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Diet of the White-headed Pigeon *Columba leucomela* near Lismore, northern New South Wales: fruit, seeds, flower buds, bark and grit

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Gut contents of 18 White-headed Pigeons *Columba leucomela,* found dead over a four-year period near Lismore in northern New South Wales, comprised fruits and seeds of the invasive plant Camphor Laurel *Cinnamomum camphora* almost exclusively. Birds frequently ingested *Melaleuca quinquenervia* bark, which, as far as I am aware, constitutes the first record of consumption of bark in the Columbidae, prompting some interesting hypotheses. It is suggested that bark ingestion may counter potential adverse effects from a diet dominated by Camphor Laurel fruits and seeds, which are reputed to contain toxins. Incidental records of consumption of flower buds of indigenous plants and insects (the first such records for this species), and regular drinking from man-made structures such as roof guttering on buildings are detailed.

INTRODUCTION

The White-headed Pigeon *Columba leucomela* is known to feed on the fruits and seeds of a number of fleshy-fruited invasive plants, notably Camphor Laurel *Cinnamomum camphora,* which has become an important seasonal food source for this species in northern New South Wales (NSW) (Frith 1982; Recher and Date 1988; Date *et al.* 1991; Date *et al.* 1996; Gosper and Gosper 2008). Frith (1982) attributed recovery of populations of White-headed Pigeon following decline associated with clearing of rainforest during European settlement, to its successful switch to utilizing introduced Camphor Laurel as a winter food source. In a recent study (Gosper and Gosper 2008), gut contents from a small sample of pigeons at Goolmangar, near Lismore, complemented by observations on foraging activity, suggested that Camphor Laurel now provides food in the form of flowers, green and ripe fruits, and seeds for White-headed Pigeons locally throughout the entire year.

In order to further evaluate the seasonal utilisation of Camphor Laurel as a food source, and its importance proportionally to other foods in a fragmented landscape, monitoring of pigeon foraging behaviour at Goolmangar and the collection of dead birds for stomach contents analysis has been on-going. This note supplements earlier findings regarding the diet of White-headed Pigeons (Gosper and Gosper 2008).

STUDY AREA AND METHODS

White-headed Pigeons found dead at Goolmangar (28º42'36.1'S, 153º13'55.2'E; ~30 m asl), near Lismore in northern NSW, were collected from 2006 to early 2010. Most deaths of fledged birds were apparently accidental, resulting from collisions with motor vehicles and windows. All but three birds (of 18) were found in, or immediately adjacent to, the grounds of Goolmangar Public School (PS). This is parkland type habitat of mown grounds featuring a number of mature native and exotic trees including Camphor Laurel, and a rainforest regeneration plot (mostly <16 years old). The surrounding area is a mixture of pasture, remnant riparian rainforest and regrowth forest with extensive areas dominated by woody weed species, notably Camphor Laurel and Broad-leaved Privet *Ligustrum lucidum*, and several house gardens.

Dead pigeons were collected and crop and gizzard contents removed during subsequent dissection. Seeds and fruits found in the gut were counted and identified by comparison with specimens retained from earlier studies, with unidentified materials preserved for later determination. The condition of the lining of the gizzard and crop was also documented at the time of dissection, as was the state of the contents. Dead birds were sexed and aged by plumage, soft parts and wing measurements (using ranges given by Higgins and Davies 1996).

Opportunistic observations of foraging and drinking activities were made during the course of my work at the site, and the long-term monitoring of White-headed Pigeon breeding activity in the grounds of the school and my adjoining residence. These are described where they supplement previously published accounts (Frith 1982; Higgins and Davies 1996; Church 1997; Gosper and Gosper 2008).

RESULTS

A total of twenty-one White-headed Pigeons was found dead during the four-year period. Three of these were nestlings (estimated ages ranging from 5 to 13 days; D. Gosper unpub. data) found under collapsed nests or after nests were attacked by predators (nestlings not included in Table 1). Fourteen birds were adults (wing 218 – 243 mm) and four were recently fledged juveniles or immatures (wing 187 – 208 mm). Four birds died as a result of collisions with windows, including one, which was seen to hit a window during an attack by a Brown Goshawk *Accipiter fasciatus* on a group of pigeons drinking from the guttering of an adjacent building. Eight pigeons were road-killed and six died from undetermined causes. Dead birds were recovered in all months except May and September.

Table 1

Gut contents of 18 fledged White-headed Pigeons at Goolmangar, northern NSW

Contents	Parts	Quantity (range)	% of guts (*n*=18#)
Plants			
Cinnamomum camphora (Camphor Laurel)	fruit (whole and/or whole seeds + skin + pulp)	1 – 8	56
	seed (whole and/or fragments/ mash of seed coat + kernel)	3+ – 45+	100
Aphananthe philippinensis (Rough-leaved Elm)	fruit (whole seeds + pulp)	13+	6
Melaleuca quinquenervia (Broad-leaved Paperbark)	bark		6
Unidentified plant material fragments	seed coat (1); ? leaf (2); ? fruit pedicel (1); other (1)		28
Animals			
Hemiptera (Cicada)	nymph		6
Other materials			
Rock fragments		1 – 7	44
Crop milk			6
Feathers			6

crops (but not gizzards) of five birds empty (all early morning road or window kills); gizzard of one bird not recovered.

Gut contents

Fruits and/or seeds of Camphor Laurel were found in the guts of all specimens, and comprised the only food items in most (Table 1). Fresh Camphor Laurel fruits (together with fresh seeds) were present in specimens recovered between February and August, and the lining of the gizzard in all birds dissected during this period was stained pinkish-purple. Weathered (dry) seeds were present in guts of birds collected between August and February. In addition to weathered Camphor Laurel seeds, the gizzard of one bird recovered in December contained 13 intact seeds (some still with pulp attached) of Rough-leaved Elm *Aphananthe philippinensis,* a new food record for White-headed Pigeon. Rough-leaved Elm is a common indigenous tree of the riparian zone on nearby Goolmangar Creek.

Two pieces of bark from the Broad-leaved Paperbark *Melaleuca quinquenervia*, together with Camphor Laurel fruits and seeds, were located in the gizzard of a bird found dead in August. The maximum dimensions of the bark pieces were 9.0 x 4.5 millimetres and 9.5 x 4.0 millimetres.

The exoskeleton of a cicada nymph was found in the gut of a female pigeon found road-killed in early February. The pigeon was close to egg-laying as the body held a fully developed (hard shelled) egg. Pieces of exoskeleton (up to 15 mm in length) were found in the crop, with smaller pieces in the gizzard, which also contained Camphor Laurel, a small amount of other vegetable material and five rock fragments. Comparison of material from the gut with similar cast exoskeletons (skins) found locally suggests the body of the nymph would have measured approximately 32 x 10 x 10 millimetres.

Rock fragments, mostly blackish in colour, were present in the gizzards of eight birds (including two immatures) and were recovered from birds found dead at various times of year. Up to seven fragments (mean 3.9) were present in individual gizzards, ranging in size from 3.0 x 2.0 x 1.5 millimetres to 9.0 x 7.0 x 3.0 millimetres and 8.5 x 7.0 x 4.0 millimetres.

The walls of the crop of an adult male, found road killed in March, was extensively lined with folds of maturing crop milk, 5 – 6 millimetres in thickness. Although broken open the crop still held fresh whole Camphor Laurel fruits, and pieces of crop milk, which had separated from the lining. The gizzard contained undigested Camphor Laurel seeds and mash of broken down Camphor Laurel fruits and seed fragments.

The guts of all three nestlings contained masses of pigeon milk. In the crop this was in the form of creamy-white, curd-like pieces up to 10 x 6 millimetres, and resembling yellowish paste or egg yolk in the gizzard. In each instance, mixed through the masses of pigeon milk were up to five fine strips of *M. quinquenervia* bark. These fragments measured between 3.0 and 9.0 millimetres in length and 0.25 and 1.0 millimetre in width. Two of the guts also contained a single fragment of seed coat (Camphor Laurel) together with unidentified dark coloured specks.

Foraging and drinking

White-headed Pigeons were observed feeding on the flower buds of eucalypts. At 0650 hrs on 29 August 2007, in the grounds of Goolmangar PS, six birds were detected clambering about in the canopy of a Swamp Mahogany *Eucalyptus robusta*, which was in heavy bud. Through 10 x 40 binoculars the birds could be clearly seen actively picking off and swallowing green (unopened) flower buds, with some buds discarded or dislodged. This behaviour, which was similar to that observed when pigeons are feeding on fruiting Camphor Laurels, continued for about five minutes before the birds were flushed. Camphor Laurel fruiting had finished locally, with the little remaining unshed fruit being withered and dry. Later the same morning pigeons were observed foraging on the ground under nearby Camphor Laurels.

At times of year when White-headed Pigeons congregated to engage in terrestrial foraging under Camphor Laurels (see Gosper and Gosper 2008) they were also occasionally observed foraging on lawns, and sparsely grassed areas under stands of eucalypts (i.e. areas without overhanging Camphor Laurel, but located within 100 metres of Camphor Laurels). Inspection of

such sites revealed large quantities of Camphor Laurel seed and old (dried) fruits on the ground, presumably defecated and dropped by other frugivores, mainly Australasian Figbirds *Sphecotheres vieilloti* which used such trees as loafing perches (pers. obs.). Large numbers of Camphor Laurel seeds germinated at one of these sites where sections of the ground under the trees were left unmown.

White-headed Pigeons were observed apparently consuming bark from the branches of two Broad-leaved Paperbarks in the grounds of Goolmangar PS on many occasions. This behaviour was initially detected in May – June 2007 during morning circuits of the school grounds to check on nesting activity. On several occasions up to three pigeons were noted in the paperbark trees, with one or more birds apparently searching the surface of branches, pecking at and picking off and swallowing fragments of bark. Subsequently, in late August 2007, a series of early morning stake-outs targeting this behaviour revealed pigeons congregating in these trees each morning from before sunrise, having flown into the school grounds from multiple directions. For example, on 30 August 2007 (sunrise 0617 hrs) there were already three birds present when observations commenced at 0552, and another four had arrived by 0600. About this time the first of the pigeons present began to actively search the surface of the branches. Between 0600 and 0614 thirteen more birds arrived, mostly singly, whilst two left, and between 0614 and 0627 another 18 birds arrived, again mostly singly, while one left. Throughout this period most birds were engaged in active foraging over the branches, with a few birds just sitting and preening. Between 0627 and 0644 an additional three arrived and two departed, with one more arrival up to 0652 and 16 birds leaving in the same period. When observations were terminated at 0652 some pigeons were still foraging but the majority of those remaining were sitting and preening. The assemblage contained both adult and immature birds, many of the latter heavily in moult.

The ingestion of bark appeared to be deliberate, not incidental. Foraging behaviour involved the pigeons actively investigating the surface of the main limbs and branches at all heights, and to a lesser extent smaller branches and outer foliage-bearing twigs. The birds walked, climbed and scrambled over the bare branches, and made short flights between branches, all the while appearing to be searching the surfaces, including the sides and undersides where these could be reached. Through 10 x 40 binoculars the pigeons could clearly be seen pecking, and at times tugging, at the bark and breaking free small pieces or thin strips, and swallowing. Apparently unsuitable pieces, mainly those larger or longer, were discarded, and fell to the ground. Ingestion of bark was further confirmed in August 2008 when bark was found in the gut of a dead White-headed Pigeon (see above).

Bark foraging was mainly observed during early morning surveys, in most instances apparently before the pigeons drank or fed. Exceptionally, individuals were noted engaged in this activity later in the morning (up to 1030), and once in the afternoon (1545). Bark foraging was noted in all calendar months April to September, but as systematic monitoring was not conducted year-round, it is not known if the behaviour was confined to this period. Foraging on bark surfaces was not observed on any other tree species.

White-headed Pigeons were regularly observed drinking from man-made structures, in particular the roof guttering on my residence. This behaviour involved birds assembling in nearby trees, and then individually or in groups flying down to perch on the raised edge of the guttering. Such gatherings involved as many as 20 pigeons at a time. Once settled on the guttering and apparently satisfied no danger existed, birds tipped forward at an angle of approximately 45 degrees to access water that had pooled at low points. Individuals were recorded spending up to five minutes on the guttering, during which they drank up to eight times. Water in the guttering was derived from overnight condensation on the steel roofing sheeting, melting frost and also from rain. Pigeons were observed drinking in the mornings only, from about 30 minutes after sunrise, with most drinking between 45 and 90 minutes after sunrise, and occasionally as late as 1035.

Although the residence had been constructed in, and occupied, since 1992, drinking from roof guttering was not detected until April 2006. Subsequently this behaviour occurred with increasing frequency, and whilst not documented comprehensively, notes covering the following three years contain records of pigeons drinking from the guttering for all months except October and November. Drinking was also observed occasionally from guttering on the school buildings and a neighbouring residence.

DISCUSSION

The presence of Camphor Laurel fruits and/ or seeds in the gut of all 18 fledged White-headed Pigeons examined confirms previous findings that this invasive plant is utilized as a food source throughout the year (cf. Gosper and Gosper 2008). Camphor Laurel was the dominant (or only) fruit or seed present in the guts of all but one of the birds, demonstrating that it is an important food, and suggesting that it is more highly preferred than other fruit and seed sources available in the Goolmangar district. Camphor Laurel is an abundant food source locally, with numerous mature trees and an ever-increasing volume of trees reaching fruiting maturity (Gosper 1994; Gosper and Holmes 2002). Firth (1979, 1992) identified Goolmangar PS, established on this site in 1929, as the site of one of the original Camphor Laurel plantings in northern NSW, and the likely source of the dense Camphor Laurel distribution in the locality.

White-headed Pigeons preferentially feed on ripe Camphor Laurel fruits taken from the foliage during the fruiting season. Outside of this period they feed primarily on the ground on fallen Camphor Laurel seeds (Gosper and Gosper 2008). Seed is readily accessible on the shaded ground under dense stands of trees as the ground surface is generally bare, or sparsely covered by Camphor Laurel seedlings and leaf litter. Similarly, in parklands and school playgrounds, where mature trees are commonly retained for the provision of shade, regular mowing maintains a short grass cover and easy access to fallen seeds. Pigeons also congregate to forage under the edge of Camphor Laurel trees bordering open pasture where rank weeds and grass have been recently slashed allowing access to a previously untapped bank of fallen seeds (pers. obs.). Typically, during the early post- fruiting period, pigeons gather in loose feeding assemblages for periods of up to several weeks at sites of abundant seed supply, before disappearing when these sources are apparently exhausted (Gosper and Gosper 2008). Whether such assemblages are formed from the local population or represent an influx of wandering birds is not known.

The few local records of White-headed Pigeons consuming foods other than Camphor Laurel fruits and seeds have come from the period outside the Camphor Laurel fruiting season. Use of other foods may relate to local shortages of fallen Camphor Laurel seeds, or be opportunistic. It may also be that Camphor Laurel seeds alone are nutritionally inadequate, and pigeons may occasionally take other foods, such as fleshy fruits, flowers or buds, to supplement their primary diet of Camphor Laurel seeds during this period.

Broad-leaved Privet, also an abundant source of fruits and seeds locally in the same habitats during winter and reported to be eaten by White-headed Pigeons (Holmes 1987**;** Floyd 1990), has not been recorded as a food at Goolmangar. It is noteworthy that Topknot Pigeons *Lopholaimus antarcticus*, which also feed extensively on Camphor Laurel fruits at Goolmangar (Gosper and Gosper 2008), switched to feeding on fruiting Broad-leaved Privet following a shortened Camphor Laurel fruiting season in 2009 (pers. obs.).

The consumption of eucalypt flower buds described here provides the first evidence of White-headed Pigeons' use of flower buds from native plants (cf. Gosper and Gosper 2008), and confirms behaviour suspected on an earlier occasion. On 24 February 2001 (between 0730 and 0840), at least 10 White-headed Pigeons were present around my residence, with two pairs engaged in nest construction close to the house. While monitoring the activities of the nest builders I observed up to four pigeons engaged in typical foraging behaviour in the outer foliage at the top of a planted spotted gum (*Corymbia maculata* or *C. variegata*), which carried a few clusters of flower buds (or possibly green fruit capsules). The birds were clearly seen to be feeding on these but I did not establish at the time the exact reproductive part being consumed.

There appear to be no published records of the White-headed Pigeon eating invertebrates, although some other pigeons and doves, both in Australia and elsewhere, are known to do so (Higgins and Davies 1996; del Hoyo *et al.* 1997). As only exoskeleton was identified in the gut, it is uncertain if the cicada nymph was eaten as a living animal, or consumed as a cast skin only. Given the size and number of exoskeleton pieces found in the gut it seems unlikely that ingestion was accidental.

Ingestion of tree bark appears to be undocumented in the Columbidae (cf. Higgins and Davies 1996; del Hoyo *et al.* 1997), and the role of *M. quinquenervia* bark in the diet of White-headed Pigeons is unknown. Possible explanations could relate to the bark's nutritional properties, or perhaps that of covering lichen, or to a benefit associated with active compounds contained in the bark. *Melaleuca* is known as a medicinal plant genus, with oil from the leaves and twigs reputed to have therapeutic properties including anti-fungal, anti-bacterial and anti-microbial activity (Southwell and Lowe 1999; Anon. 2004 – 2011). Perhaps the most likely function could relate to physiological processes required to deal with a specific diet. Fruits and seeds contain a diverse range of secondary metabolites many of which are thought to be toxic if eaten in large doses, however little is known about the way fruit-eating birds metabolise and detoxify these compounds (Levey and Martinez del Rio 2001). Although credible evidence of detoxifying properties is lacking, it is plausible that *Melaleuca* bark, when ingested, acts to mitigate toxins in fruit and seeds by absorbing or filtering toxic secondary compounds. A similar function has been attributed to soil ingested by some frugivorous parrots and pigeons (del Hoyo *et al.* 1997; Diamond 1998; Diamond *et al*. 1999). Ingesting the bark may enable White-headed Pigeons to cope with a diet consisting almost exclusively of Camphor Laurel, some forms of which have fruits and other parts that are claimed to be toxic to birds (NSW Scientific Committee 2004; Friend 2006; see also discussion in Gosper and Gosper 2008). It may also be that bark ingestion is not novel but originated long ago. Fruits of congeneric indigenous plant species including *Cinnamomum oliveri*, and many other laurels, are known foods of White-headed Pigeons in the forests of south-east Queensland and north-eastern NSW (e.g. Innes 1989; Higgins and Davies 1996), and therefore have been a food source long before the introduction of Camphor Laurel.

Little has been reported about the drinking habits of White-headed Pigeons. Frith (1982) recounted often witnessing pigeons drinking from the ground at forested creeks in dry weather. Locally, in addition to drinking from roof guttering, White-headed Pigeons were recorded drinking pooled water from a garden wheelbarrow and from a pool on a bitumen road (after rain). Elsewhere in northern NSW the species has been noted drinking from a pool on a logging road in subtropical rainforest and from a cattle trough in farmland (pers. obs.). Exploitation of man-made structures to obtain drinking water appears to be a recent development locally, as it is very unlikely that such conspicuous behaviour as drinking from roof guttering (it is both highly visible, and audible due to the sound of birds moving about on metal), could have been overlooked.

Much remains to be clarified about the observations described here, particularly regarding the specific properties of *Melaleuca* bark and its function when ingested by pigeons. Also, do White-headed Pigeons inhabiting extensive, mostly Camphor Laurel free tracts of forest consume bark, or is this behaviour peculiar to areas where the pigeons have adapted to a diet comprised almost exclusively of Camphor Laurel?

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The help of students, staff and parents of Goolmangar Public School, in alerting me to the presence of dead pigeons, is greatly appreciated. I also thank Glenn and Jenny Holmes for microscopic examination of bark specimens and other plant material, and comments on an early draft, Carl Gosper for discussion and suggestions which improved the manuscript, and assistance with access to references; and referees Liz Date-Huxtable and Ronda Green for their constructive advice.

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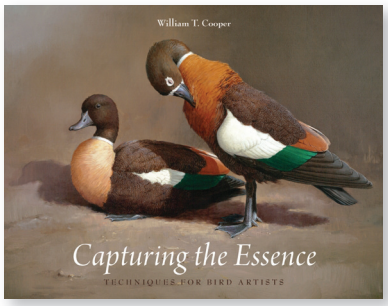
Book Reviews



Capturing the Essence: Techniques for Bird Artists

William T. Cooper. 2011. CSIRO Publishing. Hardback, 128 pages, 139 colour illustrations. ISBN: 9780643101562. RRP $59.95.

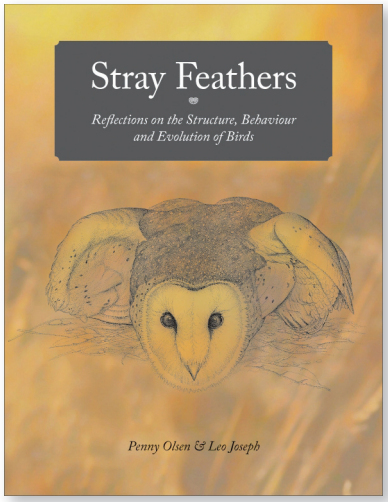
William T. Cooper is unquestionably one of the world's great bird artists, whose work will be very familiar to all with an interest particularly in Australian birds. He has had numerous collaborations with the ornithologist Joseph Forshaw, including his outstanding illustrations for *Australian Parrots* (Lansdowne Editions 1969). His ability to combine the necessary anatomical and diagnostic accuracy of his avian subjects with an environmental context of aesthetic beauty is the hallmark of his work. Each painting a true work of art! Wildlife artists, and bird enthusiasts, are fortunate indeed that Cooper has decided to provide us with an insight into how he goes about creating his art, and in doing so I believe he gives us a deeper appreciation of his formidable talent.

Capturing The Essence is primarily in two parts. The first, whilst providing useful information on artist materials and the fundamentals of drawing, is primarily all to do with the underlying philosophy of Cooper's art, which is that studiously observing the subject in the field is paramount to gaining the intimate knowledge to consequently produce a painting of both ornithological accuracy, and integrity. There is no substitute for such an approach, and he continually stresses the importance of developing life-drawing skills, and avoiding the trap of over-reliance on photographic reference that the vast majority of wildlife artists fall into in varying degrees. It is only when he refers to the drawing of birds in flight, and the necessity for postural accuracy, that he concedes that photographs of the subject matter are relatively indispensable. Of course, it must be acknowledged that to draw birds, in the field, often with only fleeting glimpses, is actually incredibly difficult and frustrating. It takes enormous perseverance, and talent, and it is little wonder that many artists simply rely on the camera for their fieldwork observations. It is a testament to Cooper's prodigious artistic talent that he can so beautifully *capture the essence* of his subjects with such an economy of line, and then translate such sketches ultimately into his masterful paintings.

Which brings me to the second part of the book: a step-by-step guide illustrating how he develops a bird painting in the mediums of watercolour, acrylic, and oil. It is always fascinating to see how an artist evolves his artwork, and there is much to be learnt from the three examples here. Each are extremely informative, and in the case of the acrylic and oil paintings of Squatter Pigeons and Raggiana Birds of Paradise respectively, I found it refreshing to see how Cooper is more than willing to make compositional changes at virtually any point in the process, constantly critiquing, always seeking to improve on the original concept. Conversely, when it comes to the watercolour example depicting a pair of Red-capped Robins, such mid-process changes are simply not possible; such is the subtlety, but permanence, of the medium. The final, finished image of the robins is gloriously delicate, so in keeping with the birds themselves, and of course featuring the signature vignetted background that has become so familiar to all who have appreciated Cooper's work for decades.

In reviewing this book, I found myself revisiting his *Australian Parrots*, and gaining a renewed appreciation for just how exceptional an artist Cooper is. Irrespective of our artistic abilities, all of us can seek to improve our observational skills by sketching birds in the field, and in doing so take more from the experience. There can be no more intimate way to *really* look, observe, learn, understand. Australian ornithology is fortunate that William T. Cooper took this path himself as an artist, and has encouraged others to do the same. Just try it, put away the camera, pick up the pencil! *Capturing The Essence* shows a master at work, but highlights that the rewards of such an approach to studying birds are tangible to us all.

Steve Tredinnick
East Blaxland, NSW



Stray Feathers: Reflections on the Structure, Behaviour and Evolution of Birds

Penny Olsen and Leo Joseph. 2011. CSIRO Publishing. Paperback 288 pp, black and white illustrations. ISBN 9780643094932. RRP $59.95.

This book is based on a large number of high quality illustrations of Australian birds, which had been gathered for a planned earlier publication by the Australian Biological Resources Study (ABRS). The authors have accompanied these beautiful illustrations with a rich and varied text that is inspired by and which supplements and extends the life and drama in the images.

Stray Feathers has been produced for the student, bird lover, teacher or general reader and it covers a wide scope of fascinating aspects of birds including chapters on anatomy and physiology, bird senses, plumage, finding and handling food, courtship, parental care, nests, living together and many others.

The book contains remarkable facts about a broad selection of birds that will be familiar to readers from the more populated parts of Australia, as well as birds from across the more remote regions including our offshore islands.

Each page provides a vignette, which is a window into selected aspects of the lives of different species. The authors explore how storm-petrels feed their young on oil and how pigeons supply theirs with milk; how a Common Koel chick uses its tiny body to evict the nestlings of its host, and what feeding niches are occupied by co-existing species of grebe. There are excellent descriptions of the synergies between Black Kites and wild fire, between the Azure Kingfisher and platypus, and between albatrosses and prevailing winds.

This book is also a useful reference for the bird hobbyist and there is considerable detail about Budgerigar skeletons, skulls, breathing systems and feathers, and the importance of tongue shape in seed eating, nectar feeding and 'talking' parrots.

The bird adaptations featured throughout the book are described in terms of evolutionary imperatives, and the bird's behaviour, structure and physiology are often related by the authors to environmental selection pressures. For example the large range of bill lengths and shapes among waders is explained in terms of adaptive radiation to enable feeding. Examples of convergent evolution are also identified, such as in the common habits of crocodiles and mound builders. There are also descriptions of how unique random genetic mutations have led to the Emu's particular method for extracting water from ingested food and this is contrasted with the different strategies employed by desert mammals.

In addition to many specific examples, there are overarching evolutionary themes, which prevail throughout the book. Some of these include the trade off between birds' need for communication and the associated enhanced risk of predation; the relative merits of solitary and group lifestyles; and the advantages or otherwise of pairing for life.

The authors also explore some unexpected evolutionary relationships such as how weak flight in Buff-banded Rail may explain how rails successfully colonised remote islands thus leading to speciation. The authors do not claim, naturally, to have all of the evolutionary or biological answers about all species, and they stimulate enquiry by setting the scene for further work such as into "the uniqueness and function of wagging behaviour in fantails", and the purpose of the Southern Cassowary's "helmet".

Whilst not a key component of this book, there are some descriptions of bird responses to current topical environmental changes, such as tree loss and bell miner-psyllid larvae-Eucalypt dieback interactions.

This book is immensely readable and is entertaining, informative and inspiring. It will stimulate and enlarge the reader's love of birds and most likely promote a closer style of observation and a deeper understanding of evolutionary mechanisms. The illustrations are at times captivating and are always clear and accurate depictions of birds in the business of going about their lives.

The text and illustrations of this book are supplemented by an excellent "Further reading" list which will be very useful for extending the reader's investigations. This book will be a valuable addition to municipal, school and tertiary institution libraries, and will be an especially useful resource for biology teachers working at upper secondary school level. Most of all it will be a useful addition to the shelves for all lovers of birds.

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