubl. Internal Rep., FAO/UNDP Quelea Project RAF/73/055, FAO, Rome.
Jackson, J. J. (1974*c*). The relationship of Quelea migrations to cereal crop damage in the Lake Chad basin. *Proc. 6th Vertebr. Pest Conf.*, Anaheim, California, **6**, 238–42.
Jackson, W. B. (1979). Subcommittee on the estimation of bird damage to grain crops. *Min. 1st Annu. Tech. Meet.*, FAO/UNDP Regional Quelea Project RAF/77/042.
Jackson, W. B. and Jackson, S. S. (1977). Estimates of bird depredations to agricultural crops and stored products. Plant Health Newsl.: Colloquium on crop protection against starlings, pigeons, and sparrows. *EPPO Publ. Ser. B*, **84**, 33–43.
Jaeger, M. E. and Jaeger, M. M. (1977). Quelea as a resource. Unpubl. Internal Rep., FAO/UNDP Quelea Project RAF/73/055, FAO, Rome.
Jaeger, M. M. (1984). Seasonal distribution and movement patterns of quelea in eastern Africa: A current perspective. *Proc. 5th Annu. Tech. Meet.*, FAO/UNDP Regional Quelea Project RAF/81/023.
Jaeger, M. M., Bruggers, R. L., Johns, B. E., and Erickson, W. A. (1986). Evidence of itinerant breeding of the red-billed quelea *Quelea quelea* in the Ethiopian Rift Valley. *Ibis*, **128**, 469–82.
Jaeger, M. M., Cunningham, D. J., Bruggers, R. L., and Scott, E. J. (1983). Assessment of methiocarb-impregnated sunflower achenes as bait to repel blackbirds from ripening sunflowers. *Proc. 9th Bird Control Semin.*, Bowling Green, Ohio, 9, 207–24.
Jaeger, M. M., Elliott, C. C., Lenton, G. M., Allan, R. G., Bașhir, S., and Ash, J. S. (1981). Monitoring of *Quelea quelea* in eastern Africa (July 1978–October 1981). Mask index and the distribution of quelea. *Proc. 3rd Annu. Tech. Meet.*, FAO/UNDP Regional Quelea Project RAF/77/042.
Jaeger, M. M. and Erickson, W. A. (1980). Levels of bird damage to sorghum in the Awash Basin of Ethiopia and the effects of the control of quelea nesting colonies (1976–1979). *Proc. 9th Vertebr. Pest Conf.*, Fresno, California, **9**, 21–8.
Jaeger, M. M. and Erickson, W. A. (1981). Lethal control of quelea nesting colonies in the Awash Valley during 1981. *Proc. 3rd Annu. Tech. Meet.*, FAO/UNDP Regional Quelea Project RAF/77/042, pp. 62–63.
Jaeger, M. M., Erickson, W. A., and Jaeger, M. E. (1979). Sexual segregation of red-billed queleas (*Quelea quelea*) in the Awash River Basin of Ethiopia. *Auk*, **96**, 516–24.
James, F. C. (1983). Environmental component of morphological differentiation in birds. *Science*, **221**, 184–6.

James, F. C., Engstrom, R. T., Nesmith, C., and Laybourne, R. (1984). Inferences about population movements of red-winged blackbirds from morphological data. *Am. Midl. Nat.*, **111**, 319–31.

James, H. W. (1928). The nesting of the southern pink-billed weaver (*Quelea quelea lathami*). *Oologists' Rec.*, **8**, 84–5.

Jarvis, M.J.F. and LaGrange, M. (In press). Conservation, quelea control, and the trap roost concept. In *The quelea problem in southern Africa* (eds. P. J. Mundy and M.J.F. Jarvis). Baobab Books, Zimbabwe.

Jarvis, M.J.F. and Vernon, C. J. (In press-*a*). Food and feeding habits of quelea in southern Africa. In *The quelea problem in southern Africa* (eds. P. J. Mundy and M.J.F. Jarvis). Baobab Books, Zimbabwe.

Jarvis, M.J.F. and Vernon, C. J. (In press-*b*). Notes on quelea ecology in southern Africa. In *The quelea problem in southern Africa* (eds. P. J. Mundy and M.J.F. Jarvis). Baobab Books, Zimbabwe.

Jensen, J. V., and Kirkeby, J. (1980). *The birds of The Gambia*. An annotated check-list and guide to localities in the Gambia. Aros Nature Guides, Denmark.

Jeremiah, H. E. and Parker, J. D. (1985). Health hazard aspects of fenthion residues in quelea birds. Int. Cent. for the Application of Pesticides, Cranfield Institute of Technology, UK.

Johnston, R. F. (1969). Character variation and adaptation in European sparrows. *Syst. Zool.*, **18**, 206–31.

Johnston, R. F. and Klitz, W. J. (1977). Variation and evolution in a granivorous bird: the house sparrow. In *Granivorous birds in ecosystems* (eds. J. Pinowski and S. C. Kendeigh). Cambridge University Press, Cambridge, England, pp. 15–51.

Jones, P. J. (1972). The status of *Quelea quelea* in Botswana and recommendations for its control. Unpubl. Rep., Centre for Overseas Pest Research, to Government of Botswana, London, UK.

Jones, P. J. (1976). The utilization of calcareous grit by laying *Quelea quelea*. *Ibis*, **118**, 575–6.

Jones, P. J. (1980). The annual mortality of *Quelea quelea* in South Africa from ringing recoveries during a period of intensive quelea control. *Proc. Pan-Afr. Ornithol. Congr.*, **4**, 423–7.

Jones, P. J. (1983). Haematocrit values of breeding red-billed queleas *Quelea quelea* (Aves: Ploceidae) in relation to body condition and thymus activity. *J. Zool. (Lond.)*, **201**, 217–22.

Jones, P. J. and Pope, G. (1977). Wheat damage by quelea in Zambia. Unpubl. Int. Rep., Centre for Overseas Pest Research, London, UK.

Jones, P. J. and Ward, P. (1976). The level of reserve protein as the proximate factor controlling the timing of breeding and clutch-size in the red-billed quelea *Quelea quelea*. *Ibis*, **118**, 547–74.

Jones, P. J. and Ward, P. (1979). A physiological basis for colony desertion by red-billed queleas (*Quelea quelea*). *J. Zool. (Lond.)*, **189**, 1–19.

Joslyn, M. A. and Goldstein, J. L. (1964). Astringency of fruits and fruit products in relation to phenolic content. *Adv. Food Res.*, **13**, 179–217.

Jowett, D. (1967). Breeding bird-resistant sorghum in East Africa. *Plant Breeding Abstracts*, **37**, 85.

Kalmbach, E. R. (1937). Blackbirds and the rice crop on the gulf coast. *Wildlife Resource Management Leaflet B5-96*, U.S. Bureau of Biological Survey, Washington, D. C.

Kaske, R. F. (1970). Trials to control weaver-birds by non aerial operations in the Sudan. Unpubl. Internal Rep., GAWI, Frankfurt, West Germany; PPD Khartoum.

Kelsall, J. P. and Burton, R. (1977). Identification of origins of lesser snow geese by X-ray spectrometry. *Can. J. Zool.*, **55**, 718–32.

Kelsall, J. P. and Burton, R. (1979). Some problems in identification of origins of lesser snow geese by chemical profiles. *Can. J. Zool.*, **57**, 2292–302.

Kelsall, J. P. and Calaprice, J. R. (1972). Chemical content of waterfowl plumage as a potential diagnostic tool. *J. Wildl. Manage.*, **36**, 1088–97.

Kelsall, J. P., Pannekoek, W. J. and Burton, R. (1975). Chemical variability in plumage of wild lesser snow geese. *Can. J. Zool.* **53**, 1369–75.

Kendall, M. D. (1980). Avian thymus glands: a review. *Dev. Comp. Immunol.*, **4**, 191–210.

Kendall, M. D. and Ward, P. (1974). Erythropoiesis in an avian thymus. *Nature (Lond.)*, **249**, 366–7.

Kendall, M. D., Ward, P., and Bacchus, S. (1973). A protein reserve in the Pectoralis major flight muscle of *Quelea quelea*. *Ibis*, **115**, 600–01.

Kendeigh, S. C. and West, G. C. (1965). Caloric values of plant seeds eaten by birds. *Ecology*, **46**, 553–5.

Kenya News Agency. (1985). Fish waste sold. *Kenya Nation*, 26 January 1985.

Kieser, J. A. and Kieser, G. A. (1978). Birds of the De Aaar district. *South. Birds* **5**.

King, J. R. (1973). Energetics of reproduction in birds. In *Breeding biology of birds* (ed. D. S. Farner). National Academy of Sciences, Washington, D.C., pp. 77–107.

Kitonyo, F. M. (1981). Indirect control achievements: Kenya (October 1980–October 1981). *Proc. 3rd Annu. Tech. Meet.*, FAO/UNDP Regional Quelea Project RAF/77/042, pp. 64–70.

Kitonyo, F. M. (1983). Control achievements of the bird control unit in Kenya 1982/83—KEN/82/003. *Proc. 4th Annu. Tech. Meet.*, FAO/UNDP Regional Quelea Project RAF/81/023, pp. 56–63.

Kitonyo, F. M. and Allan, R. G. (1979). Quantitative and qualitative assessment of bird damage in Kenya. *Proc. Ist Annu. Tech. Meet.*, FAO/UNDP Regional Quelea Project RAF/77/042.

Klopfer, P. H. (1958). Influence of social interactions on learning rates in birds. *Behaviour*, **14**, 282–99.

Knittle, C. E. and Guarino, J. L. (1976). A 1974 questionnaire survey of bird damage to ripening grain sorghum in the United States. *Sorghum Newsl.*, **19**, 93–4.

Knittle, C. E., Linz, G. M., Johns, B. E., Cummings, J. L., Davis, J. E. Jr., and Jaeger, M. M. (1987). Dispersal of male red-winged blackbirds from two spring roosts in central North America. *J. Field Ornithol.*, **58**, 490–8.

Krebs, J. R. and McCleery, R. H. (1984). Optimization in behavioural ecology. In *Behavioural ecology* (eds. J. R. Krebs and N. B. Davies). Blackwell Scientific Publications, Oxford, England, pp. 91–121.

Krebs, J. R., Stephens, D. W., and Sutherland, W. J. (1983). Perspectives in optimal foraging. In *Perspectives in ornithology* (eds. A. H. Brush and G. A. Clark, Jr.). Cambridge University Press, Massachusetts, pp. 165–216.

Lack, D. (1954). *The natural regulation of animal numbers*. Oxford University Press, Oxford, UK.

Lack, D. (1966). *Population studies of birds*. Clarendon Press, Oxford, UK.

Lack, D. (1968). *Ecological adaptations for breeding in birds*. Methuen, London, UK.

LaGrange, M. (In press-*a*). The effect of rainfall on the numbers of quelea destroyed in Zimbabwe. In *The quelea problem in southern Africa* (eds. P. J. Mundy and M.J.F. Jarvis). Baobab Books, Zimbabwe.

LaGrange, M. (In press-*b*). Past and present control methods for quelea in Zimbabwe. In *The quelea problem in southern Africa* (eds. P. J. Mundy and M.J.F. Jarvis). Baobab Books, Zimbabwe.

Lamarche, B. (1981). Liste commentée des oiseaux du Mali, Part II. *Malimbus*, 3, 73–102.

Lamm, D. W. (1955). Local migratory movements in southern Mozambique. *Ostrich*, 26, 32–7.

Lane, A. B. (1984). An inquiry into the response of growers to attacks by insect pests in oilseed rape (*Brassica napus* L.), a relatively new crop in the United Kingdom. *Protect. Ecol.*, 7, 73–8.

Latigo, A.A.R. and Meinzingen, W. (1986). Guided application dose (GAD) for aerial control of quelea (*Quelea quelea*). *Proc. 1st Quelea Tech. Meet.*, Desert Locust Control Organization for Eastern Africa, Nairobi, Kenya.

Lawlor, D. W., Day, W., and Legg, B. J. (1979). Metabolism of water- stressed barley. *Field Crop Abstracts*, 32, 944.

Lazarus, J. (1979). The early warning function of flocking in birds: An experimental study with captive quelea. *Anim. Behav.*, 27, 855–65.

LeClerg, E. L. (1971). Field experiments for assessment of crop losses. In *Crop loss assessment methods*. FAO manual on the valuation and prevention of losses by pests, disease and weeds (ed. L. Chiarappa), pp. 2.1/1–2.1/11.

Leinati, L. (1968). Contribution to the knowledge of repellents against game birds. *Proc. 22nd Congr. Italian Soc. Vet. Sci.*, Grado, Italy, 26–29 September 1968.

Lenton, G. (1981). Qualitative and quantitative assessment of bird pests in Eastern Africa: Sudan. *Proc. 3rd Annu. Tech. Meet.*, FAO/UNDP Regional Quelea Project RAF/77/042.

Lenton, G. M. (1980). Monitoring and research on *Quelea quelea aethiopica* in Sudan 1979–1980. *Min. 2nd Annu. Tech. Meet.*, FAO/UNDP Regional Quelea Project RAF/77/042.

Leuthold, D. and Leuthold, B. (1972). Blutschnabelweber *Quelea quelea* als Beute von Greif- und Stelzvoegeln. *Vogelwarte*, 26, 352–4.

Linz, G. M. and Fox, G. (1983). Food habits and molt of red-winged blackbirds in relation to sunflower and corn depredation. *Proc. 9th Bird Control Semin.*, Bowling Green, Ohio, 9, 167–80.

Lofts, B. (1962). Photoperiod and the refractory period of reproduction in an equatorial bird (*Quelea quelea*). *Ibis*, **104**, 407–14.

Lofts, B. (1964). Evidence of an autonomous reproductive rhythm in an equatorial bird (*Quelea quelea*). *Nature (Lond.)*, **201**, 523–4.

Lofts, B. and Murton, R. K. (1968). Photoperiodic and physiological adaptations regulating avian breeding cycles. *J. Zool. (Lond.)*, **155**, 327–94.

Loman, J. and Tamm, S. (1980). Do roosts serve as 'information centers' for crows and ravens? *Am. Nat.*, **115**, 284–9.

Lourens, D. C. (1957). Parathion versus Quelea. CSA Symposium on Quelea, Livingstone, 1957. CCTA/CSA Joint Secretariat, Bukavu.

Lourens, D. C. (1960). Contribution: Union of South Africa. CCTA/CSA Quelea (60) 6. *CCTA/FAO Symp. on Quelea*, Bamako, 1960. Lagos, Nairobi and London. CCTA/CSA Publ. **58**, 95–118.

Lourens, D. C. (1961). Comments on the new race of the red-billed quelea. *Ostrich*, **32**, 187.

Lourens, D. C. (1963). The red-billed quelea. Unpubl. Ph.D. thesis, Pretoria University, South Africa.

Luder, R. (1985*a*). Weeds influence red-billed quelea damage to ripening wheat in Tanzania. *J. Wildl. Manage.*, **49**, 646–7.

Luder, R. (1985*b*). Guidelines to estimate the first possible installation dates of red-billed quelea colonies from daily rainfall figures. Unpubl. Internal Rep., FAO/UNDP Quelea Project URT/81/013, FAO, Rome.

Luder, R. and Elliott, C.C.H. (1984). Monitoring quelea at the national level: Tanzania. *Proc. 5th Annu. Tech. Meet.*, FAO/UNDP Regional Quelea Project RAF/81/023.

Mabbayad, B. B. and Tipton, K. W. (1975). Tannin concentration an in vitro dry matter disappearance of seeds of bird-resistant sorghum hybrids. *Philipp. Agric.*, **59**, 1–6.

MacCuaig, R. G. (1984). Terminal report of avian toxicologist. *Proc. 5th Annu. Tech. Meet.*, FAO/UNDP Regional Quelea Project RAF/81/023, pp. 19–25.

MacCuaig, R. G. (1986). Avicide index. Monograph, Food and Agriculture Organization, Rome, Italy.

Mackworth-Praed, C. W. and Grant, C. H. B. (1973). *Birds of west central and western Africa*. Ser. III, Vol. II. Longmans, London, UK.

Maclean, G. L. (1957). A summary of the birds of Westminster, O.F.S. and surroundings. *Ostrich*, **28**, 217–32.

Magor, J. (1974). Quelling the quelea-bird plague of Africa. *Spectrum*, **118**, 8–11.

Magor, J. I. and Ward, P. (1972). Illustrated descriptions, distribution maps and bibliography of the species of Quelea (weaver-birds: Ploceidae). *Trop. Pest. Bull.*, **1**, 1–23. Centre for Overseas Pest Research, London, UK.

Mallamaire, A. (1959*a*). Control of weaverbirds in Africa. *FAO Plant Protect. Bull.*, **7**, 105–12.

Mallamaire, A. (1959*b*). La lutte contre le quelea en Afrique-Occidentale francaise. *Bull. Phytosanitaire FAO*, **7**, 109–16.

Mallamaire, A. (1961). La lutte contre les oiseaux granivores en Afrique Occidentale (Mauretanie, Senegal, Soudan, Niger). *J. Agric. Trop. Bot. Appl.* **8**,141–265.

Manikowski, S. (1975). The influence of vegetation and meteorological conditions in the Lake Chad Basin on the distribution of *Quelea quelea*. Part I. Dry season. Unpubl. Internal Rep., FAO/UNDP Quelea Project RAF/73/055, FAO, Rome.

Manikowski, S. (1980). The dynamics of the Chari-Logone population of *Quelea quelea* and its control. *Proc. 4th Pan-Afr. Ornithol. Congr.*, **4**, 411–21.

Manikowski, S. (1981). Les resultats d'études sur les *Quelea quelea* dans le delta central du Niger. Unpubl. Internal Rep., FAO/UNDP Quelea Project RAF/77/047, FAO, Rome.

Manikowski, S. (1984). Birds injurious to crops in West Africa. *Trop. Pest Manage.*, **30**, 349–87.

Manikowski, S. (1988). Aerial spraying of quelea. *Trop. Pest Manage.*, 34, 133–40.

Manikowski, S. and Da Camara-Smeets, M. (1975*a*). Estimation de dégâts d'oiseaux sur la sorgho dans la region de N'Djamena. Unpubl. Internal Rep., FAO/UNDP Quelea Project RAF/73/055, FAO, Rome.

Manikowski, S. and Da Camara-Smeets, M. (1975*b*). Observations sur les dégâts d'oiseaux dans la zone de Maroua-Lere-Pala. Unpubl. Internal Rep., FAO/UNDP Quelea Project RAF/73/055, FAO, Rome.

Manikowski, S. and Da Camara-Smeets, M. (1979*a*). Estimating bird damage to sorghum and millet in Chad. *J. Wildl. Manage.*, 43, 540–4.

Manikowski, S. and Da Camara-Smeets, M. (1979*b*). Preferences alimentaires chez *Quelea quelea quelea* (L.). *Terre Vie*, 33, 611-22.

Marshall, A. J. and Disney, H. J. de S. (1956). Photostimulation of an equatorial bird (*Quelea quelea*, Linnaeus). *Nature (Lond.)*, 177, 143–4.

Marshall, A. J. and Disney, H. J. de S. (1957). Experimental induction of the breeding season in a xerophilous bird. *Nature (Lond.)*, 180, 647–9.

Martin, L. (1976). Tests of bird damage control measures in Sudan, 1975. *Proc. 7th Bird Control Semin.*, Bowling Green, Ohio, 7, 259–66.

Martin, L. R. (1979). Effective use of sound to repel birds from industrial waste ponds. *Proc. 8th Bird Control Semin.*, Bowling Green, Ohio, 8, 71–6.

Martin, L. R. and Jackson, J. J. (1977). Field testing a bird repellent chemical on cereal crops. In *Vertebrate pest control and management Materials, ASTM STP 680* (ed. R. E. Marsh). Am. Soc. for Testing and Materials, pp. 177–85.

Mason, J. R., Glahn, J. F., Dolbeer, R. A., and Reidinger, R. F., Jr. (1985). Field evaluation of dimethyl anthranilate as a bird repellent livestock feed additive. *J. Wildl. Manage.*, 49, 636–42.

Mason, J. R. and Reidinger, R. F. (1982). Observational learning of food aversion in red-winged blackbirds (*Agelaius phoeniceus*). *Auk*, 99, 548–54.

Mason, J. R. and Reidinger, R. F., Jr. (1981). Effects of social facilitation and observational learning on feeding behavior of the red-winged blackbird (*Agelaius phoeniceus*). *Auk*, 98, 778–84.

Mathew, D. N. (1976). Ecology of the weaver birds. *J. Bombay Nat. Hist. Soc.*, 73, 249–60.

Mayo, E. S. and Lesur, J.-C. (1985). The control of quelea and other weaverbird pests by direct treatment of wheat with the avicide fenthion. Unpubl. Internal Rep., FAO/UNDP Project URT/81/013, Tanzania.

Mayr, E. (1971). *Populations, species, and evolution.* Belknap Press, Cambridge, Massachusetts.

McCourtie, W. D. (1973). Traditional farming in Liberia. Unpubl. Rep., FAO/UNDP Project, College of Agriculture and Forestry, University of Liberia.

McCullough, R. A. (1953). Supplementary whole grouse study to evaluate laboratory analysis of ruffed grouse wing and tail study. Unpubl. Internal Rep., New Hampshire Fish and Game Department, Concord, New Hampshire.

McGrath, R. M., Kaluza, W. Z., Daiber, K. H., Van der Riet, W. B., and Glennie, C. W. (1982). Polyphenols of sorghum grain, their changes during malting, and their inhibitory nature. *J. Agric. Food Chem.*, 30, 450–6.

McLachlan, G. R. (1961). Seventh ringing report. *Ostrich*, 32, 36–47.

McLachlan, G. R. (1962). Eighth ringing report. *Ostrich*, 33, 29–37.

McLachlan, G. R. (1963). Ninth ringing report. *Ostrich*, 34, 102–9.

McLachlan, G. R. (1964). Tenth ringing report. *Ostrich*, 35, 101–10.

McLachlan, G. R. (1965). Eleventh ringing report. *Ostrich*, 36, 214–23.

McLachlan, G. R. (1966). The first ten years of ringing in South Africa. *Ostrich [Suppl.]*, 6, 255–63.

McLachlan, G. R. (1967). Twelfth ringing report. *Ostrich*, 38, 17–26.

McLachlan, G. R. (1969). Thirteenth ringing report. *Ostrich*, 40, 37–50.

McLachlan, G. R. and Liversidge, R. (1971). *Roberts birds of South Africa.* John Voelcker Bird Book Fund, South Africa.

Mead, C. J. and Watmough, B. R. (1976). Suspended moult of Trans-Saharan migrants in Iberia. *Bird Study*, 23, 187–96.

Meanley, B. (1971). Blackbirds and the southern rice crop. *U.S. Fish Wildl. Serv. Resour. Publ.*, 100.

Meanley, B. and Royall, W. C. (1976). Nationwide estimates of blackbirds and starlings. *Proc. 7th Bird Control Semin.*, Bowling Green, Ohio, 7, 39–40.

Means, J. W., Jr. (1981). X-ray microanalysis of Kirtland's warbler feathers for possible population discrimination. Unpubl. M.S. thesis, Ohio State University, Columbus, Ohio.

Meinzingen, W. (1980). Development of aerial application for the control of *Quelea quelea* in Africa. Unpubl. Internal Rep., FAO/UNDP Regional Quelea Project RAF/81/023.

Meinzingen, W. (1983). Comparison study of droplet behaviour with an application rate of 2 l and 4 l/ha. Unpubl. Internal Rep. FAO/DLCO-EA.

Meinzingen, W. (1984). Effect of different application rates in quelea control in Ethiopia 1984. *Proc. 5th Annu. Tech. Meet.*, FAO/UNDP Regional Quelea Project RAF/81/023, pp. 54–6.

Meinzingen, W. and Latigo, A.A.R. (1986). A new technique for mass-marking of quelea (*Quelea quelea*). *Proc. 1st Quelea Tech. Meet.*, Desert Locust Control Organization for Eastern Africa, Nairobi, Kenya.

Mierzejewski, K. (1981). The physics of aerial and groundbased spraying for quelea control. Unpubl. Internal Rep., FAO/UNDP Regional Quelea Project URT/78/022.

Mitaru, B. N., Reichert, R. D., and Blair, R. (1983). Improvement of the nutritive value of high tannin sorghums for broiler chickens by high moisture storage (reconstitution). *Poult. Sci.*, 62, 2065–72.

Mitchell, R. T. (1963). The floodlight trap—a device for capturing large numbers of blackbirds and starlings at roosts. *U.S. Fish Wildl. Serv. Spec. Sci. Rep. Wildl.*, 77.

Moreau, R. E. (1960). Conspectus and classification of the ploceine weaver-birds, Part I and Part II. *Ibis*, 102, 298–321;443–71.

Morel, G. (1965). La riziculture et les oiseaux dans la vallée du Sénégal. *Congr. Protect. Cultures Trop.*, Marseille, pp. 640–2.

Morel, G. (1968). L'impact écologique de *Quelea quelea* (L.) sur les savanes sahéliennes raisons du pullulement de ce plocéide. *Terre Vie*, **1**, 69–98.

Morel, G. and Bourlière, F. (1955). Recherches écologiques sur *Quelea quelea quelea* (L.) de la basse vallée du Sénégal. I. Données quantitatives sur le cycle annuel. *Bull. Inst. Fr. Afr. Noire Ser. A*, **17**, 617–63.

Morel, G. and Bourlière, F. (1956). Recherches écologiques sur les *Quelea quelea quelea* (L.) de la basse vallée du Sénégal. II. La reproduction. *Alauda*, **24**, 97–122.

Morel, G., Morel, M.-Y., and Bourlière, F. (1957). The blackfaced weaver bird or dioch in West Africa: an ecological study. *J. Bombay Nat. Hist. Soc.*, **54**, 811–25.

Morel, G. J. and Morel, M.-Y. (1978). Recherches écologiques sur une savane sahélienne du Ferlo septentrional, Sénégal. Etude d'une communaute avienne. *Cah. ORSTOM Ser. Biol.*, **XIII**, 3–34.

Morel, J. G. (1980). Liste commentee des oiseaux du Sénégal et de la Gambie. Suppl. No. 1, ORSTOM, Dakar.

Morel, J. G. and Morel, M.-Y. (1982). Dates de reproduction des oiseaux de Senegambie. *Bonn. Zool. Beitr.*, **33**, 249–68.

Morse, D. H. (1980). *Behavioral mechanism in ecology*. Harvard University Press, Cambridge, Massachusetts.

Moseman, A. H. (1966). Pest control: its role in the United States economy and in the world. Scientific aspects of pest control. *Natl. Acad. Sci.*, **1402**, 26–38. Washington, D.C.

Mosha, A. S. and Munisi, E. N. (1983). Focus on research for rainfed wheat production in Tanzania. *Proc. Regional Wheat Workshop East, Cent. and Southern Africa*, Arusha, Tanzania. Nakuru Press, Kenya, pp. 20–3.

Mott, D. F., Guarino, J. L., Schafer, E. W., Jr., and Cunningham, D. C. (1976). Methiocarb for preventing blackbird damage to sprouting rice. *Proc. 7th Vertebr. Pest Conf.*, Monterey, California, 7, 22–5.

Muhammed, A. and Khan, A. (1982). Perspective of edible oils research and production in Pakistan. *Pakistan Agric. Res. Council*, Islamabad, Pakistan, Unnumbered Rep.

Munck, L., Knudsen, K. E. B., and Axtell, J. D. (1982). Industrial milling of sorghum for the 1980s. In *Sorghum in the Eighties: Proc. Int. Symp. on Sorghum* (ed. J. Mertin). ICRISAT, Patancheru, A. P., India, pp. 565–70.

Murton, R. K. (1965). Natural and artificial population control in the woodpigeon. *Ann. Appl. Biol.*, **55**, 177–92.

Murton, R. K. and Westwood, N. J. (1977). *Avian breeding cycles*. Oxford University Press, Oxford, UK.

Nakamura, K. and Matsuoka, S. (1983). The food-searching and foraging behaviours of rufous turtle dove, *Streptopelia orientalis* (Lathem), in soybean fields. *Proc. 9th Bird Control Semin.*, Bowling Green, Ohio, 9, 161–6.

Naude, T. J. (1955*a*). The quelea problem in the Union of South Africa CCTA/CSA Africa (55)120. CSA Réunion des Specialistes du Quelea, Dakar, 1955. Secretariat Conjoint CCTA/CSA, Bukavu.

Naude, T. J. (1955*b*). Quelea control South Africa. Foreign correspondence, Vol. I, 1952–56. Unpubl. Rep., Govt. of South Africa, Pretoria.

Ndege, J. O. (1982). Evaluation of methiocarb efficacy in reducing bird damage to ripening wheat in Arusha-Tanzania. Unpubl. M.S. Thesis, Bowling Green State University, Bowling Green, Ohio.

Ndege, J. O. and Elliott, C.C.H. (1984). Quelea control achievements of the Tanzanian Bird Control Unit, June 1983–October 1984. *Proc. 5th Annu. Tech. Meet.*, FAO/UNDP Regional Quelea Project RAF/81/023, pp. 135–57.

Ndiaye, A. (1974). Fluctuation des populations aviaires dans la vallée du fleuve Sénégal. Unpubl. Internal Rep., FAO/UNDP Quelea Project RAF/73/055, FAO, Rome.

Ndiaye, A. (1979). OCLALAV experience in the field of bird control in West Africa. *Min. 1st Annu. Tech. Meet.*, FAO/UNDP Regional Quelea Project RAF/77/042.

Neth, J. W. (1971). Identifying natal areas of Ohio-hatched Canada geese by neutron activation analyses. Unpubl. M.S. thesis, Ohio State University, Columbus, Ohio.

Newby, J. (1980). The birds of Ouadi Rime-Ouadi Achim Faunal Reserve. A contribution to the study of the Chadian avifauna, Part II. *Malimbus* **2**, 29–50.

Newton, I. (1967). The adaptive radiation and feeding ecology of some British finches. *Ibis*, **109**, 33–98.

Newton, I. (1968). Bullfinches and fruit buds. In *The problems of birds as pests* (eds. R. K. Murton and E. N. Wright). Academic Press, London, pp. 199–209.

Nice. M. M. (1953). The question of ten day incubation periods. *Wilson Bull.*, **65**, 81–93.

Nicolaus, L. K., Cassel, J. F., Carlson, R. B., and Gustavson, C. R. (1983). Taste aversion conditioning of crows to control predation on eggs. *Science*, **220**, 212–4.

Nikolaus, G. (1981). Wir und die Voegel. *Deutsches Buchverzeichnis* **13**, 16.

Nilsson, G. (1981). *The bird business—A study of the commercial cage bird trade*. Animal Welfare Institute, Washington, D.C.

Nur, N. (1984). The consequences of brood size for breeding blue tits. I. Adult survival, weight change and the costs of reproduction. *J. Anim. Ecol.*, **53**, 479–96.

Orians, G. H. (1961). The ecology of blackbird (*Agelaius*) social systems. *Ecol. Monogr.*, **31**, 285–312.

ORSTOM. (1970). Monographie hydrologique de Bassin du Niger. 2ème partie La Cuvette Lacustre. Unpubl. Rep., Office de la Recherche Scientifique et Technique Outre-Mer, Paris.

Oswalt, O. L. (1975). Estimating the biological effects of tannins in grain sorghum. *Proc. Int. Sorghum Workshop*, (ed. Publication Staff). U.S. Agency for International Development, Washington, D.C., pp. 530–54.

Otis, D. L. (1984). A method for estimating sorghum loss to birds over large areas of Eastern Africa. Unpubl. Consultancy Rep., RAF/81/023, to FAO/UNDP, Rome, Italy.

Otis, D. L., Holler, N. R., Lefebvre, P. W., and Mott, D. F. (1983). Estimating bird damage to sprouting rice. In *Vertebrate pest control and management materials, ASTM STP 817* (ed. D. E. Kaukeinen). Am. Soc. for Testing and Materials, pp. 76–89.

Otis, D. L., Knittle, C. E., and Linz, G. M. (1986). A method for estimating turnover in spring blackbird roosts. *J. Wildl. Manage.*, **50**, 567–71.

Park, P. O. (1973). Attacks by bird enemies of rice and their control. Plant protection

for the rice crop. *Proc. Semin. Liberia*. Unpubl. Rep., FAO/UNDP, Rome, Italy.
Park, P. O. (1974). Granivorous bird pests in Africa; towards integrated control. *Span*, **17**, 126–8.
Park, P. O. (1975). The socio-economic effects of the control of grain-eating birds. Unpubl. Internal Rep., FAO/UNDP Quelea Project RAF/73/055, FAO, Rome.
Park, P. O., Adam, J., and Lubazo, R. (1975). Trials of repellency for the protection of sorghum at Deli. Unpubl. Internal Rep., FAO/UNDP Quelea Project RAF/73/055, FAO, Rome.
Park, P. O. and Adam, J. A. (1976). Trials of repellents for the protection of rice in the ear—Cameroons, 1975. Unpubl. Internal Rep., FAO/UNDP Quelea Project RAF/73/055, FAO, Rome.
Park, P. O. and Assegninou, W. (1973). Trials at Deli of chemical repellents to protect sorghum against grain-eating birds. Unpubl. Internal Rep., FAO/UNDP Quelea Project RAF/73/055, FAO, Rome.
Parker, J. D. (1986). A novel sprayer for the control of quelea birds. *Trop. Pest Manage.*, **32**, 243–5.
Parker, J. D. and Casci, F. M. (1983). Report of a consultancy carried out with URT/81/013-FAO/UNDP Quelea Bird Control Project, Arusha, Tanzania.
Parrish, J. R., Rogers, D. T., Jr., and Prescott Ward, F. (1983). Identification of natal locales of peregrine falcons (*Falco peregrinus*) by trace-element analysis of feathers. *Auk*, **100**, 560–7.
Pavlov, A. N. and Kolesnik, T. I. (1979). The attracting ability of caryopses as one of the factors determining level of protein accumulation in wheat grain. *Field Crop Abstracts*, **32**, 394.
Payne, R. B. (1972). Mechanics and control of molt. In *Avian biology*, Vol. 2 (eds. D. S. Farner and J. R. King). Academic Press, New York and London.
Payne, R. B. (1980). Seasonal incidence of breeding, moult and local dispersal of red-billed firefinches *Lagonosticta senegala* in Zambia. *Ibis*, **122**, 43–56.
Peña, M. (1977). Proposal for studying and establishing a control program for Madam Sarah (*Ploceus cucullatus*) in Hispaniola. National Zoological Park, Santo Domingo, Dominican Republic.
Pepper, S. R. (1973). Observations on bird damage and traditional bird pest control methods on ripening sorghum. Unpubl. Internal Rep., FAO/UNDP Quelea Project RAF/73/055, FAO, Rome.
Perrins, C. M. (1970). The timing of birds' breeding seasons. *Ibis*, **112**, 242–55.
Perumal, R. S. and Subramaniam, T. R. (1973). Studies on panicle characteristics associated with bird resistance in sorghum. *Madras Agric. J.* 60, 256–8.
Pienaar, V. de V. (1969). Observations on the nesting habits and predators of breeding colonies of red-billed quelea, *Quelea quelea lathami*, in the Kruger National Park. *Bokmakierie*, **21**, [Suppl.],11–5.
Pinowski, J. (1973). The problem of protecting crops against harmful birds in Poland. *European and Mediterranean Plant Protect. Organization OEPP/EPPO Bull.*, 3, 107–10.
Pinowski, J., Tomek, T., and Tomek, W. (1972). Food selection in the tree sparrow, *Passer m. montanus* (L.). Prelim. Rep. In *Productivity, population dynamics and systematics of granivorous birds* (eds. S. C. Kendeigh and J. Pinowski). Polish Scientific Publishers, Warszawa, Poland, pp. 263–73

Pitman, C.R.S. (1957). Further notes on aquatic predators of birds. *Bull. Br. Ornithol. Club*, **77**, 89–97,105–10,122–6.
Pitman, C.R.S. (1961). More aquatic predators of birds. *Bull. Br. Ornithol. Club*, **81**, 57–62,78–81,105–6.
Plowes, D.C.H. (1950). The red-billed quelea—a problem for grain- sorghum growers. *Rhod. Agric. J.*, **47**, 98–101.
Plowes, D.C.H. (1953). Report on red-billed queleas, Oct. 1952–Feb. 1953. Unpubl. Rep., Nyamandhlovu.
Plowes, D.C.H. (1955). Queleas in Southern Rhodesia, CCTA/CSA Africa (55) 121. CSA Réunion des Specialistes du Quelea, Dakar, 1955. Secretariat Conjoint CCTA/CSA., Bukavu.
Poché, R. M., Karim, Md. A., and Haque, Md. E. (1980). Bird damage control in sprouting wheat. *Bangladesh J. Agric. Res.*, **5**,41–6.
Pope, G. G. and King, W. J. (1973). Spray trials against the Red-billed Quelea (*Quelea quelea*) in Tanzania. Misc. Rep. 12, Centre for Overseas Pest Research, London, UK.
Pope, G. G. and Ward, P. (1972). The effects of small applications of an organophosphorus poison, fenthion, on the weaver-bird *Quelea quelea*. *Pestic. Sci.*, **3**, 197–205.
Power, D. M. (1970). Geographic variation of red-winged blackbirds in central North America. *Univ. of Kansas Publ. of the Mus. Nat. Hist.* **19**, 1–83.
Prakash, I. (1982). Vertebrate pest problems in India. In *Proc. Conf. on The Organisation and Practice of Vertebrate Pest Control* (ed. A. C. Dubock). Imperial Chemical Industries PLC, Dramrite Printers Ltd., London, pp. 29–35.
Price, M. L., Butler, L. G., Rogler, J. C., and Featherston, W. R. (1979). Overcoming the nutritionally harmful effects of tannin in sorghum grain by treatment with inexpensive chemicals. *J. Agric. Food Chem.*, **27**, 441–5.
Price, M. L., Van Scoyoc, S., and Butler, L. G. (1978). A critical evaluation of the vanillin reaction as an assay for tannin in sorghum grain. *J. Agric. Food Chem.*, **26**, 1214–8.
Prozesky, O. P. (1964). Comprehensive bird concentration at Lake Ngami. *Afr. Wildl.*, **18**, 137–42.
Pulliam, H. R. (1973). On the advantages of flocking. *J. Theor. Biol.*, **38**, 419–22.
Pulliam, H. R. (1975). Diet optimization with nutrient constraints. *Am. Nat.*, 109, 765–8.
Pyke, G. H., Pulliam, H. R., and Charnov, E. L. (1977). Optimal foraging: a selective review of theory and tests. *Q. Rev. Biol.*, **52**, 137–54.
Quesnel, V. C. (1968). Fractionation and properties of the polymeric leucocyanidin of the seeds of *Theobrama cacao*. *Phytochemistry*, **7**, 1583–92.
Raju, A. S. and Shivanarayan, N. (1980). Extent of damage in some early rice varieties due to bird pests at Maruteru. *Int. Rice Comm. Newsl.*, **29**, 44–5.
Ramachandra, G., Virupaksha, T. K., and Shadaksharaswamy, M. (1977). Relationship between tannin levels and in vitro protein digestibility in finger millet (*Eleusine coracana* Gaertn.). *J. Agric. Food Chem.*, **25**, 1101–4.
Rattray, J. M. (1960). Tapis graminéens d'Afrique. Etudes Agricoles No. 49. FAO, Rome.
Reichert, R. D., Fleming, S. E., and Schwab, D. J. (1980). Tannin deactivation and

nutritional improvement of sorghum by anaerobic storage of H_2O, HCl, or NaOH-treated grain. *J. Agric. Food Chem.*, **28**, 824–9.

Reichert, R. D. and Youngs, C. G. (1977*a*). Dehulling cereal grains and grain legumes for developing countries. I. Quantitative comparison between attrition- and abrasive-type mills. *Cereal Chem.*, **53**, 829–39.

Reichert, R. D. and Youngs, C. G. (1977*b*). Dehulling cereal grains and grain legumes for developing countries. II. Chemical composition of mechanically and traditionally dehulled sorghum and millet. *Cereal Chem.*, **54**, 174–8.

Ricklefs, R. E. (1973). Fecundity, mortality and avian demography. In *Breeding biology of birds* (ed. D. S. Farner). National Research Council, Washington, D.C.

Roberts, N. (1909). *Pyromelana oryx* and its nesting parasites. *J. South Afr. Ornithol. Union*, **5**, 22–4.

Roberts, T. J. (1974). Bird damage to farm crops in Pakistan with special reference to sunflower (*Helianthus annus*). Vertebrate Pest Control Centre, Karachi, Pakistan.

Roberts, T. J. (ed.) (1981). *Handbook of Vertebrate Pest Control in Pakistan*. Pakistan Agric. Res. Council and Food and Agriculture Organization of the United Nations, Vertebrate Pest Control Research Centre, Karachi, Pakistan.

Rogers, J. G., Jr. (1974). Responses of caged red-winged blackbirds to two types of repellents. *J. Wildl. Manage.*, **38**, 118–23.

Rogers, J. G., Jr. (1978*a*). Repellents to protect crops from vertebrate pests: some considerations for their use and development. In *Flavor chemistry of animal foods* (ed. R. W. Bullard). ACS Symp. Ser. No. 67, American Chemical Society, Washington, DC. pp. 150–84.

Rogers, J. G., Jr. (1978*b*.) Some characteristics of conditioned aversion in red-winged blackbirds. *Auk*, **95**, 362–9.

Rogers, J. G., Jr. (1980). Conditioned taste aversion: its role in bird damage control. In *Bird problems in agriculture* (eds. E. N. Wright, I. R. Inglis, and C. J. Feare). British Crop Protection Council (BCPC) Publications, Croydon, UK, pp. 173–9.

Rooke, I. J. (1983). Conditioned aversion by Silvereyes *Zosterops lateralis* to food treated with methiocarb. *Bird Behav.*, **4**, 86–9.

Rooney, L. W. and Murty, D. S. (1982). Color of sorghum food products. In *Proc. Int. Symp. Sorghum Grain Quality* (eds. L. W. Rooney and D. S. Murty). ICRISAT, Patancheru, A.P., India, pp. 323–7.

Rosa Pinto, A. A., da. (1960). O problema 'Quelea' e a agricultura em Angola. *Melhoramento*, **13**, 79–113.

Rosa Pinto, A. A., da and Lamm, D. W. (1960). Memorias do Museu Dr Alvaro de Castro, no. 5. Lourenco Marques.

Rowan, M. K. (1964). An analysis of the records of a South African ringing station. *Ostrich*, **35**, 160–87.

Royama, T. (1966). A re-interpretation of courtship feeding. *Bird Study*, **13**, 116–29.

Royama, T. (1970). Factors governing the hunting behaviour and selection of food by the great tit (*Parus major* L.). *J. Anim. Ecol.*, **39**, 619–68.

Ruelle, P. and Bruggers, R. L. (1979). Evaluating bird protection to mechanically sown rice seed treated with methiocarb at Nianga, Senegal, West Africa. In *Vertebrate pest control and management materials, ASTM STP 680* (ed. J. R. Beck). Am. Soc. for Testing and Materials, pp. 211–6.

Ruelle, P. and Bruggers, R. L. (1982). Traditional approaches for protecting cereal crops from birds in Africa. *Proc. 10th Vertebr. Pest Conf.*, Monterey, California, **10**, 80–6.

Ruelle, P. and Bruggers, R. L. (1983). Senegal's trade in cage birds 1979–81. *U.S. Fish Wildl. Serv. Wildl. Leafl.*, **515**.

Ruelle, P. J. (1983). Control of granivorous bird pests of rice using the partial crop treatment method in West Africa. *Trop. Pest Manage.*, **29**, 23–6.

Ryan, J. (1981). Songbird stew. *Int. Wildl.*, **11**, 44–8.

Salvan, J. (1967). Contribution a l'etude des oiseaux du Tschad. *Oiseau Rev. Fr. Ornithol.*, **37**, 255–84.

Salvan, J. (1969). Contribution a l'etude des oiseaux du Tschad. *Oiseau Rev. Fr. Ornithol.*, **39**, 38–69.

Schafer, E. W., Jr. (1972). The acute oral toxicity of 369 pesticidal, pharmaceutical and other chemicals to wild birds. *Toxicol. Appl. Pharmacol.*, **21**, 315–30.

Schafer, E. W., Jr. (1979). Registered bird damage chemical controls. *Pest Control*, **47**, June:36–9.

Schafer, E. W., Jr. (1981). Bird control chemicals—nature, modes of action, and toxicity. In *CRC handbook of pest management in agriculture* (ed. D. Pimentel) Vol. III. CRC Series in Agriculture, Boca Raton, Florida, pp. 129–39.

Schafer, E. W., Jr. and Brunton, R. B. (1971). Chemicals as bird repellents: two promising agents. *J. Wildl. Manage.*, **35**, 569–72.

Schafer, E. W., Jr., Brunton, R. B., Lockyer, N. F., and De Grazio, J. W. (1973). Comparative toxicity of seventeen pesticides to the *Quelea*, house sparrow and red-winged blackbird. *Toxicol. Appl. Pharmacol.*, **26**, 154–7.

Schildmacher, H. (1929). Über den Wärmehaushalt kleiner Körnerfresser. *Ornithol. Monatsber.*, **37**, 102–6.

Schmutterer, H. (1969). *Pests of crops in north-east and central Africa*. Gustav Fisher, Stuttgart, West Germany, and Portland, USA.

Schuler, W. (1980). Factors influencing learning to avoid unpalatable prey in birds relearning new alternative prey and similarity of appearance of alternative prey. *Z. Tierpsychol.*, **54**, 105–43.

Seber, G. A. (1970). Estimating time-specific survival and reporting rates for adult birds from band returns. *Biometrika*, **57**, 313–8.

Seber, G.A.F. (1973). *The estimation of animal abundance and related parameters*. Charles Griffin, London, UK.

Selander, R. K. and Johnston, R. F. (1967). Evolution in the house sparrow. I. Intrapopulation variation in North America. *Condor*, **69**, 217–58.

Sengupta, S. (1973). Significance of communal roosting in the common mynah, *Acridotheres tristis* (L.). *J. Bombay Nat. Hist. Soc.*, **70**, 204–6.

Serrurier, A. (1965). Ecologie du *Quelea quelea quelea*. *Congr. Protect. Cultures Trop.*, Marseille, pp. 643–5.

Serrurier, A. (1966). La lutte anti-aviaire en Afrique sahelienne. *Mach. Agric. Trop.*, **13**, 28–33.

Shannon, J. G. and Reid, D. A. (1976). Awned vs awnless isogenic winter barley grown at three environments. *Crop Sci.*, **16**, 347–9.

Shefte, N., Bruggers, R. L., and Schafer, E. W., Jr. (1982). Repellency and toxicity of three bird control chemicals to four species of African grain-eating birds. *J. Wildl. Manage.*, **46**, 453–7.

Shepherd, A. D. (1981). How a typical sorghum peels. *Cereal Chem.*, **58**, 303–6.

Shivanarayan, N. (1980). Role of birds in agriculture. *Souvenir: Int. Meet. on Wild. Resources in Rural Development.* July 7–11, 1980, Hyderabad, India, pp. 25–30.

Shumake, S. A., Gaddis, S. E., and Garrison, M. V. (1983). Development of a preferred bait for quelea control. In *Vertebrate pest control and management materials: 4th Symp., ASTM STP 817* (ed. D. E. Kaukeinen). Am. Soc. for Testing and Materials, pp. 118–26.

Shumake, S. A., Gaddis, S. E., and Schafer, E. W., Jr. (1976). Behavioral response of quelea to methiocarb (Mesurol®). *Proc. 7th Bird Control Semin.*, Bowling Green, Ohio, **7**, 250–4.

Sinclair, A.R.E. (1978). Factors affecting the food supply and breeding season of resident birds and movements of Palaearctic migrants in a tropical African savannah. *Ibis*, **120**, 480–97.

Slater, P.J.B. (1980). Bird behaviour and scaring by sounds. *Proc. Bird Problems in Agric. Symp.* (eds. E. N. Wright, I. R. Inglis, and C. J. Feare). University of London, BCPC Publ., pp. 105–20.

Smith, J.N.M. and Sweatman, H.P.A. (1974). Food-searching behavior of titmice in patchy environments. *Ecology*, **55**, 1216–32.

Sonnier, J. (1957). Report on the action taken during 1956, in Senegal and Mauritania by the Department for Bird Control. *CSA Symp. Quelea*, Livingstone, 1957. CCTA/CSA Joint Secretariat, Bukavu.

Stewart, D. R. (1959). The red-billed quelea in northern Rhodesia. *North Rhod. J.*, **4**, 55–62.

Stickley, A. R., Otis, D. L., Bray, O. E., Heisterberg, J. F., and Grandpre, T. F. (1979*a*). Bird and mammal damage to mature corn in Kentucky and Tennessee. *Proc. Annu. Conf. Southeast. Assoc. Fish. Wildl. Agencies*, **32**, 228–33.

Stickley, A. R., Jr., Otis, D. L., and Palmer, D. T. (1979*b*). Evaluation and results of a survey of blackbird and mammal damage to mature field corn over a large (three-state) area. In *Vertebrate pest control and management materials, ASTM STP 680* (ed. J. R. Beck). Am. Soc. for Testing and Materials, pp. 169–77.

Stone, C. P. and Mott, D. F. (1973*a*). Bird damage to sprouting corn in the United States. *U.S. Fish Wildl. Serv., Spec. Sci. Rep. Wildl.*, **173**.

Stone, C. P. and Mott, D. F. (1973*b*). Bird damage to ripening field corn in the United States, 1971. *U.S. Fish Wildl. Serv. Wildl. Leaf.*, **505**, 1–8.

Stone, R. J. (1976). Chemical repellents can save crops. *World Crops*, May/June, pp. 132–3.

Stresemann, E. (1965). Die Mauser der Huehnervoegel. *J. Ornithol.*, **106**, 58–64.

Stroosnijder, L. and van Hempst, H.D.J. (1982). La meteorologie du sahel et du terrain d'etude. In *La productivité des paturages sahéliens* (eds. F.W.T. Penning De Vries and M. A. Djiteye). Centre for Agricultural Publishing and Documentation, Wageningen, pp. 37–51.

Sultana, P., Brooks, J. E., and Bruggers, R. L. (1986). Repellency and toxicity of bird control chemicals to pest birds in Bangladesh. *Trop. Pest Manage.* **32**, 246–8.

Taber, R. D. and Cowan, I. McT. (1969). Capturing and marking wild animals. In *Wildlife management techniques* (ed. R. H. Giles). Wildlife Society, Washington, D.C., pp. 227–318.

Tarboton, W. (1987). Redbilled Quelea spraying ... *Gab...*

Taylor, L. E. (1906). The birds of Irene, near Pretoria, Transvaal. *J. S. Afr. Ornithol. Union*, **2**, 55–83.

Thiollay, J. M. (1975). Exemple de predation naturelle sur une population nicheuse de *Quelea qu. quelea* L. au Mali. *Terre Vie*, **29**, 31–54.

Thiollay, J. M. (1978*a*). Production et taux de mortalité dans les colonies de *Quelea quelea* (Aves: Ploceidae) en Afrique Centrale. *Trop. Ecol.*, **19**, 7–24.

Thiollay, J. M. (1978*b*). Les migrations des rapaces en Afrique occidentale; adaptations écologiques aux fluctuations de production des écosystèmes. *Terre Vie*, **32**, 89–133.

Thompson, B. W. (1965). *The climate of Africa.* Oxford University Press, London, UK.

Thompson, J. and Jaeger M. M. (1984). Regional mass-marking and fingerprinting analysis during 1984. *Proc. 5th Annu. Tech. Meet.*, FAO/UNDP Regional Quelea Project RAF/81/023.

Thomsett, S. (1987). Raptor deaths as a result of poisoning quelea in Kenya. *Gabar*, **2**, 33–8.

Tinbergen, J. M. and Drent, R. H. (1980). The starling as a successful forager. In *Bird problems in agriculture* (eds. E. N. Wright, I. R. Inglis, and C. J. Feare). BCPC Publications, Croydon, England, pp. 83–97.

Traylor, M. A. (1963). *Check-list of Angolan birds.* Museu do Dundo, Lisbon.

Treca, B. (1976). Les oiseaux d'eau et la riziculture dans le Delta du Sénégal. *Oiseau Rev. Fr. Ornithol.*, **45**, 259–65.

Tree, A. J. (1962). The birds of the Leopardshill area of the Zambesi escarpment. *Ostrich*, **33**, 3–23.

Uk, S. and Munks, S. (1984). Fenthion residues in quelea birds from experimental aerial spraying of Queletox at Makayuni, Tanzania, in June 1983. International Centre for the Application of Pesticides, Cranfield Institute of Technology, UK.

UNESCO. (1959). Carte de la vegetation de l'Afrique au sud du tropique du cancer. Unpubl. Rep., United Nations Educational, Scientific, and Cultural Organization (UNESCO).

Urban, E. K. and Brown, L. H. (1971). *A checklist of the birds of Ethiopia.* Haile Sellassie I University Press, Addis Ababa, Ethiopia.

Van Ee, C. A. (1973). Cattle egrets prey on breeding queleas. *Ostrich*, **44**, 136.

Van Someren, V.G.L. (1922). Notes on the birds of East Africa. *Novit. Zool.*, **29**, 1–246.

Vernon, C. J. (In press). The quelea in natural ecosystems. In *The quelea problem in southern Africa* (eds. P. J. Mundy and M.J.F. Jarvis). Baobab Books, Zimbabwe.

Vesey-FitzGerald, D. F. (1958). Notes on the breeding colonies of the red-billed quelea in S. W. Tanganyika. *Ibis*, **100**, 167–74.

Voss, F. (1986). *ATLAS: Quelea habitats in East Africa.* Food and Agriculture Organization, Rome

Walsberg, G. E. and King, J. R. (1980). The thermoregulatory significance of the winter roost-sites selected by robins in eastern Washington. *Wilson Bull.*, **92**, 33–9.

Ward, P. (1965*a*). Feeding ecology of the black-faced dioch *Quelea quelea* in Nigeria. ... 214.

Ward, P. (1965*b*). The breeding biology of the black-faced dioch *Quelea quelea* in Nigeria. *Ibis*, **107**, 326–49.
Ward, P. (1965*c*). Biological implications of quelea control in West Africa. *Congres de la Protection des Cultures Tropicales* 661-6, Marseilles.
Ward, P. (1965*d*). Seasonal changes in the sex ratio of *Quelea quelea* (Ploceidae). *Ibis*, **107**, 397–9.
Ward, P. (1966). Distribution, systematics, and polymorphism of the African weaver-bird (*Quelea quelea*). *Ibis*, **108**, 34–40.
Ward, P. (1969). The annual cycle of the yellow-vented bulbul *Pycnonotus goiavier* in a humid equatorial environment. *J. Zool. (Lond.)*, **157**, 25–45.
Ward, P. (1971). The migration patterns of *Quelea quelea* in Africa. *Ibis*, **113**, 275–97.
Ward, P. (1972*a*). East Africa tropical bird-pest research project. Final Rep., Centre of Overseas Pest Research. ODA Res. Scheme R. 2092.
Ward, P. (1972*b*). Synchronisation of the annual cycle within populations of *Quelea quelea* in East Africa. *Proc. Int. Ornithol. Congr.*, **15**, 702–3.
Ward, P. (1973*a*). A new strategy for the control of damage by queleas. *PANS*, 19, 97–106.
Ward, P. (1973*b*). *Manual of techniques used in research on quelea birds*. AGP:RAF/67/087 Working Paper (Manual), United Nations Development Programme/FAO, Rome.
Ward, P. (1978). The role of the crop among red-billed quelea *Quelea quelea*. *Ibis*, **120**, 333–7.
Ward, P. (1979). Rational strategies for the control of queleas and other migrant bird pests in Africa. *Philos. Trans. R. Soc. Lond. B Biol. Sci.*, **287**, 289–300.
Ward, P. and Jones, P. J. (1977). Pre-migratory fattening in three races of the red-billed quelea *Quelea quelea* (Aves: Ploceidae), an intra-tropical migrant. *J. Zool. (Lond.)*, **181**, 43–56.
Ward, P. and Kendall, M. D. (1975). Morphological changes in the thymus of young and adult red-billed queleas *Quelea quelea* (Aves). *Philos. Trans. R. Soc. Lond. B Biol. Sci.*, **273**, 55–64.
Ward, P. and Pope, G. G. (1972). Flight-tunnel experiments with red-billed queleas to determine the distribution of a solution sprayed onto birds in flight. *Pestic. Sci.*, **3**, 709–14.
Ward, P. and Zahavi, A. (1973). The importance of certain assemblages of birds as 'information centres' for food finding. *Ibis*, **115**, 517–34.
WARDA. (1983). Preliminary analysis of socio-economic baseline data. West Africa Rice Development Association WARDA/TAT/83/ARR-8A.
Weatherhead, P. J. (1983). Two principal strategies in avian communal roosts. *Am. Nat.*, **121**, 237–43.
Weatherhead, P. J., Tinker, S., and Greenwood, H. (1982). Indirect assessment of avian damage to agriculture. *J. Appl. Ecol.*, **19**, 773–82.
Weidner, T. (1983). Why do pesticides cost so much $$$? *Pest Control Technol.*, July, pp. 50–2,76.
Wiens, J. A. and Dyer, M. I. (1975). Simulation modeling of red-winged blackbird impact on grain crops. *J. Appl. Ecol.*, **12**, 63–82.
Wiens, J. A. and Dyer, M. I. (1977). Assessing the potential impact of granivorous birds in ecosystems. In *Granivorous birds in ecosystems* (eds. J. Pinowski and S. C. Kendeigh). Cambridge University Press, Cambridge, England, pp. 205–66.
Wiens, J. A. and Johnston, R. F. (1977). Adaptive correlates of granivory in birds. In *Granivorous birds in ecosystems* (eds. J. Pinowski and S. C. Kendeigh). Cambridge University Press, Cambridge, England, pp. 301–340.
Wilkinson, G. S. and English-Loeb, G. M. (1982). Predation and coloniality in cliff swallows (*Petrochelidon pyrrhonota*). *Auk*, **99**, 459–67.
Williams, J. G. (1954). The quelea threat to Africa's grain crops. *East Afr. Agric. J.*, **19**, 133–6.
Wilson, S. W. (1978). Food size, food type, and foraging sites of red-winged blackbirds. *Wilson Bull.*, **90**, 511–20.
Winstanley, D., Spencer, R., and Williamson, K. (1974). Where have all the whitethroats gone? *Bird Study*, **21**, 1–14.
Wolfson, A. and Winchester, D. P. (1959). Effect of photoperiod on the gonadal cycle in an equatorial bird *Quelea quelea*. *Nature (Lond.)*, **184**, 1658–9.
Woronecki, P. P. and Dolbeer, R. A. (1980). The influence of insects in bird damage control. *Proc. 9th Vertebr. Pest Conf.*, Fresno, California, **9**, 53–9.
Woronecki, P. P., Dolbeer, R. A., and Stehn, R. A. (1981). Response of blackbirds to Mesurol and Sevin applications on sweet corn. *J. Wildl. Manage.*, **45**, 693–701.
Woronecki, P. P., Stehn, R. A., and Dolbeer, R. A. (1980). Compensatory response of maturing corn kernels following simulated damage by birds. *J. Appl. Ecol.*, **17**, 737–46.
Worthing, C. R. (Ed.) (1979). *The pesticide manual—a world compendium*, 6th edn. British Crop Protection Council, UK.
Wright, E. N. (1981). Chemical repellents—a review. In *Bird problems in agriculture, Proc. Conf. 'Understanding agricultural bird problems'* (eds. E. N. Wright, I. R. Inglis and C. J. Feare). Royal Holloway College, University of London, April 4–5, 1979, pp. 164–72.
Yahia, G. (1957). A note on the occurrence and control of the Red-billed Weaver (*Quelea quelea aethiopica*) in the Sudan. *CSA Symp. Quelea*, Livingstone, 1957. CCTA/CSA Joint Secretariat, Bukavu.
Yates, F. and Zacopanay, B. A. (1935). The estimation of the efficacy of sampling, with special reference to sampling for yield in cereal experiments. *J. Agric. Sci.*, **25**, 545–77.
Yom-Tov, Y., Imber, A., and Otterman, J. (1977). The microclimate of winter roosts of the starling *Sturnus vulgaris*. *Ibis*, **119**, 366–8.
York, J. O., Howe, D. F., Bullard, R. W., Nelson, T. S., and Stallcup, O. T. (1981). The purple testa in sorghum, *Sorghum bicolor* (L.) Moench. *Proc. 12th Biennial Grain Sorghum Research Utilization Conf.* (ed. D. E. Weibel). Grain Sorghum Producers Association and Texas Grain Sorghum Producers Board, Lubbock, Texas, p. 113.
York, J. O., Bullard, R. W., Nelson, T. S., and Stallcup, O. T. (1983). Dry matter digestibility in purple testa sorghums. *Proc. 37th Annu. Corn Sorghum Research Conf.*, Chicago, Illinois (eds. H. T. Loden and D. Wilkinson). American Seed Trade Association, Washington, D.C., pp. 1–9.

Zahavi, A. (1971). The function of pre-roost gatherings and communal roosts. *Ibis*, 113, 106–9.
Zaske, J. (1973). Tropfengroessenanalyse unter besonderer Beruecksichtigung der Zerstaeubung im chemischen Pflanzenschutz. Dissert. Tech. Univ. Berlin.
Zeinelabdin, M. H. (1980). The potential of vegetable tannin as a bird repellent. Unpubl. M.A. thesis, Bowling Green State University, Bowling Green, Ohio.
Zeinelabdin, M. H., Bullard, R. W., and Jackson, W. B. (1983). Mode of repellent activity of condensed tannin to quelea. *Proc. 9th Bird Control Semin.*, Bowling Green, Ohio, 9, 241–6.