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An adjustable, lightweight pole system for catching birds in mist nets in the low- to mid-canopy

Andrew Peters[1] and Shane R. Raidal

[1]Corresponding author: E. H. Graham Centre for Agricultural Innovation,
Wagga Wagga Agricultural Institute, PMB, Wagga Wagga, NSW, Australia. Email: apeters@csu.edu.au

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Various methods exist for the elevation of mist nets in order to capture canopy birds for study. The use of trees for support enables mist nets to be raised to a great height, though this often limits where a net can be placed. The use of free-standing poles for support can allow mist nets to be located at the best possible site, such as along a frequented flight path. However, this technique has previously been limited to the capture of birds less than eight metres above ground. We describe in detail a lightweight pole system constructed of two metre-long black carbon fibre tubes connected with stainless steel joints. Thin black guy ropes provide support, while nets are connected to a dark-coloured 'flagpole' rope on each pole. This system allows mist net elevation to 12 metres above ground, great flexibility, ease of set-up and serial net connection. The high cost may be outweighed by greater capture success in many situations and with advances in materials and technique, the system may allow net placement above 12 metres.

INTRODUCTION

Mistnetting for the purpose of banding birds was described in detail more than half a century ago following its introduction from Japan (Low 1957; McClure 1984), and has since become a widely used technique in field ornithology. Early on it was recognized that birds that spent a lot of time higher than 2 metres above ground level were underrepresented by mistnetting, and that this was a significant factor limiting the extrapolation of relative species abundances from mist net data at many sites (MacArthur and MacArthur 1974; Remsen and Good 1996).

In response to this problem a variety of methods were developed for the elevation of mist nets five metres or more above ground level, with several of these techniques still being used successfully by field ornithologists today. These include vertically aligned nets suspended from individual canopy branches (Greenlaw and Swinebroad 1967; Munn 1991), horizontal nets suspended from rope or metal wire running between trees (Humphrey *et al.* 1968; Paton *et al.* 1992; Stokes *et al.* 2000), horizontal nets strung between ropes suspended from separate canopy branches (Whitaker 1972), and poles with or without rope-and-pulley systems (Albanese and Piaskowski 1999; Bleitz 1970; Bonter *et al.* 2008; McClure 1966; Meyers and Pardieck 1993).

The use of canopy-suspended nets is dependent on the location of trees. Furthermore, nets cannot be elevated as high as the tops of isolated trees, and their use may involve sophisticated rope or wire set-ups that preclude spontaneous translocation of mist nets. Poles, by contrast, provide flexibility in the placement, length, and serial connection of mist nets (Low 1957; Sappington and Jackson 1973), but have only been reported as reaching up to 8.5 metres above ground (Albanese and Piaskowski 1999; Meyers and Pardieck 1993).

We designed and trialled a lightweight, adjustable pole system capable of elevating mist nets up to 12 metres above ground for the capture of arboreal Australian pigeon and dove species. Despite a high cost for construction, our system allows serial net connection, flexibility in height, and rapid set-up.

METHODS

System dimensions and manufacture.

Poles consisted of several two-metre-long carbon fibre tubes connected by stainless steel joints and supported by guy ropes. Poles could be made to either eight metres (low canopy) or 12 metres (mid canopy) length.

Carbon fibre tubes (2 m long, 30 mm external diameter, 25 mm internal diameter, 3K plain weave fibre arrangement) were custom made and shipped to Australia (Weihai ChuangXin Carbon Fiber Products Factory, Weihai, Shandong, China).

Joints for connecting carbon fibre tubes and for attachment of guy ropes and pulleys were custom made by a local stainless steel machinist. The joints consisted of 25 millimetres external diameter stainless steel tube (3 mm wall thickness) that was machined to allow frictionless sliding into the carbon fibre tube ends. We initially used standard-grade aluminium tubing with walls up to three millimetres thick to produce joints, but they bent with loading.

We fastened 50-millimetre-long collars of carbon fibre tubing (cut from a spare tube of the same dimensions as described above) onto the stainless steel joints. Plastic or metal eyelets were tapped and screwed into these collars to allow attachment of guy ropes and pulleys. Fixtures were of marine-grade stainless steel or polymer. Four types of joints were produced (Fig. 1): (1) top cap – 150 millimetres long with collar

Figure 1. *Stainless steel joints used to connect carbon fibre tubes together. A lateral view for each joint type is illustrated above, with the corresponding end-on view directly below. From left to right: top cap, support joint, simple joint, and bottom cap.*

attached at one end, with a metal eyelet with pulley and three plastic eyelets, (2) support joint – 250 millimetres long with collar attached mid-shaft, with three plastic eyelets, (3) simple joint – 250 millimetres long with collar attached mid-shaft, with no fixtures, and (4) bottom cap – 150 millimetres long with collar attached at one end, with a single metal eyelet with pulley.

All pole set-ups had a bottom cap and top cap at opposite ends, plus alternating support and simple joints connecting the two-metre-long tubes (Fig. 2A). For two 12-metre-high poles, two bottom caps, two top caps, four support joints, and six simple joints were required.

A dark five-millimetre-diameter static kernmantle rope was fed through pulleys attached to the top and bottom caps and tied to form a loop (Fig. 3A). The loop was tied tight enough to prevent sagging of the net without bending the pole. Total length of these ropes depended on the pole lengths. Two of these ropes of 17-metre-length were required for 8-metre-high poles and two of 25-metre-length were required for 12-metre-high poles.

Three, two-millimetre-diameter black braided guy ropes ran between pegs (3 metres from the base of the pole) and the three plastic eyelet fixtures on each of the support joints connecting poles at four metres and eight metres above ground, and on the top caps (Fig. 2A). An additional three guy ropes ran from the top cap on 12-metre-high poles to pegs 10 metres from the base of the pole. Sliding two half-hitches knots were used at the base of guy ropes to allow these to be tensioned to effect (Fig. 3B). Pegs were either of steel or heavy-duty plastic, depending on the ground type (the latter was used for soft or sandy ground).

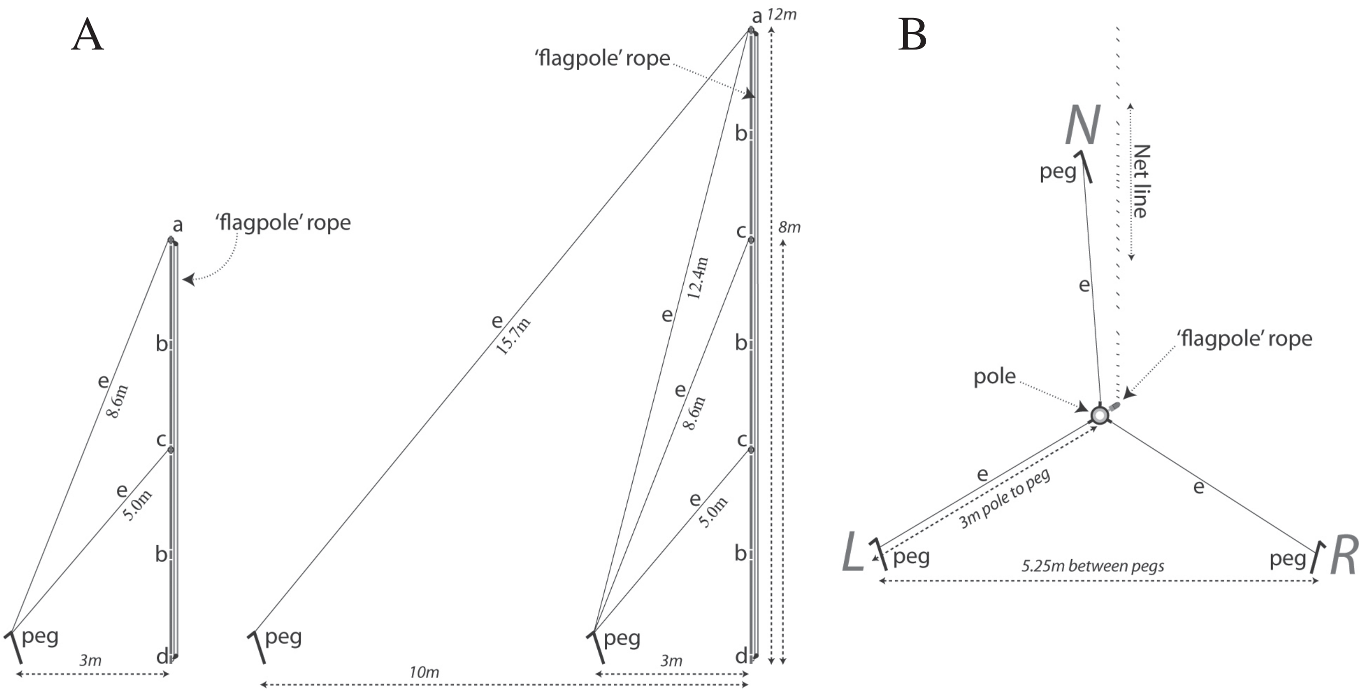

Figure 2. A: *Lateral view of the carbon fibre pole set-up for eight-metre-high (left) and 12-metre-high (right) mist netting. Illustrated features include: (a) the top cap; (b) simple joints; (c) support joints; (d) bottom cap; (e) guy ropes (with minimum lengths); pegs; and 'flagpole' rope.* **B:** *View from above of a low canopy carbon fibre pole set-up showing the position of the three guy rope support pegs (N, L, and R) relative to the base of the pole and to each other. The net line is illustrated. Outer (10 metre) guy rope support pegs are not shown.*

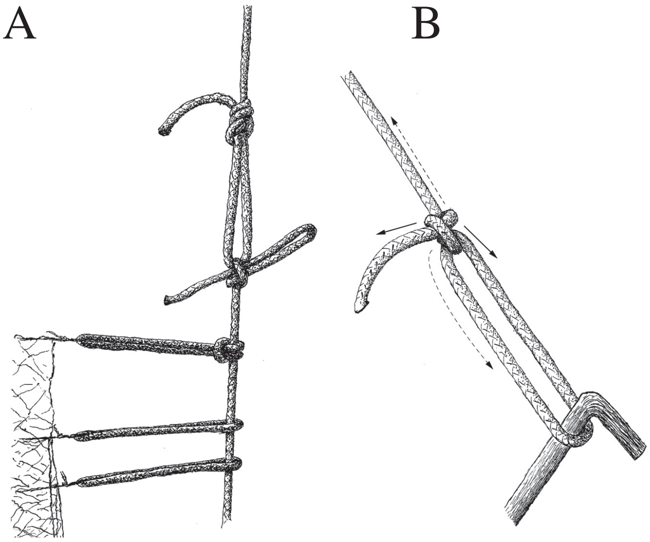

Figure 3. A: *Illustration of part of the 'flagpole' rope; including the upper tail with loop, the lower tail which is tied onto the loop with a half-hitch and the arrangement of net loops on the rope.* **B:** *Illustration of the lower end of a guy rope with a two half-hitches knot forming a loop running around a peg. This allowed adjustable tensioning of the guy rope (dashed arrows) but must be tightened (solid arrows) to prevent slippage.*

Setting up the poles.

In addition to the materials described above, mist nets, a mallet, a three-metre-long measuring cord with a loop tied in the end, and a 20-metre retractable measuring tape were used to set up poles. The ground was cleared of debris along the planned net line. Pegs (with fluorescent flagging tape) were used to mark the locations of the poles, the distance between them was measured based on the desired net length (plus an additional 0.5 metre to prevent sagging; Fig. 4a).

Three guy rope pegs were placed three metres from the base of each pole and 5.25 metres apart (Figs. 2B and 4b). For 12-metre-high poles, an additional three guy rope pegs were placed 10 metres from the base of the pole, directly out from the three-metre pegs.

Carbon tubes were laid out along the net line and connected using simple and support joints to create two poles of desired height (Fig. 2A). Top and bottom caps were placed at the appropriate ends. Flagpole ropes were set up on each of the poles. A small tie was used to fasten the metal eyelet of the bottom cap of each pole to its placement peg (Fig. 4c). Guy ropes of appropriate length were attached to the support joints and top caps. All guy ropes facing the net line (ropes *N* in Fig. 2B) were tied to their peg using two half-hitches knots. All guy ropes facing away from the net line (ropes *L* and *R* in Fig. 2B) were laid out towards their respective pegs in preparation for raising the poles.

Two operators were needed to raise a 12-metre-high pole, but one person could raise an eight-metre-high pole with some practice. Importantly, both operators needed to work together and without hesitation to prevent the 12-metre-high poles from bending and breaking during lifting.

To lift a pole, each operator would take hold of all of the guy ropes facing each of the two pegs opposite the net line (either *L* or *R* in Fig. 2B). They would place even tension on the ropes, gently lifting the top end of the pole off the ground first (Fig. 4d). Together, they would pull the guy ropes back away from the net line to lift the pole upright in one action, with the top end of the pole at all times bending up slightly (Fig. 4e). If the top of the pole started to flex down towards the ground, the pole was immediately lowered and the guy ropes attached to the top joint were tightened in the hand to achieve a slight upwards bend. Once the pole was raised (Figs. 5A and 5B), the operators fastened the guy ropes to the pegs using two half-hitches knots. Poles were inspected and guy rope lengths modified to achieve a straight set-up. Care was taken to ensure all 'two half-hitches' knots were pulled tight (Fig. 3B) to prevent slippage.

A net was attached to the flagpole rope of one pole, and was then unwrapped and walked out to the second pole where it was attached to its flagpole rope. To attach nets to the flagpole ropes, the bottom net loops were fed onto the lower tail of the untied rope in order. The uppermost net loop was then tied to the rope using a cow hitch (Fig. 3A) before the upper and lower tails of the flagpole rope were refastened with moderate tension. Nets could be placed in series by attaching two nets (alternating the net loops from either) to a flagpole rope and then walking these in opposite directions to corresponding poles as described previously for other set-ups (Low 1957).

The net was raised at both ends using the flagpole ropes, and could be unfurled or furled during raising or lowering (Fig. 4f) (Low 1957). When birds were captured, either end of the nets was lowered until the bird could be reached. This process was more efficient with an operator at each pole.

Trial period.

We used this pole set-up with 12-metre and 18-metre long mist nets (30 mm square mesh with four shelves) over a four-month field season in savannah, rainforest, sclerophyll woodland and mangrove environments of northern and eastern Australia. Five species of arboreal pigeons and doves, especially the Pied Imperial-pigeon *Ducula bicolor*, were targeted for capture and nets were placed directly besides feeding trees (Fig. 5A) or on flyways based on observation of the target species. We attempted to minimise the unintentional capture of other species. Other techniques for mist net support (Low 1957; Whitaker 1972) were considered and used at a number of sites for the capture of other species of pigeons and doves. Nets were only unfurled when the target species were present.

RESULTS

All five targeted species of arboreal pigeons and doves were captured exclusively using the carbon fibre pole set-up (Table 1). When supporting 18-metre-long mist nets they were particularly successful at the capture of adult Pied Imperial-pigeons, a highly arboreal species which others have found difficult to capture in reasonable numbers despite their abundance (Price 2006). Another species, the Peaceful Dove *Geopelia striata*, was captured using the described pole set-up but more frequently by using 1.75-metre-high poles. Six other species of pigeons and doves were exclusively captured using a 1.75 metre ground pole set-up. Canopy-suspended nets were not

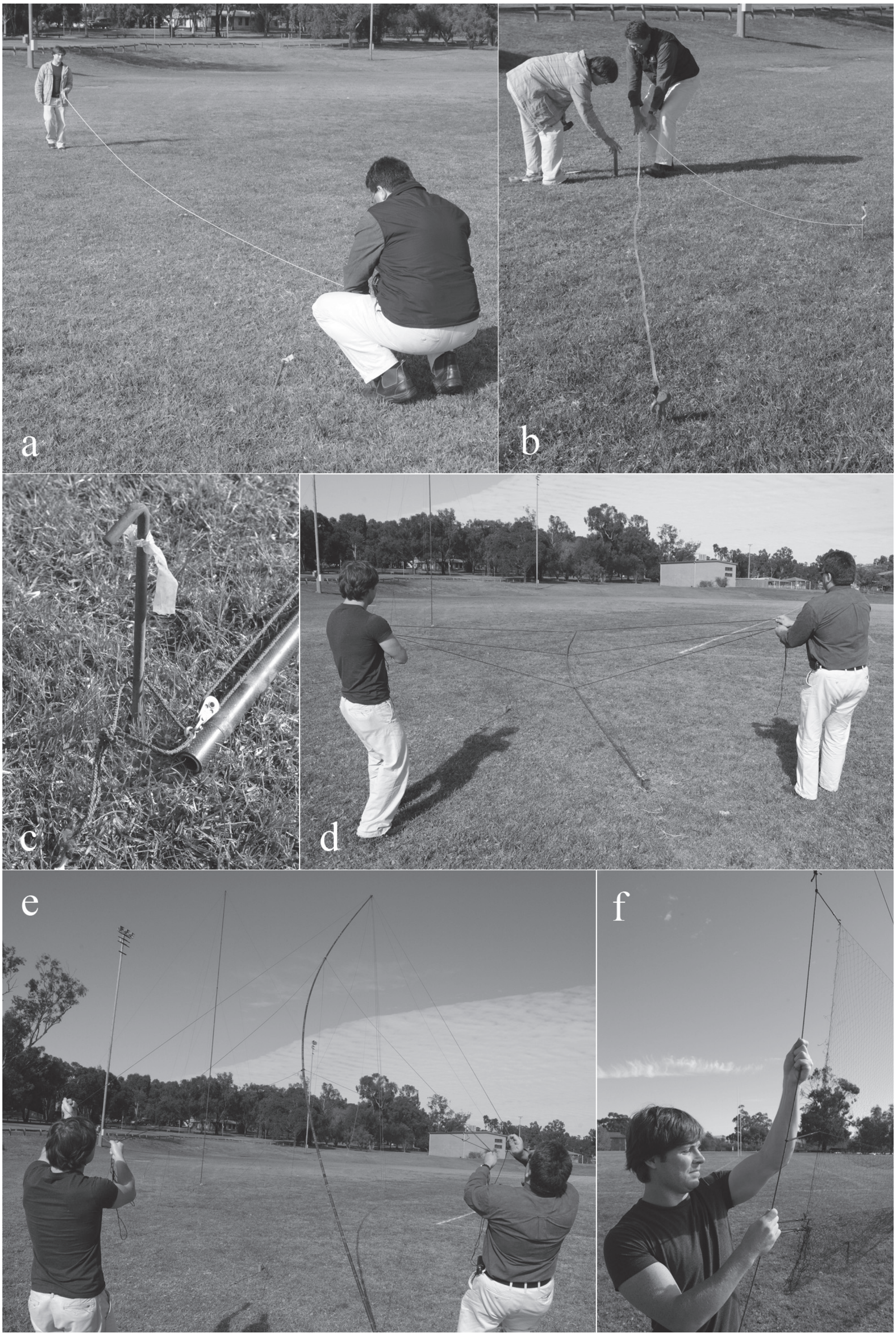

Figure 4. *Photograph series of pole and net set-up, including: a) measuring out the net line; b) measuring out and placing guy rope pegs; c) attachment of the base of the pole to the peg marking the location of the raised pole; d) operators placing even tension on the guy ropes; e) operators raising the pole in a steady, even motion, and f) raising the 'flagpole' rope and opening out the net at the same time.*

TABLE 1

Species captured using 8-metre and 12-metre-high carbon fibre poles supporting 12-metre to 20-metre-long mist nets (30 mm square mesh, four shelves). The arboreal species we targeted are marked with an asterisk.

Species		8-m pole capture	12-m pole capture
Brown Cuckoo-Dove	*Macropygia amboinensis**	4	–
Common Bronzewing	*Phaps chalcoptera**	3	–
Peaceful Dove	*Geopelia striata*	3	–
Bar-shouldered Dove	*Geopelia humeralis**	7	1
Rose-crowned Fruit-Dove	*Ptilinopus regina**	5	–
Pied Imperial-Pigeon	*Ducula bicolor**	34	4
Rainbow Lorikeet	*Trichoglossus haematodus*	5	5
Laughing Kookburra	*Dacelo novaeguinae*	2	2
Blue-winged Kookaburra	*Dacelo leachii*	–	2
Forest Kingfisher	*Todiramphus macleayii*	–	2
Rainbow Bee-eater	*Merops ornatus*	1	1
Great Bowerbird	*Ptilonorhynchus nuchalis*	–	10
Yellow-tinted Honeyeater	*Lichenostomus flavescens*	1	1
Rufous-throated Honeyeater	*Conopophila rufogularis*	1	1
Dusky Honeyeater	*Myzomela obscura*	1	–
Brown Honeyeater	*Lichmera indistincta*	1	2
Varied Triller	*Lalage leucomela*	1	–
Australasian Figbird	*Sphecotheres vieilloti*	1	–
Olive-backed Oriole	*Oriolus sagittatus*	2	1
White-breasted Woodswallow	*Artamus leucorynchus*	1	–
Pied Currawong	*Strepera graculina*	–	1
Willy Wagtail	*Rhipidura leucophrys*	–	2

used during the trial period because of a lack of suitable sites. A variety of other species were captured unintentionally in the eight-metre and 12-metre-high pole supported nets (Table 1). No injuries or mortalities occurred during the trial period with any species, including two small bats that were unintentionally captured. Target birds did not manage to avoid capture by bouncing out of the nets, although occasionally would fly above (and rarely below) the nets.

When supporting unfurled nets, the carbon fibre poles could withstand winds of up to 25 kph, although successful trapping invariably occurred with little or no wind. One of the carbon fibre tubes developed fine longitudinal cracks at one end following dropping of the pole over a rise in the ground and extension of these cracks was prevented through the use of a stainless steel hose clamp at that end.

DISCUSSION

We developed this adjustable, lightweight carbon fibre pole system for mistnetting in the low- to mid-canopy in response to our need to capture arboreal pigeons and doves. Early attempts at gaining the required heights (i.e. up to 12 metres) using aluminium poles were unsuccessful. Telescopic, painted eight-metre aluminium poles were effective in the low canopy, but became scratched with repeated use making them highly visible to the target species, were heavier and more awkward to transport and had a high frequency (approximately 30%) of large pigeons which we targeted bouncing out of the nets. This was not observed with the carbon fibre poles despite using the same mist nets, possibly because the poles absorbed more of the energy of these relatively heavy and fast-flying birds as they hit the net. At all of our field sites, canopy suspended nets (which the author has used successfully before) were impractical because of a lack of suitably located trees with overhanging branches and a clear understorey. This is a common scenario in the relatively open savannah of northern Australia and the low littoral woodlands and mangroves of the coast. Thus, while canopy-supported systems are capable of elevating mist nets to great heights (Table 2), their need for well placed trees make them highly inflexible for many studies focused on capture of a particular species.

Setting up two, eight-metre poles required approximately 45 minutes with experience. Unlike many canopy supported mist nets, no technical expertise (e.g. tree climbing, shooting lines) was necessary (Table 2). Set up may have been faster by attaching nets to the flagpole ropes using shower curtain rings (Humphrey *et al.* 1968). The use of three millimetres (instead of 2 mm) guy ropes may have avoided some issues with tangling, making set up easier and faster.

The cost for a pair of custom-made 12-metre-high poles with all joints, ropes and spares was approximately AUS$1600, but this may vary with the manufacturer and the quantity of each order. While considerably more expensive than other described canopy and elevated pole set-ups (Table 2), the advantages of the carbon fibre poles as a portable, easy-to-use and highly

TABLE 2

Comparison of net support type, maximum height attained, relative ease of set up, flexibility in placement and price (adjusted by CPI to 2010 AUS$ value) of elevated mist net set-ups. (NA = data not available).

Reference	Support	Max. height	Ease of set up	Flexibility	Price (AUS$)
Albanese and Piaskowski (1999)	Poles	8.5m	Easy	Good	46
Greenlaw and Swinebroad (1967)	Canopy	21m	Easy	Poor	NA
Humphrey et al. (1968)	Canopy	30m	Moderate	Moderate	90
Meyers and Pardieck (1993)	Poles	7.3m	Easy	Good	213
Munn (1991)	Canopy	45m	Moderate	Poor	NA
Paton et al. (1992)	Canopy	45m	Technical	Poor	NA
Stokes et al. (2000)	Canopy	30m	Technical	Poor	203
Whitaker (1972)	Canopy	18m	Moderate	Moderate	146
This study	Poles	12m	Easy	Good	1600

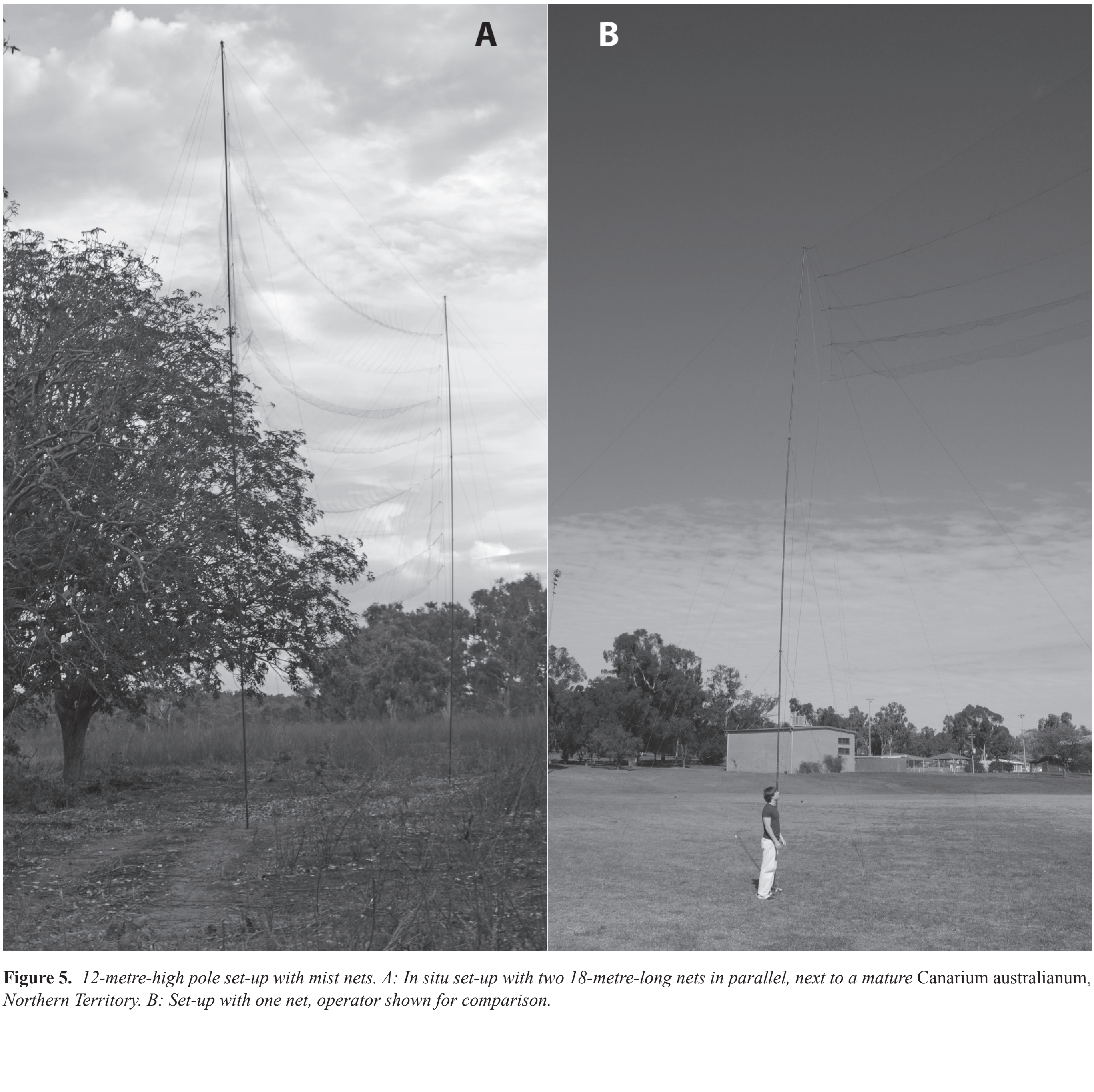

Figure 5. *12-metre-high pole set-up with mist nets. A: In situ set-up with two 18-metre-long nets in parallel, next to a mature* Canarium australianum, *Northern Territory. B: Set-up with one net, operator shown for comparison.*

flexible system for elevating mist nets to 12 metres justify the outlay in many situations. Furthermore the equipment showed no wear over four months of near continuous transport and use (with assembly and disassembly every few days) and is likely to remain in good condition for a prolonged period.

This system for elevating mist nets is unlikely to replace those described previously but will assist in correcting the recognised low-level bias in studies utilising mist nets (Bonter *et al.* 2008; MacArthur and MacArthur 1974; Ralph and Dunn 2004; Remsen and Good 1996) and will be an especially useful tool for those targeting particular arboreal species.

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