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Mangrove kingfishers (*Halcyon senegaloides*; Aves: Alcedinidae) nesting in arboreal *Nasutitermes* (Isoptera: Termitidae: Nasutitermitinae) termitaria in central Mozambique

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Across the world's tropics at least six genera and more than 40 species of kingfisher (Alcedinidae) are known to nest in arboreal termite nests or termitaria (Fry *et al.*, 1992). They form part of a tropicopolitan guild of arboreal termitaria nesters that includes trogons, parrots, barbets, woodpeckers, jacamars, and puffbirds (Hindwood, 1959; Brightsmith, 2000, 2004). Amongst the Afrotropical *Halcyon* kingfishers, the behaviour is best known from Central and West Africa where it is documented in three species: chocolate-backed (*Halcyon badia*), blue-breasted (*H. maxima*) and woodland (*H. senegalensis* subspecies *fuscopilea*) kingfishers (Chapin, 1939; Brosset and Erard, 1986; Fry *et al.*, 1988, 1992; Clancey, 1992). By contrast, in southern Africa, *Halcyon* kingfishers breed exclusively in tree holes or tunnels in embankments and pits (Tarboton, 2001). In this paper, however, we show that there is an important regional exception amongst the southern African kingfisher assemblage.

Mangrove kingfisher (*Halcyon senegaloides*) has an extensive coastal distribution from southern Somalia to the Eastern Cape, South Africa (Fry *et al.*, 1988, 1992). However, in the Zambezi and Save River valley it ranges far inland; in the Save valley extending at least 120 km or more inland (Allan *et al.*, 2000: 21) and in the Zambezi valley approximately 150 km inland to the Caia-Inhamitanga district (authors, pers. obs.). There is also a sight record of mangrove kingfisher in riverine vegetation from the confluence of the Sabi-Lundi rivers in southeastern Zimbabwe, July 1999 (R. Boon, pers. comm.), a locality *c.* 270 km inland (and also representing a new addition to the Zimbabwean avifauna).

Little has been recorded regarding the nesting biology of *H. senegaloides* and until the 1990s fewer than ten nests were documented in the literature. In South Africa the species is known to nest almost exclusively in old barbet and woodpecker tree holes in the Eastern Cape, South Africa (Boon, 2000), the only exception being a second-hand and equivocal report of riverbank nesting (Jonsson, 1965). These Eastern Cape nests have been in coastal *terra firme* forest and it is doubtful that *H. senegaloides* breeds in mangrove forests in South Africa as there are few suitable tree holes in that habitat (Boon, 2000). East African breeding records are particularly sparse, but it appears to be a hole-nester in that region (Pakenham, 1943: 182; Fry *et al.*, 1988).

In December 1969, while collecting birds in the Inhamitanga Forest, Sofala Province, central Mozambique, ornithologist M. P. S. Irwin noticed mangrove kingfishers perched near arboreal termitaria and suspected them to be nesting in these termitaria (M. P. S. Irwin, pers. comm.). Although Irwin's suspicion has been cited by several authors (e.g., Clancey, 1971, 1992, 1996; Turpie, 2005), published confirmation has been lacking to date and Irwin's original observations were unfortunately overlooked by some authoritative publications (e.g., Fry *et al.*, 1988, 1992; Tarboton, 2001). Aside from Irwin, Parker (2005: 47) commented that breeding by *H. senegaloides* had been 'observed' in January in central Mozambique, but his text gave no elaboration. There are no other published breeding records of *H. senegaloides* for central or southern Mozambique.

In January 2007, at the northern edge of Inhamitanga Forest (*c.* 18°03′S 35°27′E; *c.* 150 m a.s.l.), Sofala Province, central Mozambique, G.B.P.D. saw a *H. senegaloides* perched within a few metres of an arboreal termitarium attached to the main trunk of a huge *Sterculia appendiculata* (Sterculiaceae) tree. The termitarium had a distinct, circular entrance hole and grooves made into the lower lip of the hole. The kingfisher was not seen to enter the hole, but, as in Irwin's case, it was strongly suspected the kingfishers were breeding in the

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termitarium. Unfortunately, further observations were not possible at this termitarium.

In 2009 and 2010 the authors operated again in Sofala Province, central Mozambique, and obtained definitive evidence that *H. senegaloides* routinely nests in arboreal termitaria in this part of the southern African subregion. Details of these findings are presented below.

METHODS

Field work was undertaken in Sofala Province, central Mozambique in November 2009 and December 2010. During the November 2009 trip, opportunistic observations were made of *H. senegaloides* whenever they were found in the Inhamitanga area in the northern part of Sofala Province. In December 2010, field work was conducted for 22 days on the Catapu Concession (*c*. 17°55–18°06′S 34°55–35°15′E; *c.* 100–200 m a.s.l.), a 24 821 hectare logging concession, *c*. 30 km south of the Zambezi River in the Caia-Inhamitanga area. The vegetation and woody flora of Catapu Concession has been described by Coates Palgrave *et al*. (2007), most of the concession being a mosaic of dry, deciduous forest and thickets and open woodland of mixed floral composition (but lacking *Brachystegia* and *Colophospermum*, which are common constituents of woodland/savanna vegetation elsewhere in Mozambique). While engaged in other types of field work, we searched for *H. senegaloides* by working the road network system in the concession listening for the distinctive vocalizations of the kingfishers (trilled song) and searching for arboreal termitaria with signs of excavation or cavities. To establish the identity of the termites involved, samples were collected from the termitaria, stored in ethanol and identified using the dichotomous keys in Uys (2002).

BREEDING OBSERVATIONS

In November 2009, H.N.C., J.R.P. and J. Carlyon found 11 termitaria occupied by *H. senegaloides* in deciduous forest in the Inhamitanga area (Figs 1, 2). Three of these nests were in tall *Sterculia appendiculata* trees, while the identity of the other nest trees was not recorded. All eleven termitaria had either incubating birds or nestlings being fed by the adults. The kingfishers were seen and photographed perching and entering these termitaria (Fig. 1). Three active nests in arboreal termitaria, with the kingfishers entering and exiting termitaria, were also found *c.* 14 km south of the Save River, Inhambane Province, November 2009 in deciduous forest.

In December 2010, G.B.P.D., C.T.S. and D.W. Pietersen found several arboreal termitaria with entrance holes and kingfishers perched or calling nearby on the Catapu Concession, but only two termitaria were proven to be definitely occupied by mangrove kingfishers, one southwest of M'phingwe Camp in open woodland (18°04′17.3″S 35°10′56.3″E, 92 m a.s.l.; termitarium-nest 1) and another on the southwestern boundary of the concession (18°09′17.2″S 35°07′28.9″E, 184 m a.s.l.; termitarium-nest 2). Both termitarium-nests of December 2010 were in tall (*c.* 30 m) *Sterculia appendiculata* trees. The occupied termitaria were large, sub-globular, sub-pendant, black-coloured and plastered to the tree trunk (as in Fig. 2). The measurements of termitarium-nest 1 were 48 × 35 × 27 cm (*i.e.*, a volume of *c.* 45 l); termitarium-nest 2 was not measured. Nest 1 was 11 m above ground, while termitarium-nest 2 was approximately 10–15 m above ground.

The *Sterculia* of termitarium-nest 1 stood in an open, grassy area about 30 m from an expanse of dry, deciduous forest while the *Sterculia* of termitarium-nest 2 was within dense, dry deciduous forest, although about 20 m from the edge of a broad dirt road. At termitarium-nest 2, the adults were not incubating on 4 December, although one adult did fly to the termitarium on two occasions and briefly cling to the entrance hole; it did not enter. On 8 December, courtship feeding and mating was observed at termitarium-nest 2. By discerning the sexes from mating, it was noted that the female remained in the nest tree while the male left and returned with food items (invertebrates, reptiles) to feed her. By 15 December the kingfishers were incubating at this nest (regularly entering and exiting termitarium), suggesting egg-laying had taken place between 8 and 15 December. Most birds in the Inhamitanga district of Mozambique began egg-laying after the monsoonal rains broke in the first week of December (authors' personal observations during December 2010).

On 20 December, at termitarium-nest 1, by observing change-overs at the termitarium, it was confirmed that both sexes incubate, a point not yet established (*cf*. Fry *et al*., 1988, 1992; Boon, 2000; Turpie, 2005). At 06:38 a mangrove kingfisher emerged from the termitarium (having incubated since 05:18) and joined another kingfisher that had been singing in the canopy, a minute later the kingfisher that had emerged from the termitarium flew off from the nest tree and the singing kingfisher flew to and entered the termitarium (where it remained until 07:40). Later, at 08:57, a mangrove kingfisher exited the termitarium, joined its mate, the exiting bird perched briefly next to the other kingfisher before flying away from the nest tree, and the other kingfisher then entered the termitarium.

No interactions between the kingfishers and other birds in the nest trees were noticed. On 4 December

Fig. 1

Mangrove kingfisher (*Halcyon senegaloides*) perched at the entrance to termitarium-nest, Inhamitanga district, central Mozambique. Photograph by J. R. Peek.

2010, a bearded woodpecker (*Thripias namaquus*) – plausibly a nest-hole competitor – foraged in the *Sterculia* of termitarium-nest 2 about 10 m from the nest-termitarium, but the kingfishers did not react to the presence of the woodpecker. Also on 4 December, a pair of vanga flycatchers (*Bias musicus*), nesting in the same *Sterculia*, vigorously and noisily dive-bombed a crowned hornbill (*Tockus alboterminatus*) that had flown into the canopy, but again the kingfishers were unresponsive to this potential nest predator. On 12 December when C.T.S. was climbing to termitarium-nest 1, one of the kingfishers flew and struck the climbing rope (without calling), perhaps mistaking the rope for a snake. When measurements of this termitarium were being taken the kingfisher was undemonstrative and perched quietly in the canopy before flying away.

TERMITE ACTIVITY IN OCCUPIED TERMITARIA AND IDENTITY OF TERMITES

Observations at the termitarium-nest 1 on 12 December showed that the termitarium still had an active colony of termites, these were found crawling around on the surface of the termitarium and where small pieces of the termitarium were chipped away. Photographs taken by H.N.C. from directly in front of at least three of the nests in 2009 also showed that the inside walls of occupied termitaria were re-sealed by the termites and that limited termite activity was continuing within the nest cavity. Samples of the termites showed them to be black-snouted termites of the subfamily Nasutitermitinae (Isoptera: Termitidae), characterized by the soldiers having a tubular extension on the head capsule. They were identified as belonging to the genus *Nasutitermes* Dudley and Beaumont, 1890, proba-

Fig. 2

Nasutitermes sp. (Isoptera) termitarium on *Sterculia appendiculata* (Sterculiaceae) trunk with entrance hole to kingfisher nest chamber visible in centre of termitarium, Inhamitanga district, central Mozambique. Photograph by H. N. Chittenden.

bly the species *N. infuscatus* (Sjöstedt). The termitaria are not made of mud or soil (as they appear to be when studying them from ground level), but rather faecal carton, which gives the termitaria a brittle texture. We found it easy to break into other *Nasutitermes* termitaria examined, an attribute that may contribute greatly to the appeal of the termitaria as potential nesting sites. It is our strong suspicion that the holes in the termitaria are excavated by the kingfishers.

STATUS OF MANGROVE KINGFISHER IN MOZAMBIQUE

The abundance of *H. senegaloides* in the deciduous inland forests and woodlands of the Caia-Inhamitanga district is also worth underscoring. Mangrove kingfisher is the most abundant dryland kingfisher in this region, its trilled song being one of the dominant sounds of the dawn chorus. Although present, its congener woodland kingfisher (*H. senegalensis*) is extremely scarce in the district. For example, during December 2010 we only had two records of woodland kingfisher, both in open woodland, once on the Catapu concession (18°03′27.8″S 35°11′08.9″E), and just before the entrance track to Coutada 12 (18°14′32.1″S 35°11′42.8″E).

During the breeding season, mangrove kingfishers in the Caia-Inhamitanga district are not associated with mangroves or riverine habitat; however in the austral winter it is likely they migrate to the enormous coastal mangrove forests in the Zambezi Delta (mangrove forests totaling >150 000 ha in the delta, Beilfuss *et al.*, 2001). The distribution of man-

grove kingfisher in central Mozambique is, however, localized. To the south of the Zambezi Valley is the Cheringoma Plateau, a low, seaward-inclined block of white, nutrient-poor sands covered predominantly in a mosaic of *Brachystegia* woodland, riverine forest and dambos, and to the southwest of the Inhamitanga-Caia district is the arid, low-lying Urema Graben, the southernmost extension of the African Rift Valley and covered in mixed *Acacia-Sclerocarya-Adansonia* savanna, deciduous forests and floodplain grasslands (see Tinley, 1977 for detailed discussion). Mangrove kingfishers are scarce on the Cheringoma Plateau and completely absent from the Urema Graben. The general absence of mangrove kingfisher from the closed-canopy riparian forests of the Cheringoma Plateau, such as occur in the Chinizuia River drainage forests, may be related to the fact that there are no major river valleys (like the Zambezi or Save) connecting these forests and woodlands with the coast, which also have smaller mangrove forests than the Zambezi or Save River deltas. The absence of the kingfisher from the Urema Graben may be related to the unsuitability of the vegetation in this part of the Rift Valley; *Nasutitermes* termitaria also appear to be absent from the Graben, but corroboration on this point is needed.

The abundance of mangrove kingfishers in the Caia-Inhamitanga district also contrasts with the situation apparently prevailing on the northern side of the Zambezi River in northern Mozambique. From the Mopeia area, Zambezia Province (17°56′S 35°37′E), Hanmer (1976: 34) could only give one record of *H. senegaloides*, which was less common than *H. senegalensis*, *i.e.*, a reverse of the situation prevailing in the Caia-Inhamitanga district on the south bank. Later, Hanmer (1983, 1984, 1989) described anomalous woodland kingfishers from Nchalo, southern Malawi (16°16′S 34°55′E) with patches of red on the (lower) mandible, which may have been hybrids between the two species, even though mangrove kingfisher surprisingly does not occur in Malawi (Dowsett-Lemaire and Dowsett, 2006). Inconclusively, Vincent (1934: 775), during his landmark expedition through northern Mozambique, did not find a single woodland kingfisher and only had one coastal record for mangrove kingfisher (Lurio River mouth). In a similar vein, Roberts (1912), during his expedition to Boror, Quelimane district, Zambezia Province, northern Mozambique from April–November 1908, did not encounter woodland or mangrove kingfisher. It is clear that further observations from northern Mozambique of these two kingfishers would be desirable to clarify their status there, as the ostensible rarity of *H. senegaloides* there may be an artifact of having been overlooked.

GREEN-BACKED WOODPECKER AS A TERMITARIA-NESTING SPECIES

Davies and Boon (1999) described an active green-backed (little-spotted) woodpecker (*Campethera cailliautii*) nest in what they called a cocktail-ant *Crematogaster* species (Hymenoptera: Formicidae: Myrmicinae) nest *c.* 6 m above ground-level in a *Brachystegia spiciformis* (Fabaceae) tree in pristine Miombo woodland, Chinizuia-Condue district, Sofala Province (*c.* 18°54′S 35°00′E; *c.* 200 m a.s.l.) during December 1998. This nest contained two, nearly-fledged chicks. In retrospect and with further experience, G.B.P.D. now realizes that this 'ant nest' was a *Nasutitermes* termitarium, and this paper serves to correct that error. At the time, G.B.P.D. could find no reference to termitarium- or formicarium-nesting by this woodpecker, but he did overlook that the species account for black-backed barbet (*Lybius minor*) in *Birds of Africa* noted that a 'pair of Green-backed Woodpeckers *Campethera cailliautii* nest[ed] only 8 m [from the Black-backed Barbets] in another arboreal ant nest' (Short and Horne, 1988: 471), this record apparently referring to Zambia. Curiously, although L. L. Short was the senior author for both the barbet and woodpecker sections in this volume of *Birds of Africa*, the statement relating to formicarium-nesting by *C. cailliautii* was not repeated under its species account (Short, 1988: 529). Although Short and Horne (1988: 471) reported that the woodpeckers were nesting in an 'ant nest', it is more likely to have been a termitarium. Our breeding record for green-backed woodpecker has been overlooked by authoritative publications (e.g., Tarboton, 2001, 2005)

Breeding records for *C. cailliautii* from Mozambique are especially sparse, the only other primary reference being Roberts (1911: 75), who took a clutch of three eggs in the Quelimane district on 3 November 1908, but unfortunately his paper and the label with the original clutch in the Ditsong (Transvaal) Museum do not indicate the type of nest site. Since Davies and Boon's (1999) record, no other observations of green-backed woodpecker nesting in arboreal termitaria (or formicaria) have been published, but, in December 2008, G.B.P.D. did find a male green-backed woodpecker clinging to a *Nasutitermes* termitarium 10 m above ground level in open woodland, approximately 5 km southwest of M'phingwe Camp, Catapu Concession. This termitarium had a distinct entrance hole, but the male was evidently alarmed by Davies's presence and did not enter while he watched; unfortunately further observations were not possible at this nest. It is probable green-backed woodpecker nests regularly in arboreal termitaria in Sofala Province.

DISCUSSION

To recapitulate, mangrove kingfishers in the Zambezi River valley extend far inland (>100 km) where they breed in arboreal termitaria in deciduous forest and woodland; similar behaviour also occurs in the Save River valley. It is important to stress that during our time in central Mozambique we did not find any evidence that mangrove kingfishers nest in tree holes; they appear to be obligate termitaria-nesters in the Caia-Inhamitanga district, and probably also in the Save River drainage. Thus, the nest sites differ starkly between the central Mozambican and Eastern Cape populations. It is also our impression – subject to confirmation with further research – that the kingfishers prefer to nest in termitaria plastered on smooth-boled *Sterculia* trees, and that only larger termitaria are selected. Speculatively, smooth-boled trees like *Sterculia* may be chosen because potential nest-predators like baboons (*Papio* sp.) find them extremely difficult to climb. Larger termitaria would be selected because these must been of a sufficient size to accommodate the nest cavity safely. We also established that both sexes of *H. senegaloides* incubate, as is common with other kingfisher species.

As with termitaria-nesters elsewhere in the world (Brightsmith, 2000), we found that the termitarium-nests were still occupied by colonies of *Nasutitermes* termites. It is noteworthy that in South America, southeast Asia and Africa, avian termitaria-nesters select *Nasutitermes* arboreal termitaria, suggesting that this one termite genus is a 'keystone' taxon for avian termitaria-nesters throughout the tropics.

On the southern side of the lower Zambezi River valley, *H. senegaloides* is common, far outnumbering *H. senegalensis*, a situation apparently different to that on the north bank. Mangrove kingfishers breeding in the inland deciduous forests and woodlands of the Zambezi and Save River valleys probably migrate during the austral winter to the extensive mangrove forests at the mouths of these rivers. The situation prevailing in southern Mozambique also warrants further investigation. Occasional records of mangrove kingfisher from riparian vegetation in the Kruger National Park, South Africa (e.g., Kemp, 1974; Newman, 1980; Baldo, 2006) indicates movement up rivers from the southern Mozambican coastal plain, and, in the Maputo Elephant Reserve, Parker and de Boer (2000: 34) reported that mangrove kingfisher 'travels inland to breed in riverine vegetation in midsummer', but provided no further details. The termite genus *Nasutitermes* reaches as far as northern Zululand, South Africa (Uys 2002) and these kingfishers in southern Mozambique may also be using termitaria for nesting.

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