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OLIVES AND THEIR EFFECT ON THE PLUMAGE OF SPOTTED TURTLE-DOVES *Streptopelia chinensis* AND CRESTED PIGEONS *Ocyphaps lophotes* IN SUBURBAN ADELAIDE

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During winter Crested Pigeons *Ocyphaps lophotes* and Spotted Turtle-Doves *Streptopelia chinensis* often develop dark-brownish plumage in suburban Adelaide. Up to 80 per cent of pigeons and doves censused in the Gilberton area developed darker plumage. This darkening coincided with the presence of European olives *Olea europea* in the birds' diets. We argue that these pigeons and doves splash olive oil and an associated dark-purplish pigment onto their feathers while tearing chunks of mesocarp from fallen olives. Captive birds fed on a diet that included ripe olives developed the dark plumage while birds fed only on grain did not. Birds fed mainly on olives also lost weight.

In parts of suburban Adelaide, some Spotted Turtle-Doves *Streptopelia chinensis* and Crested Pigeons *Ocyphaps lophotes* develop a dark-brownish plumage during winter. The extent and intensity of this darkening varies. Some birds remain 'pale' and of normal appearance during winter while others vary from slight darkening on the breast to extensive darkening over the breast, head and upper back. This is not due to replacement of pale feathers with darker feathers, since the birds do not moult during winter (D. Paton, unpubl. data). Examination of feathers on wild-trapped birds suggests some external factor soils or stains the feathers in winter. In this paper we (1) document the seasonal occurrence and extent of darkened plumage in populations of Crested Pigeons and Spotted Turtle-Doves in an inner north-eastern suburb of Adelaide, and (2) test the hypothesis that this is due to the birds feeding on the ripe fruits of the introduced European olive *Olea europea* during late autumn and winter.

METHODS

Seasonal occurrence of dark-plumaged birds

During 1984 and 1985, we made regular surveys of the plumages of Spotted Turtle-Doves and Crested Pigeons living around our home at Gilberton, South Australia (34°54′S, 138°37′E). About once a month we scored the number of pale, partly darkened (feathers on breast dark) and fully darkened (feathers on breast, head and back dark) birds that we encountered during a 1 to 2 hour walk around Gilberton. Many of the brids that we scored were also caught or had been previously marked and colour-banded, and so we could keep track of plumage changes for some individual birds as well. We also scored the plumages of Crested Pigeons and Spotted Turtle-Doves encountered along the south-eastern boundary of the Adelaide Zoological Gardens (about 2 km SW of Gilberton), at similar intervals.

Aviary experiments

Six 'pale' Crested Pigeons and two 'pale' Spotted Turtle-Doves were caught in early July 1985 using mist nets and cage traps. These birds were then fed on either a control or an experimental diet for 2 months to test the hypothesis that olives were causing the darkening of the plumage. Each bird was weighed and banded with a coloured ring and a numbered band provided by the Australian Bird and Bat Banding Scheme. This enabled individual birds to be recognized during the experiment. Three

pigeons and one turtle-dove were picked at random and housed in a 6 m × 4 m × 2 m aviary and fed on a predominantly 'olive' diet. For the first week these experimental birds were fed entirely on olives, but because the birds lost their appetite during the first week, a small quantity of wheat screenings (*ca* ¼ cup per day) was added to the olive diet for the next 3 weeks. Since all of the experimental birds had lost weight during the first month (see results), the ration of wheat was doubled for the second month. The three other pigeons and one turtle-dove were housed in an identical aviary but only fed on wheat screenings. These birds acted as controls. Notes on the plumages of all birds were kept during the course of the experiment and we took photographs of selected birds during and at the end of the experiment. All birds were reweighed at monthly intervals. The birds were then released at the end of the experiment.

RESULTS

Seasonal occurrence of dark-plumaged birds

Seasonal changes in the proportion of dark-plumaged birds are shown for two populations of Crested Pigeons and one population of Spotted Turtle-Doves in Figure 1. Crested Pigeons and Spotted Turtle-Doves started to attain dark plumage in April and May in the Gilberton area and by August over 75 per cent of the birds in this area had darker plumage. In 30 to 40 per cent of the Crested Pigeons and about 50 per cent of the Spotted Turtle-Doves the amount of darkened plumage was extensive. We hold 35 mm transparencies that show the range and extent of darkening that was observed. Not all birds developed dark plumage and this was not related to their age or sex. Some first year birds, some second year and older birds, some males and some females developed the darker plumage, while others did not. Marked individuals that developed darker plumage during winter, replaced the dark plumage with pale plumage during late spring and summer, when they moulted. The only individual found with dark plumage in January and February (see Figure 1a) was yet to undergo moult and still retained dark feathers from the previous winter.

The period in which these birds attained their darker plumage coincided with the period when olives were available in the Gilberton area. Olives ripened during April and May and large numbers

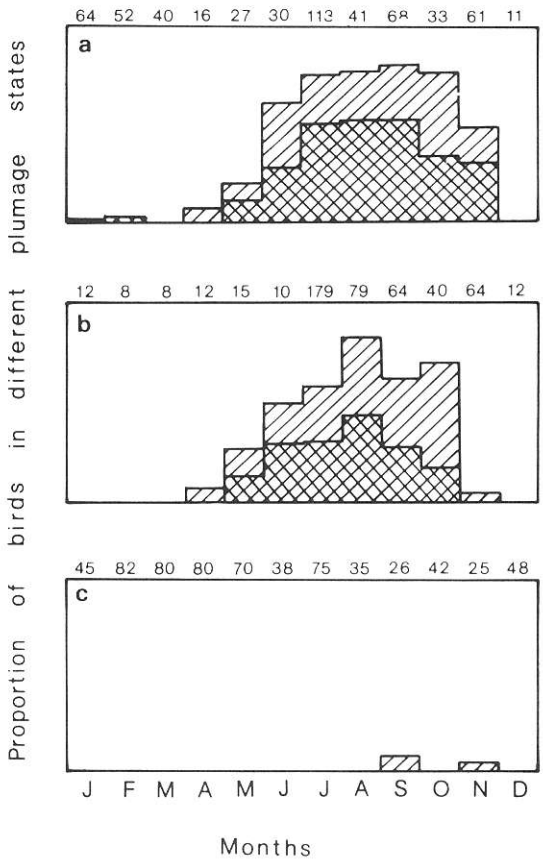

Figure 1. *Seasonal occurrence of dark-plumaged Crested Pigeons and Spotted Turtle-Doves during 1984 and 1985.* **a** *Spotted Turtle-Dove in the Gilberton area,* **b** *Crested Pigeons in the Gilberton area, and* **c** *Crested Pigeons near the Adelaide Zoo. The figures show the proportion of birds in pale (blank), partially dark (hatched), and extensively dark (cross-hatched) plumage throughout the year. The number of birds in each monthly sample is given across the top of each figure.*

of ripe olives fell to the ground during strong winds, remaining there during winter or until eaten. Many of the pigeons and doves that we scored in the Gilberton area during May to September were pecking at fallen olives. Pigeons and doves never consumed whole fruit, but attempted to tear small amounts of flesh from the olives. They appeared to have difficulty in doing this and usually only attempted to rip flesh from olives whose skin had been ruptured. As a result

the pigeons and doves that we scored had congregated in areas where the fallen olives had been crushed by vehicles or foot traffic. Often the birds picked up these slightly damaged olives in their bills and shook the olives vigorously to tear a small amount of flesh from the fruit which they then consumed. In the process of tearing this flesh from the olives the birds appeared to splash olive oil and other material onto the feathers of their breast, head and neck. This observation led to our hypothesis that olive oil and the dark-purplish pigment present in ripe olives was staining the birds' plumage. At other times in the year, Crested Pigeons and Spotted Turtle-Doves fed on spilt food in domestic fowl yards and on a variety of small seeds and other plant material, most of which was too small for us to locate and identify. During autumn, many pigeons and turtle-doves consumed the seeds of the introduced wireweed *Polygonum aviculare*.

Our observations near the Zoological Gardens contrasted with those at Gilberton. The population of Crested Pigeons living along the south-eastern boundary of the Zoo remained pale throughout the year, except for a couple of individuals (Figure 1c). There were few olive trees in this area and the birds fed largely on spilt grain and other foods within the Zoo. Spotted Turtle-Doves were infrequently encountered along the south-eastern boundary of the Zoo, and we did not score sufficient birds to warrant presenting these results in a figure. Only two Spotted Turtle-Doves were recorded with darker plumage in this area during winter, and then only with light to moderate staining of their breast feathers.

Aviary experiments

Experimental birds fed on a diet of olives gradually acquired darker plumage. Within a week all the experimental birds had light staining on their breasts, and one Crested Pigeon and the Spotted Turtle-Dove also had several spots on their heads. The extent and intensity of this darkening continued and by 3 weeks all the experimental birds were moderately dark over their breasts, necks and heads. By 5 weeks the birds were heavily stained and similar to the darkest birds observed in the field. The darkening also extended to all other feather tracts on the birds but was most intense on the breast, head and neck. The control birds, fed entirely on wheat screenings, remained pale throughout the experiment.

Birds fed on the predominantly olive diet lost weight, particularly during the first month (Figure 2). Within the first week these birds had become lethargic and were hesitant to feed. A small quantity of wheat screenings was added after the first week, and this wheat was consumed before the birds touched the olives. After 1 month all four birds on the olive diet had lost at least 30g or about 15 to 20 per cent of their original body mass (Figure 2a). The wheat ration was then

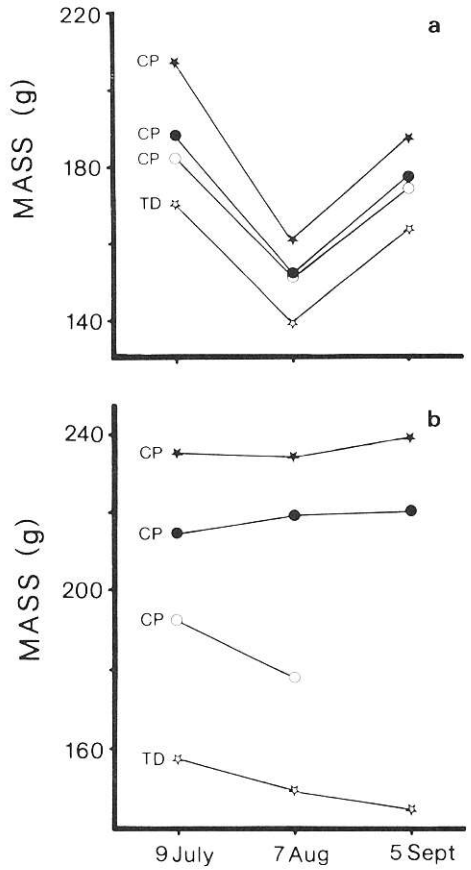

Figure 2. *Changes in the mass of Crested Pigeons (CP) and Spotted Turtle-Doves (TD) fed on either a diet of olives supplemented with wheat screenings* (a) *or a diet of wheat screenings only* (b). *All weights were taken between 1300 and 1400 h. One Crested Pigeon fed on the wheat screenings died of unknown causes on 21 August 1985. The experiments commenced on 9 July 1985 and were completed on 5 September 1985 when the birds were released from captivity. See text for more details on diet.*

doubled, and all birds showed an increase in mass of around 25g during the next month. The control birds did not show a dramatic loss in mass. Two Crested Pigeons increased slightly in weight, while the third pigeon and the turtle-dove lost up to 15g (Figure 2b).

The pigeons and dove fed on the high olive diet did not produce the firm faeces of birds fed on grain, particularly during the first week. Instead the faeces were larger and almost jelly-like, and appeared to contain large quantities of oil.

DISCUSSION

A variety of birds consume olives in southern Australia. Forde (1986) lists Spotted Turtle-Doves, Crested Pigeons, parrots, lorikeets, Blackbirds *Turdus merula*, Common Starlings *Sturnus vulgaris*, Silvereyes *Zosterops lateralis*, and Australian Magpies *Gymnorhina tibicen* as consuming the fruits of olives. In addition to these, Black-faced Cuckoo-shrikes *Coracina novaehollandiae* (J. Tucker pers. comm., D. Paton pers. obs.), Golden Whistlers *Pachycephala pectoralis* and Red Wattlebirds *Anthochaera carunculata* (J. Paton pers. comm.), House Sparrows *Passer domesticus* (P. Paton pers. obs.) and Red-rumped Parrots *Psephotus haematonotus* (D. Paton pers. obs.) occasionally take and peck at the fruit. Crimson Rosellas *Platycercus elegans* also attack the fruit in April, before the fruit is ripe, and crack open the stone and eat the kernel (J. Paton pers. comm.). Of all of these birds, only the pigeons and doves develop dark plumage. This is because of the way in which pigeons and doves handle olives relative to other species of birds. All the other species have bills that are capable of piercing or rupturing the skins (epicarp) of ripe olives, or they take whole fruit, as is the case with cuckoo-shrikes, starlings occasionally, and possibly magpies (Cleland 1952, pers. obs.). The bills of pigeons and doves, on the other hand, are blunt and bulbous. Instead of pecking chunks of flesh (mesocarp) out of olive fruits or consuming whole olives, pigeons and doves often picked up damaged olives in their bills and shook the olive vigorously from side to side to tear off smaller, bite-sized, chunks of flesh. In the process of doing this they splashed the dark-staining fluids and oil present in the mesocarp onto their feathers. Most of this fluid and oil is splashed onto the feathers of the breast and head. Eventually the oil and dark-staining pigment may be redistributed over the rest of the birds body during preening.

Our aviary experiments supported our hypothesis that olive-feeding by pigeons caused the plumage to darken. However, birds fed almost entirely on olives lost physical condition. Olives consist of about 66 to 72 per cent water, 5 to 30 per cent oil, 2 to 5 per cent protein, 5 to 9 per cent carbohydrates and 1 to 1.5 per cent minerals, according to their maturity (Levinson and Levinson 1984). The oil content increases as the fruit ripens, and may reach as much as 49 per cent in some varieties. The protein in olives contains most essential, as well as non-essential amino acids, but in varying amounts that result in dietary deficiencies (Levinson and Levinson 1984). Thus animals feeding solely on olives might be expected to lose physical condition. However, such deficiencies are unlikely to develop within a week and so some other explanation is required to explain the almost immediate loss of condition when birds were fed olives.

To process large amounts of fats and oils, birds need to produce large quantities of bile. Bile is produced in the liver and is released into the intestine via the hepatic duct (Ziswiler and Farner 1972). The bile salts emulsify fats and so aid in the digestion of fatty and oily substances. Some birds have a gall bladder in which bile is stored and concentrated. This enables a large volume of concentrated bile to be delivered into the intestine at the beginning of digestion to cope with high levels of fatty substances (Ziswiler and Farner 1972). Seed-eating and carnivorous birds have relatively small livers compared with fish-eating and insectivorous birds. Furthermore many of them do not have a gall bladder, including doves and pigeons (Ziswiler and Farner 1972). Thus pigeons and doves may have difficulty in coping with large quantities of fat and oil, and the presence of undigested fat in the intestine could interfere with the breakdown and absorption of other foods in the intestine. This may account for the almost immediate loss of condition when Crested Pigeons and Spotted Turtle-Doves were fed on a high olive diet.

Why should pigeons and doves feed on olives in winter, given the 'poor' quality of olives as a food, and the obvious preference that aviary birds had for grain over olives? One explanation is that a reduction in feeding grounds and in the availability of seeds may force pigeons and doves to use olives in winter. During summer pigeons and turtle-doves have large areas of relatively bare ground on which they can forage for seeds, at

least in the Gilberton area. Following autumn rains, the seeds of a large variety of weedy plant species and grasses germinate and grow. This has two effects on the feeding of pigeons and doves. First, the seeds are no longer available to pigeons and doves as food once they have germinated, and so the birds' supply of seeds is reduced as winter approaches. Second, many of the areas used for foraging in summer rapidly become overgrown with weeds and grasses, and so become unsuitable feeding grounds for pigeons. Thus many pigeons and turtle-doves may be forced to use olives during winter to supplement their diminished intake of weed and grass seeds. The paradox is that high population densities of Crested Pigeons and Spotted Turtle-Doves may be maintained in the Gilberton area simply because the birds have access to olives.

Frith (1982, Frith *et al.* 1974, 1976) lists the foods of Spotted Turtle-Doves and Crested Pigeons as being predominantly the seeds of weeds and grasses, and in urban areas on the feed of domestic and zoo animals, including bread. He does not mention olives in their diets and suggests that in urban areas there was no clear seasonal patterns to the diets of Spotted Turtle-Doves. However, there is a tendency for the seeds of weeds and grasses to be least prominent in stomach samples of Spotted Turtle-Doves taken during winter (Frith *et al.* 1976).

Despite the 'poor' quality of olive flesh, a large proportion of the olive crop in the Gilberton area is consumed by birds, and mainly by pigeons and turtle-doves. By the end of September there are few olives remaining on the ground. Since the flesh of olives is rich in energy (oil), this may outweigh the lack of an adequate mix of certain nutrients.

We do not know if feeding on olives is detrimental to pigeons and turtle-doves, but we have recently commenced a banding project that investigates the survival over winter of individuals consuming olives with those that do not. At present we do not have sufficient data to test for a difference in survival rate. Birds feeding on olives may have lowered survival because of the differences in the composition and nutrient value of olives and seeds, or because the oil that accumulates on their feathers when feeding on olives interferes with the efficiency of the birds' feathers in thermoregulation and flight.

In Europe and elsewhere, a variety of birds also consume olives, including the Blackbird, American Robin *Turdus migratorius*, Varied Thrush *T. naevius*, Common Starling, Spanish Sparrow *Passer hispaniolensis* and ravens *Corvus* sp. (Levinson and Levinson 1984). In some areas 80 per cent of the fruits can be consumed by birds during winter (Bigler and Delucchi 1981). In all cases olives only supplementd the birds' diets (Levinson and Levinson 1984). Australian birds, also, may only use olives to supplement their diets and so normally not suffer dietary deficiencies when consuming olives in winter.

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