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Methods for field recognition of individual Australian Pelicans *Pelecanus conspicillatus* from eggs to adulthood

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Recognition of individual animals is crucial to being able to answer many pure and applied research questions in zoology. Marking members of species that undergo large changes in size during development can be particularly challenging. This paper describes successful methods used to mark Australian Pelicans *Pelecanus conspicillatus,* which show mass changes of over two orders of magnitude during development. Re-sightings until the end of 2011 were recorded for birds marked between 1990 and 2003. Comparison of re-sighting rates among the different marking techniques used, their cost, practicality of application in the field and associated animal welfare issues were taken into account when choosing the best techniques. Marking eggs with non-toxic, felt-tipped pens worked well, except under wet conditions. Custom-made "velcro" wing tags worked well for nestlings. The "velcro" tags can also be used on the leg to mark small crèche-young until they are large enough for Allflex™ cattle ear tags to be used as patagial tags. The high re-sighting rates of patagial tags on fledged pelicans (>61%) demonstrated their superior utility compared with butt-ended, stainless steel leg bands (re-sightings 1.3%). Stainless steel leg bands detached from 22/311 (7%) pelicans concurrently leg-banded and patagially-tagged. The techniques described here were used sequentially to mark individual pelicans throughout their life span. They provide practical, cost-effective and safe methods for marking individual pelicans and other similar-sized birds.

INTRODUCTION

Recognition of individual animals is crucial to many studies of behavior and ecology, and provides valuable information for wildlife management. A range of techniques is available to mark individual birds, including leg bands, wing tags, leg flags, neck collars, nasal saddles, passive transponders and radio or satellite telemetry (Strait and Sloan 1975; Schreiber and Mock 1988; Warnock and Takekawa 2003; Anderson and Anderson 2005; Fuller *et al*. 2005; Roshier *et al*. 2006; Coiffait *et al*. 2009). Each marking technique has its advantages and disadvantages, and different techniques are appropriate for birds of different sizes and habits. For example, leg bands may be used on even the smallest of species, whereas satellite telemetry may only be used on larger species. Recognition of individuals in the field presents particular challenges for species that go through large changes in size during growth.

A primary ethical and methodological concern in field studies is that any method used to mark individuals does not cause distress, injury or decreased fitness in the subject of the study. Marking individual animals for field study often has no discernible impact (e.g. Guay and Mulder 2009). However, some studies have recorded problems associated with marking methods, including skin abrasion, feather wear, changes in behaviour, reduced flying or swimming efficiency, lower reproductive success, increased predation risk, and death (Calvo and Furness 1992; Zuberogoitia *et al*. 2012; Trefry *et al*. 2013). Effects may vary among species. For example, individual marks may influence dominance status or mate selection in some species (Burley *et al*. 1982; Kindel 1989; Bustnes and Erikstad 1990; Green *et al*. 2004), but not in others (Wallace *et al*. 1980; Kochert *et al*. 1983; Sweeney *et al*. 1985; Phillips *et al*. 1991; Smallwood and Natale 1998). Both direct and indirect effects of individual marks have been reported, so caution is advocated when considering a 'new' species for tagging, specifically with respect to its behaviour, habitat and conservation status. For example, the costs might outweigh the benefits for long-distance migrants, aquatic divers and threatened species (Howe 1980; Saunders 1988; Green *et al*. 2004). Documenting experiences with different tagging methods on different species is important so that future researchers understand these disadvantages and advantages. It is also important to test for any effects that marking methods have on the parameters under study, as the use of tags may influence the accuracy of data collected (Calvo and Furness 1992).

Pelicans are a charismatic group of eight species of large, almost cosmopolitan water birds (Kennedy *et al*. 2013) that go through enormous changes in size during development. Pelicans weigh ~100 g when they hatch and may grow to weigh over 10 kg during a three month period of development (Nelson 2005), a change of two orders of magnitude. After an incubation period of five weeks, pelican hatchlings are altricial and remain in the nest for ten to sixteen days. They then move away and join a crèche for ten to thirteen weeks, until they fledge (Nelson 2005). Metal leg bands placed on crèche-young and fledglings have provided valuable information on movements and mortality

patterns in pelicans after they have fledged and left a breeding colony (Schreiber and Mock 1988; Anderson and Anderson 2005; Johnston *et al*. 2015). However, leg bands suitable for adult pelicans were too large to be placed on nestlings, and so did not allow individuals to be monitored within a breeding colony during development. Metal leg bands also could not be seen on adults when they were courting or foraging in water. During a study of the breeding biology and behavioral ecology of Australian Pelicans *Pelecanus conspicillatus*, members of our field team developed techniques for field identification of individual pelicans as eggs, nestlings, crèche young and adults. Used sequentially, these techniques made it possible to identify and monitor a particular individual's development from laying to adulthood.

This paper describes techniques used to successfully mark Australian Pelicans for field recognition of individuals throughout their life. My aim is to: (1) describe the techniques so that they may be used and adapted by others in future studies of pelicans and other similar species, and (2) provide an assessment of their ability to provide useful information without compromising the bird's welfare or confounding the findings of research. The behaviour, growth, survival and movements of pelicans tagged using the techniques reported here will be the subject of separate papers.

METHODS

Study site

This study was done on an artificial island on Section Bank in the Barker Inlet-Port River estuary near Adelaide, South Australia (138°29'E, 34°47'S) (Johnston and Harbison 2005) from 1990 to 2011. The island was constructed in 1977 and pelicans were first recorded nesting there in 1986 (Vincent 1988). During the study, up to 1200 pairs of pelicans nested on the island annually and shared the island with breeding colonies of several other species of waterbirds (Johnston and Wiebkin 2008; Johnston, in press).

Australian Pelicans generally lay clutches of two eggs in nests on the ground (Vestjens 1977; Johnston 2016). At the Section Bank, nests were constructed, on average, approximately 1.2 m apart in spatially and temporally discrete colonies of about 40 nests during winter and spring (Johnston 2016).

Working in the pelican colony

Members of a field team of two to four people stayed close to each other and slowly approached pelican colonies. Adult pelicans attending nests were allowed clear passage to walk away from the colony in the opposite direction from which they were approached. Initially adult birds were clearly vigilant when approached from more than 100 m away. However, with a careful, very slow approach by exposed observers, the adults raised themselves from their nests and walked out of the colony, with minimal disturbance to eggs and nestlings. Care was taken to return back to their nest any eggs and chicks dislodged by adults, although this was rarely necessary. The colony could be entered and eggs and nestlings marked and measured, while adults stood as a flock ten to twenty metres away. When we left the colony, the adults quickly returned to their nests.

After a week or so of repeated daily visits, the adult pelicans had become noticeably calmer in response to our visits. They would wait until the field team was within five metres of nests before moving away, and appeared hesitant to leave. Making a very slow approach and maintaining a clear passage for adults to walk away from the colony remained important to minimise disturbance of breeding birds and their young.

During particularly intense periods of daily visitation over several weeks, many adult pelicans became so used to us that they simply did not move away from their nest when we approached. This required the field team to wear protective clothing to avoid serious wounds being inflicted by the sharp edges and tip of the adult pelicans' bills. Particularly 'recalcitrant' adult birds were captured by grabbing them by the base of the bill with a gloved hand. The captured pelican was taken beyond the edge of the colony to avoid disturbing other nesting birds. There it was wing-tagged and measured and a blood sample was taken before it was released. Captured birds returned to the nest within a few minutes of being released. Once two or three adults had been captured in a colony, other adults in that colony remained (just) out of reach. Once this situation had been achieved it was possible to work in a colony with adult pelicans attending eggs and nestlings within two metres of a field worker. Once eggs and nestlings had been marked and measured, the attending adults would return to the nest within a few minutes.

Pelicans in each new study colony became habituated to field workers within a few days as the field study progressed. However, on occasions members of the public and/or their pet dogs were seen entering colonies. This resulted in swift, chaotic retreat by adult pelicans, and many eggs and nestlings being flung out of nests. One pelican colony was abandoned after members of the public carried canoes through the colony, apparently oblivious to the mayhem they were causing (Johnston unpub. data).

Crèche-young were captured using methods outlined elsewhere (Waterman and Read 1992; Johnston *et al*. 2015). Briefly, when crèche-young were away from any active breeding colonies, large groups were rounded-up by a field team and slowly walked into a corral. Small groups were hand-captured and placed in a field pen. Our field pen was a folding wooden child's play pen with the base removed. It was placed upside down on the ground, with legs pointing upwards, so that crèche-young could be put on the ground inside it. The birds were then tagged quickly and released. Within minutes of being tagged, they aggregated into their crèche group 5-10 m from the tagging station. Newly marked young pelicans continued to join the crèche group as they were released.

Marking eggs

Eggs were marked with a variety of black, non-toxic, water proof, felt-tipped pens (brands: Sharpie, Staedler, Artline, Pentel™). Each egg was identified using a two-line code (Figure 1a). The first line indicated the colony and nest in which the egg was located and had an individual identifier to distinguish eggs within each clutch. The second line indicated the date on which the egg was first found. Eggs were picked up carefully while kneeling or squatting next to a nest. Particular care was taken to

avoid spinning or swivelling eggs, which may have disrupted embryonic membranes.

Individual colonies were identified by sequential letters in the alphabet, corresponding to the temporal order in which colonies were established at the study site. Colony labels were reset to 'A' at the beginning of each calendar year. Nests within a colony were given a sequential number reflecting the order in which they were found. The individual identifier consisted of a letter code if the laying order of the eggs was unknown, i.e. if two eggs were present when the nest was initially found. Eggs were individually identified with a number (usually 1 or 2) indicating the laying order, where this was known, i.e. if one egg was present when the nest was initially found and one or more other eggs were found in the nest subsequently.

Marking nestlings

Nestlings were individually marked with either masking tape tags (n = 174) in 2001 and 2002 or "velcro" tags (n = 102) in 2003. Masking tape tags were made from a roll of 20 mm wide pale tan masking tape (brands: 3M, Accent, Bear™). Each tag was made from an 80-100 mm length of tape folded in half lengthwise (Figures 1c and 2a). This length was varied according to the size of the nestling. The folded length of tape was wrapped around the humerus of a nestling pelican and the ends were stapled (brands: Staedler, Rexel™) together so that the band was loose enough to allow for growth, but could not fall off. An individual code was written on the tag using a felt-tipped pen. Tags were replaced as the nestling grew and/or as the tags became too soiled for the code to be read. This was necessary every one to three days, depending on the age and growth rate of the nestlings.

"Velcro" tags (Figures 1d and 2b) were made from white, flexible, 20 mm wide hook-and-loop tape (http://www.lincraft.com.au, viewed 19 September 2015). This was cut down the center lengthwise to create 10 mm wide strips, which were then cut into 25 to 50 mm lengths. This length was varied according to the size of the nestling. The paired hook-and-loop sections were sewn together at one end with the hook surfaces facing each other, so that they could be attached to a nestling pelican by being wrapped around the humerus or femur. An individual code was written on the tag using a felt-tipped pen. Tags were replaced as they became too soiled for the code to be read, but could be adjusted as the nestling grew. As with masking tape tags, adjustment was necessary every one to three days, depending on the age and growth rate of the nestlings. "Velcro" tags could be reused after being soaked in alcohol to remove the labeling and washed in soapy water. For both types of nestling tag, we used the same individual code as for the egg from which the nestling hatched.

Figure 1. *Five methods used to mark Australian Pelicans for individual recognition in the field: (a) felt-tipped pen marking on eggs, (b) an Allflex cattle ear tag used as a patagial tag for crèche-young and adults (c) a masking tape wing tag used for nestlings, (d) a "velcro" wing or leg tag used for nestlings and crèche young, and (e) a butt-ended, stainless steel leg band. Scale bar = 50 mm.*

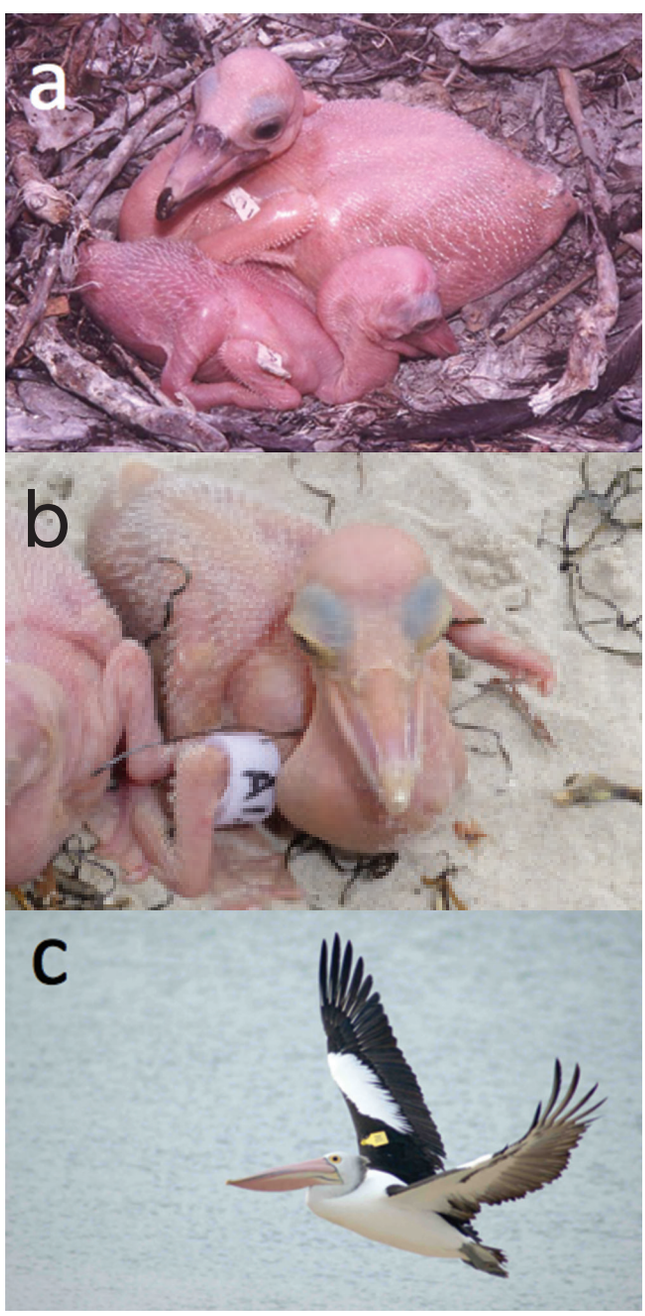

Figure 2. *Masking tape wing tags (a) and a "velcro" wing tag (b) on nestling Australian Pelican, and an Allflex cattle ear tag used as a patagial tag (c) on an adult in the field.*

Plastic, wrap-on, coloured leg bands designed for marking domestic pigeons (8 mm diameter) and small chickens (13 mm diameter) (http://store.incubatorsandmore.com.au/, viewed 19 September 2015) were trialed on 30 nestling pelicans in 2003. These were always found in the nest during the visit after their application, having fallen from the bird, and were quickly abandoned as a method for marking nestlings.

Marking crèche-young and adults

Size 17 series, butt-ended, stainless steel leg bands were kindly supplied by the Australian Bird and Bat Banding Scheme (ABBBS) (Figure 1e). Each band was individually embossed with a unique number and the contact details of the ABBBS. These bands were applied to a total of 621 crèche-young Australian Pelicans over two time periods. During the first period (12 July 1990 to 19 September 1992) 310 crèche-young were leg-banded. Movements and mortality data derived from these and other leg banding have been reported by Johnston *et al*. (2015). In the present paper, these data are used solely to compare the utility of metal leg bands, and other forms of marking for individual recognition.

A second lot of leg bands were applied to 311 crèche-young and adult Australian Pelicans when they were wing-tagged between 30 July 2002 and 31 December 2003. The presence of wing-tags on these birds allowed us to test the hypothesis that butt-ended, stainless steel leg bands dislodge from banded birds (see Waterman *et al*. 2014).

Allflex super maxi cattle ear tags (http://www.allflex.com.au, viewed 24 June 2015) (Figures 1b and 2c) were applied to the patagium of crèche-young (n = 316) and adult (n = 22) pelicans from 30 July 2002 to 31 December 2003. Each tag consisted of a 'female' tag measuring 121 mm x 76 mm held in place by a 29 mm diameter 'male' button applied using an Allflex universal applicator. Tags weighed 15 g, which equated to 0.8% of the weight of a small 2 kg crèche-young pelican or 0.15% of the weight of a large 10 kg male pelican. These tags were yellow, with 30 mm high and 15 mm wide black numbers laser-printed on them to allow identification of individual pelicans from a distance. Each tag also had the words "Adelaide Zoo" printed below the number to encourage members of the public who saw a tagged pelican to report their observation via a dedicated website administered up until 2014 by the Royal Zoological Society of South Australia. Since then observations have been reported directly to the author or through the ABBBS.

Data analysis

Re-sighting frequencies were recorded from field observations made at the study site by the research team, or by members of the public from further afield. Distances between sighting and re-sighting locations were calculated from Google Earth (https://earth.google.com/, viewed 19 September 2015). Descriptive statistics were given as mean ± standard deviation and were calculated using the statistical package SPSS v20.

RESULTS

Eggs

In 2002, 1482 eggs were laid in 741 nests from February to October. These nests were distributed among twenty nesting colonies. Each colony contained up to 148 nests (mean = 37.1 ± 38.4). In 2003, 1626 eggs were laid in 856 nests from June to October. These nests were distributed among sixteen nesting colonies, each of which contained 13 to 127 nests (mean = 53.5 ± 39.9).

All of the 3108 individually marked eggs were located again at least once (Table 1), and most were located multiple times. Marking individual eggs allowed an assessment of hatching success, and provided incidental observations of egg predation and adoption of eggs that had rolled from neighbouring nests (Johnston in 2016).

Various brands of felt-tipped pens were used during the study (see Methods). At an average cost of $AU 0.02 per egg, all could be relied upon to mark 200+ individual eggs, so long as the eggs were dry. If eggs were wet due to rain or condensation, it was not possible to write on them with felt-tipped pens due to the eggs' soft, chalky surface. Wet eggs were not marked until they were found dry on a subsequent visit to the colony.

Nestlings

All 174 nestlings marked with a masking tape wing tag as hatchlings were re-sighted again during the ensuing 10 days while they were restricted to the nest (Table 1). Similarly, all 102 nestlings marked with a "velcro" wing tag as hatchlings were re-sighted while they were restricted to the nest (Table 1).

Masking tape tags could be made at a cost of $AU 0.02 each, but took around 60 seconds to apply in the field and needed to be replaced every one to three days as nestlings grew. Using them involved spending a considerable time in a pelican colony to mark even a modest number of nestlings. "Velcro" tags could be made at a cost of $AU 0.10 each. They had the advantages over masking tape tags that they were quicker to apply (< 15 s) initially in the field, and could be quickly (~5 s) adjusted for reuse in the field as nestlings grew. "Velcro" tags could also be washed and reused on several different nestlings during a prolonged study.

Crèche-young and adults

All 22 patagial tags applied to adult Australian Pelicans were re-sighted on birds which returned to their nest after being tagged (Table 1). One hundred and ninety two of the 316 wing tags (60.8%) applied to crèche-young over the same period were re-sighted after the young had fledged (Table 1). The maximum number of sightings for a wing-tagged pelican was thirty. The longest period over which a pelican was known to carry a wing tag was eight years and seven months for a bird wing-tagged as a crèche-young on 28th November 2002; this bird was re-sighted five times until 15 June 2011, when it was found dead ten kilometers south-east of where it had been tagged. The longest distance travelled by a wing-tagged pelican was 1616 kilometers by a bird wing-tagged as a crèche-young on 10 October 2002; this individual was re-sighted twice before it was found dead 3 years and 11 months later on 12 September 2005 at Gayndah on the Burnett River in Queensland (25°37'22" S; 151°36'38" E). At the time of the study, laser printed Allflex wing tags could be purchased at a cost of $AU 4.50 each and required a universal applicator to attach them ($AU 50.00 each).

Butt-ended, stainless steel leg bands were also placed on 311 of the 338 wing-tagged pelicans between 2002 and 2003.

Table 1

Recovery rates % for five different kinds of tags used on Australian Pelicans.

Tag type	Life stage	No. tagged	No. re-sighted	Recovery rate %
Felt-tipped pen markings	eggs	3108	3108	100
Leg bands[1]	adults	310	4	1.3
Masking tape	nestlings	174	174	100
Velcro	nestlings	102	102	100
Patagial tags	crèche-young	316	192[2]	60.8
Patagial tags	adults	22	22	100

[1] Data from Johnston, Waterman and Manning (2015)
[2] Recoveries made after the tagged crèche-young had fledged.

Twenty-two of the leg bands (22/311 = 7%) dislodged from these pelicans during the study.

DISCUSSION

The high resighting rates of marked individuals demonstrated the utility of the marking methods reported here for individually identifying Australian Pelicans in the field. Used sequentially, these techniques made it possible to identify and monitor individual pelicans from laying to adulthood. The methods used to mark eggs and nestlings provided a reliable means of identifying individuals for a range of studies conducted at pelican breeding colonies. Marking fledgling and adult pelicans with patagial tags also provided a significantly higher 'recovery' rate away from the breeding colony than did traditional metal leg bands. Sighting patagial tags on adults in a breeding colony or elsewhere was considerably easier than sighting metal leg bands, and permitted relatively easy identification of individual adult pelicans.

It is important to note that the various techniques for marking Australian Pelicans reported here were not trialled simultaneously, so differences in recovery rates between the techniques are temporally confounded. Whilst a study properly designed a priori could take this into account, the problem was unavoidable in the present investigation. For this reason, formal statistical comparison of recovery frequencies was not attempted. I have described the techniques so that they may be used and adapted by others in future studies of pelicans and other similar species. The results provide a pragmatic assessment of which techniques are the most cost-effective and have the greatest capacity to provide useful information, while minimizing the impacts on the birds being studied.

Felt-tipped pens have been used to mark eggs in agriculture, aviculture and field ornithology for some time (e.g. Anderson 1990). Although pens were used that were specifically labeled non-toxic, this presumably refers to humans, and it remains possible that ink or solvent from them could have been toxic to avian embryos. However, inspection of the inside of many hundreds of hatched and failed pelican eggs showed that ink did not penetrate the egg shell matrix or pores (Johnston unpub. data). Volatile solvents from the pens evaporated within seconds of marking the eggs and are unlikely to have entered the eggs and affected embryos. Many thousands of marked eggs hatched successfully during this study. Thus it was unlikely, and no evidence was found, that marking eggs influenced the health of embryos or the likelihood of hatching.

Masking tape and "velcro" tags were used to permit objective recognition of individual pelican nestlings. This was an important component of the research program, which focused on aspects of sibling rivalry and brood reduction (see Mock *et al*. 1990). Other studies of sibling rivalry in nestling birds have used differently coloured paints to mark individuals (e.g. Ploger 1997). Paints were tried in the early stages of the present study, but were inconvenient to use in the field, required too much time and so disturbed natural behaviour in the breeding colony, and needed to be re-applied frequently (Johnston unpub. data). Masking tape tags were used initially, but were later replaced by "velcro" tags, which were quicker to apply and adjust. This change was made so that we could spend less time in the pelican colony disturbing the birds. We saw no sign that nestling pelicans changed their behaviour in response to having either masking tape or "velcro" wing tags placed on them. The tags did not create abrasions on the nestlings' skin or developing down. On no occasion did a pelican chick show any outward signs of responding to a tag; nestlings were not observed to peck at a tag. "Velcro" wing tags provided a cheap, convenient method for marking nestling pelicans which did not appear to influence the natural behaviour of the nestlings. For studies where daily visits to breeding colonies (necessary to adjust wing tags as nestlings grew) were not possible, foot web punching might offer an alternative method for tagging pelican nestlings, but raises welfare issues.

Various kinds of patagial tags have been used to study a number of bird species (Anderson 1963; Marion and Shamis 1977; Sweeney *et al*. 1985; Pineau *et al*. 1992; Trefry *et al*. 2013). Commercially available cattle ear tags have been applied successfully to new world vultures and Australian White Ibis *Threskiornis molucca* (Wallace *et al*. 1980; Sweeney *et al*. 1985; Martin and Major 2010). However, they are not suitable for smaller birds e.g. Torresian Crows *Corvus orru* (D. Drynan pers. comm. 2015). These tags are available in a range of colours and sizes and there

are a number of ready options for individually marking the tags that may be prescribed by the user. Cattle ear tags are also inexpensive, lightweight, and simple and quick to attach.

Whilst tag loss and fading has been reported for other patagial tags (Maddock and Geering 1994; Buckley 1998), we did not observe any loss or fading of cattle tags during the present study, even though some tagged birds have been at large for over a decade at the time of writing. Cattle tags are known to last up to 20 years (Wallace *et al*. 1980), providing the level of permanency required of a tag for long-lived birds such as pelicans. Australian Pelicans have been recorded living for at least 15 years in the field (Johnston *et al*. 2015). On occasion, the complete identification of patagial tags on fledglings and adults was hampered by feathers covering part or all of the tag. However, tags generally became readable when the bird adjusted its wings (i.e. preened or flapped). From our observations, size-14 cattle tags allowed visual re-sightings at considerable distances with binoculars (~100 m) or spotting scopes (~200 m).

We recorded no adverse effects of patagial tagging. Pelicans usually, but not always, flinched at the moment when the patagium was punched, but otherwise showed no behavioural changes. Traces of blood from minor veins were apparent on one of the 338 pelicans wing-tagged as part of this study. However, there was not sufficient blood to warrant the application of a swab, and bleeding stopped within a few seconds. No bleeding was apparent in any other pelicans in response to application of patagial tags. All pelicans engaged in normal behaviours after application of a patagial tag. Crèche-young joined with other crèche members, and successfully begged for food from their parents. Adults attended nests and young, and undertook foraging flights away from the breeding colony. The patagium generally heals quickly after tagging, with negligible abrasion or wear (Southern 1971; Wallace *et al*. 1980; Sweeney *et al*. 1985; Martin and Major 2010), as was the case for Australian Pelicans in the present study. The much lower re-sighting rate for patagial tags on crèche young than for those on adults reflects the expected higher mortality among young birds, rather than any negative effect of the tags. This was clear from inspection of tagged birds that had died at the study site before fledging. Although death by entanglement of a patagial tag has been reported in an American White Pelican *Pelecanus erythrorynchos* (Chapman and Chapman 1990), there was no indication that any injuries or deaths occurred as a result of patagial tags during our study. The stiff plastic and rounded-edge design of the cattle tags makes entanglement very unlikely.

The patagial tags used here could be applied more quickly than leg bands, resulting in shorter handling periods and reduced opportunity for capture-related stress. Applying coloured leg-bands to pelicans was not considered a viable option for marking crèche-young or adults for this reason. Multiple leg bands were also discounted as an option for this study because the pelicans at our study site nest among twiggy *Nitraria billardierei* and *Lycium ferocissimum* bushes, which present a likely entanglement risk. Young pelicans with metal leg bands were seen temporarily entangled in vegetation, but were generally able to free themselves (Johnston unpub. data). Moreover, metal leg bands did not permit ready identification of individual wild pelicans that was required for our behavioural and ecological research.

This study permitted an incidental test of the hypothesis that leg bands being used by the ABBBS prior to 2008 were becoming dislodged from Australian Pelicans. This suggestion was made because butt-ended, stainless steel bands, which relied on tensile strength to keep them attached to a bird's leg, had a high incidence of being recovered unattached to a pelican within a year of deployment (Waterman *et al*. 2014). In the present study, seven percent of the 311 pelicans simultaneously marked with leg bands and patagial tags lost their leg bands, thus confirming Waterman *et al*.'s (2014) suggestion. Since 2008, the ABBBS has provided different, side-opening, stainless steel bands for Australian Pelicans, which appear to have solved this problem (D. Drynan pers. comm. 2015). This paper describes methods for tagging pelicans in the field for behavioural and ecological studies which require reliable and repeated recognition of individual birds without the need for recapture (patagial tags). This should not be taken to imply that these methods should replace the existing leg banding program administered by ABBBS. Indeed, the hard-won leg band data available through the ABBBS are invaluable, and often provide the only available source of information on the movements and longevity in the field for many Australian birds.

Visits to water bird colonies can influence the birds' behaviour, survival and breeding success, and may affect the results of scientific studies (Nisbet 2000; Beale and Monaghan 2004; Carey 2011). Disturbance by humans is known to have influenced breeding success in pelicans (Bunnell *et al*. 1981; Catsadorakis *et al*. 1996). Although they can habituate to humans quickly, nesting pelicans have been shown to exhibit behavioral changes in response to human approach (Barter *et al*. 2008). For these reasons, we made considerable effort to minimize our influence on breeding pelicans, and could find no negative effect of our visits on breeding success (Johnston in press).

Whilst there is always the potential for tagging studies to compromise an animal's welfare, there was no evidence that this occurred in the short-term for any of the marking techniques we used. Further tests are required to determine whether they result in any long-term costs in terms of survival or reproductive success. The methods outlined in this paper greatly assisted our studies of Australian Pelican ecology and behaviour by providing practical, cost-effective and seemingly safe methods for recognizing individual pelicans in the field.

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