From field to museum tray: shrinking of the Mallard *Anas platyrhynchos*

MURRAY WILLIAMS

68 Wellington Road, Paekakariki 5034, New Zealand.
E-mail: murraywilliamsnz@outlook.com

Abstract

Four commonly-recorded body measurements were collected from fresh specimens of Mallard *Anas platyrhynchos* and of captive-raised Mallard × Grey Duck *A. superciliosa* hybrids, and the same specimens were measured again 25+ years later to determine the extent of tissue shrinkage. There was little shrinkage in bill length but average shrinkage in bill widths, tarsus lengths and wing lengths were between 3.0–4.7%, with changes in bill width and tarsus length being the most variable and extreme. Correction values to allow the combining of field and museum specimen measurements are provided.

Key words: Anatidae, *Anas platyrhynchos,* Mallard, measurements, specimen shrinkage.

Avian biometric data, whether from field or museum specimens, or both, have assisted studies seeking, for example, sex and age discrimination (*e.g.* Ó hUallacháin & Dunne 2010), population or taxonomic differentiation (*e.g.* Weidinger & van Franeker 1998; Robertson & Wareham 1994), evaluations of environmental responses (*e.g.* Gardner *et al.* 2009), and detection of latitudinal influences in avian body size (*e.g.* Engelmoer & Roselaar 1998; Graves 1991). However, detecting small differences in measurements can be corrupted by the shrinking of tissues as fresh specimens dry during the preservation process, especially of those body parts where the bone is overlain by flesh or connective tissue not removed when the specimen is prepared. Thus, the mixing of measurements from fresh or field specimens with those from dried museum specimens is problematic unless this shrinkage can be accounted for.

Several studies have identified the extent of tissue shrinkage that affects the commonly-taken measurements of bill, legs, wing and tail, for example Kinsky & Harper (1968) in prions *Pachyptila* sp., Harris (1980) and Ewins (1985) in Puffins *Fratercula arctica* and Black Guillemots *Cepphus grylle* respectively, Fjeldså (1980) in grebes *Podiceps* sp., Jenni & Winkler (1979) and Winker (1993) for passerines and Greenwood (1979), Green (1980) and Engelmoer *et al.* (1983) in small waders (Charadriiformes). These studies identified a considerable variability in the extent of shrinkage in individuals of the same species and highlighted the need for

mean shrinkage estimates to be determined from substantial sample sizes. Collectively, they also suggest that the extent of shrinkage may differ between species within avian families but may be more consistent across species of similar size.

Wilson & McCracken (2008) provided correction values for measurements from specimen skins of a small (350–550 g) duck, Cinnamon Teal *Anas cyanoptera*, for comparing them with measurements obtained from live birds. This appears to be the only such assessment for Anseriformes despite some published compilations of waterfowl measurements, either freely combining field and museum measurements (*e.g.* some species accounts in Kear 2005) or, more rarely, listing both side by side (*e.g.* Marchant & Higgins 1990). I therefore assessed tissue shrinkage for larger (900–1,300 g) ducks by comparing fresh and dry lengths for wings of wild Mallard *Anas platyrhynchos*, and for bill and tarsus measurements taken from captive-raised Mallard × Grey Duck *Anas superciliosa* hybrids.

Methods

Source of specimens

Wings were obtained from wild Mallards shot by New Zealand hunters in May 1991. After collection, the sex of the bird was determined from the wing samples, according to whether the white bar anterior to the speculum extended onto the greater tertial coverts (females) or not (males; Carney 1992), but were not aged. The wings were measured by the author, muscle tissue between the ulna and radius was then removed and each wing attached to a cardboard backing sheet and air-dried. These wings were lodged in Museum of New Zealand Te Papa Tongarewa, Wellington as specimen numbers OR028752–OR028908 where 95 (48 females, 47 males) were re-measured 25 years later, again by the author.

Mallard × Grey Duck hybrids were bred in captivity 1967–1972 at Mt Bruce Native Bird Reserve near Masterton, New Zealand. Freshly-killed specimens were sexed by cloacal examination (Mosby 1963), weighed, measured (as below), prepared as specimen skins or pelts, and subsequently air-dried. A representative selection of F1, F2 and F3 hybrids was lodged in Museum of New Zealand Te Papa Tongarewa, Wellington as specimen numbers OR027923–31 and OR028494–568, where 60 specimens (30 females, 30 males) were re-measured by the author in 2016–17.

Mean weights (g) in May of wild Mallard in New Zealand are: males = 1,193 ± s.d. 104, n = 593; females = 1,075 ± s.d. 105, n = 336 (M. Williams, unpubl. data) and mean weights (g) in May of Grey Duck in New Zealand are: males = 1,054 ± s.d. 92, n = 234; females = 934 ± s.d. 84, n = 177 (Williams 2017). Mean weights (g) of the studied hybrids at death (mostly in May and August) were: males = 1,133 ± s.d. 141, n = 30; females = 1,041 ± s.d. 116, n = 30.

Measurement procedure

Wings of wild Mallard were measured while fresh (to nearest 1 mm) following Baldwin *et al.* (1931), as reported by Gurr (1947), using a steel ruler, and re-measurement was done the same way.

Measurements from freshly-killed Mallard × Grey Duck hybrids were of bill length (exposed culmen), bill width and tarsus length, all measured to 0.1 mm using a Vernier calliper. Bill and tarsus length measurements followed Baldwin *et al.* (1931), as reported by Gurr (1947), and bill width was measured at the gape, immediately below the culmen's proximal point of measurement. Re-measurement was conducted in the same way.

A paired *t*-test was used to compare differences between fresh and dry measurements. Pearson correlation values were used to examine the relationship between body mass and the percent shrinkage of bill and tarsus measurements.

Results

Significant reductions in wing and tarsus lengths, and also in bill widths, occurred after drying whereas bill lengths were little changed (Table 1).

Although the lengths of three dried wings were measured as being longer than when fresh (two by 1 mm; one by 2 mm), and a fourth wing was recorded as being unchanged, lengths of the remaining 91

Table 1. Mean (± s.d.) fresh and dry wing lengths (mm) of Mallards, and bill lengths, bill widths and tarsus lengths (mm) of Mallard × Grey Duck hybrids, with results of *t*-tests (analysing differences between the fresh and dry measurements), the percent shrinkage of the tissue, and correction values for converting dry measurements to fresh measurements. *** = $P < 0.0001$.

	n	Fresh (mm) mean ± s.d.	Dry (mm) mean ± s.d.	*t*	% Shrinkage mean ± s.d.	Correction factor ± 95% C.I.
Wing length						
Males	47	277.5 ± 11.2	269.2 ± 10.3	9.92***	3.0 ± 2.0	1.031 ± 0.006
Females	48	264.5 ± 9.6	256.0 ± 8.6	13.29***	3.2 ± 1.6	1.034 ± 0.006
Tarsus length						
Males	30	48.8 ± 1.6	47.3 ± 1.5	6.35***	3.0 ± 2.5	1.032 ± 0.010
Females	30	46.2 ± 1.9	44.5 ± 1.7	7.04***	3.6 ± 2.6	1.038 ± 0.010
Bill width						
Males	30	21.6 ± 0.9	20.6 ± 1.4	5.88***	4.7 ± 4.7	1.052 ± 0.018
Females	30	20.6 ± 0.8	19.8 ± 1.2	4.58***	3.8 ± 4.4	1.042 ± 0.017
Bill length						
Males	30	54.3 ± 2.7	54.6 ± 3.0	1.48	–0.5 ± 2.0	0.995 ± 0.007
Females	30	51.7 ± 2.5	51.9 ± 2.3	1.38	–0.5 ± 1.8	0.996 ± 0.006

dried wings were significantly shorter than their corresponding fresh measurement (by 1–19 mm, mean = 8.8 mm; t_{90} = 17.55, $P < 0.0001$).

The average percentage change in tarsus length following drying was similar to that of wing length, but more variable, as indicated by the larger s.d. (Table 1) and the range of the changes from an increase of 4.1% to a reduction of 9.9%. Five (8.3%) tarsus lengths increased after drying.

Changes in bill widths were the most extreme of all characters measured, and the most variable. In 11 (18%) of the specimens, shrinkage was > 8% (maximum 13.5%). Of 13 (22%) specimens having increased bill widths after drying, eight had extended by < 1% (overall maximum 3.7%).

The mean length of dried bills differed from that of fresh bills by 0.3 mm (0.5%), and had marginally increased rather than decreased in length. Whereas 42% of the dried bills measured were shorter than when fresh (mean = 0.7 mm, range = 0.1–2.0 mm) those longer were by an average 0.9 mm (range = 0.1–2.8 mm). Differences between the fresh and dry bill length measures however were not statistically significant (males: t_{29} = 1.48, P = 0.15, n.s.; females: t_{29} = 1.38, P = 0.18, n.s.; Table 1).

For none of the four characters measured was there a significant difference between males and females in the extent of tissue change on drying the specimens (wing length: t_{93} = 0.64, n.s.; tarsus length: t_{58} = 0.91, n.s.; bill width: t_{58} = 0.81, n.s.; bill length: t_{58} = 0.10, n.s.). Percentage reductions in tarsus and bill lengths, and in bill width, were not related to body mass (Pearson correlation values, tarsus length: r_{58} = –0.193, n.s.; bill width: r_{58} = 0.226, n.s.; bill length: r_{58} = 0.027, n.s.).

Correction values (± 95% C.I.) for converting dry measurements to fresh measurements, and derived from combining male and female measurements for each character, are: wing length = 1.032 (± 0.004); tarsus length = 1.034 (± 0.007); bill width = 1.047 (± 0.050); and bill length = 0.995 (± 0.005).

Discussion

Reduction in wing, bill and tarsus lengths following specimen preparation and drying is now a well-recognised phenomenon (*e.g.* Table 2 for wing length measures), matched also with the realisation that repeat measurements by the same measurer, or measurements made by different measurers, are variable (*e.g.* Nisbet *et al.* 1970; Ewins 1985; Barrett *et al.* 1989). Both can produce confounded interpretations when attempting to discriminate small measurement differences. Herremans (1985) has suggested that, where tissue shrinkage or measurement variability is small, the range of normal variation within a population may be sufficient to buffer these effects and allow the combining of fresh and specimen measurements for most purposes. This perspective of convenience, nevertheless, ignores that real differences were detected.

In this study of large ducks, shrinkage significantly affected wing and tarsus lengths, and bill width at the gape, but not bill length. Compared to the shrinkage recorded for the smaller Cinnamon Teal (Wilson & McCracken 2008), mean wing length shrinkage was approximately 50%

Table 2. Examples of shrinkage in wing length on dried specimens of various species. Species weights (g) from Dunning (2007).

Species		Mean weight	Mean wing length (mm)	% Shrinkage mean ± s.d.	Source
Mallard	*Anas platyrhynchos*	1080	271	3.1 ± 1.8	This study
Cinnamon Teal	*Anas cyanoptera*	383 (♂)	194	2.12 ± 2.24	Wilson & McCracken 2008
		372 (♀)	189	2.17 ± 1.99	
Oystercatcher	*Haemantopus ostralegus*	526	~260	2.7 ± 0.9	Engelmoer *et al.* 1983
Horned Grebe	*Podiceps auritalis*	453	140	1.02	Fjeldså 1980
Rook	*Corvus frugilegus*	450	308	1.24	Knox 1980
Puffin	*Fratercula arctica*	381	157	1.10	Harris 1980
Black Guillemot	*Cepphus grylle*	378	162	1.55	Ewins 1985
Dunlin	*Chalidris alpina*	56	114	1.8 ± 0.9	Engelmoer *et al.* 1983
Tennessee Warbler	*Vermivora peregrina*	8.9	62	1.44	Winker 1993

greater and more consistent across the specimens sampled. Tarsus shrinkage was similar however (3.4–3.9% in Cinnamon Teal; 3.6% in this study). Mean bill length (of exposed culmen) shrank by *c.* 1.1% in the teal, but was less than half of that for the larger ducks in this study and with slightly less variability.

Bill width (at gape) and tarsus length are two measurements that are problematic on dry specimens (*e.g.* Kinsky & Harper 1968; Fjeldså 1980). Distortion during the drying process of the flaccid bill flap and, especially, of the thick leg skin in the notch between femur and tarsus, make both measurements variable and poor indicators of the measurements from live specimens. Not surprisingly, both characters returned the most extreme and the most variable measurements from the dried specimens, as they did from the Cinnamon Teal (Wilson & McCracken 2008) where bill width measurement was taken below the nares.

It was pointed out in review that the correction values for converting dry measurements to fresh measurements are, themselves, only estimates, and that their application to small numbers of specimens and when seeking to correct for small measurement changes, may introduce additional bias. Confidence intervals, if provided with the correction values, may indicate the possible magnitude of any such bias. In addition, correction for small measurement changes can also be compromised by the generally undeclared variation in measurement consistency within or between measurers (Barrett *et al.* 1989).

The results of this study are from the largest waterfowl yet studied, and perhaps from the largest bird yet reported upon. Wing shrinkage recorded for 350–500 g birds (Table 2) appears to be unrelated to body size. However, more examples of specimen shrinkage from a diverse range of species may suggest otherwise. In the meantime, species-specific assessments are still required to allow combined use of measurements from live and dried museum specimens.

Acknowledgements

I acknowledge with gratitude the workspace and library access provided by the School of Biological Sciences, Victoria University of Wellington, New Zealand, and I thank Colin Miskelly, curator of birds at Museum of New Zealand Te Papa Tongarewa for access to specimen skins. I am also grateful to Jeremy Greenwood and an anonymous referee, for the perspectives offered and the discipline demanded.

References

Baldwin, S.P., Oberholser, H.C. & Worley, L.G. 1931. Measurements of birds. *Scientific Publications of the Cleveland Museum of Natural History* 2: 1–165.

Barrett, R.T, Peterz, M., Furness, R.W. & Durinck, J. 1989. The variability of biometric measurements, *Ringing & Migration* 10: 13–16.

Carney, S.M. 1992. *Species, Age and Sex Identification of Ducks using Wing Plumage*. US Department of Interior, US Fish & Wildlife Service, Washington D.C., USA.

Dunning, J.B. 2007. *Handbook of Avian Body Masses. Second Edition*. CRC Press, Florida, USA.

Engelmoer, M. & Roselaar, K. 1998. *Geographic Variation in Waders*. Springer, Dordrecht, The Netherlands.

Engelmoer, M., Roselaar, K., Boere, G.C. & Nieboer, E. 1983. Post-mortem changes in measurements of some waders. *Ringing & Migration* 4: 245–248.

Ewins, P.J. 1985. Variation in Black Guillemot wing lengths post-mortem and between measurers. *Ringing & Migration* 6: 115–117.

Fjeldså, J. 1980. Post-mortem changes in measurements of grebes. *Bulletin of the British Ornithologist's Union* 100: 151–154.

Gardner, J.L., Heinsohn, R. & Joseph, L. 2009. Shifting latitudinal clines in avian body size correlate with global warming in Australian passerines. *Proceedings of the Royal Society, B.* doi:10.1098/rspb.2009.1011.

Graves, G.R. 1991. Bergmann's rule near the equator: Latitudinal clines in body size of an Andean passerine bird. *Proceedings of National Academy of Science USA* 88: 2322–2325.

Green, G.H. 1980. Decrease in wing length of skins of Ringed Plover and Dunlin. *Ringing & Migration* 3: 27–28.

Greenwood, J.G. 1979. Post-mortem shrinkage of Dunlin *Calidris alpina* skins. *Bulletin of the British Ornithologists Club* 99: 143–145.

Gurr, L. 1947. Measurements of birds. *New Zealand Bird Notes* 2: 57–61.

Harris, M.P. 1980. Post-mortem shrinkage of wing and bill of Puffins. *Ringing & Migration* 3: 60–61.

Herremans, M. 1985. Post-mortem changes in morphology and its relevance to biometrical studies. *Bulletin of the British Ornithologist's Club 105*: 89–91.

Jenni, L. & Winkler, R. 1989. The feather length of small passerines: a measurement for wing length in live birds and museum skins. *Bird Study* 36: 1–15.

Kear, J. (ed.). 2005. *Ducks, Geese and Swans of the World*. Oxford University Press, Oxford, UK.

Kinsky, F.C. & Harper P.C. 1968. Shrinkage of bill width in skins of some *Pachyptila* species. *Ibis* 110: 100–102.

Knox, A. 1980. Post-mortem changes in wing lengths and wing formulae. *Ringing & Migration* 3: 29–31.

Marchant, S. & Higgins, P. (eds). 1990. *Handbook of Australian, New Zealand and Antarctic Birds. Volume 1, Part B*. Oxford University Press, Melbourne, Australia.

Mosby, H.S. (ed.). 1963. *Wildlife Investigational Techniques. Second edition*. The Wildlife Society, Washington, USA.

Nisbet, I.C.T., Baird, J., Howard, D.V. & Anderson, K.S. 1970. Statistical comparison of wing lengths measured by four observers. *Bird Banding* 41: 307–308.

Ó hUallacháin, D. & Dunne, J. 2010. Analysis of biometric data to determine the sex of Woodpigeons *Columba palumbus*. *Ringing & Migration* 25: 29–32.

Robertson, C.J.R. & Wareham, J. 1994. Measurements of *Diomedia exulans antipodensis* and *D. e. gibsoni*. *Bulletin of the British Ornithologist's Club* 114: 132–134.

Weidinger, K. & van Franeker, J.A. 1998. Applicability of external measurements to sexing of the Cape Petrel *Daption capense* at within-pair, within-population and between-population scales. *Journal of Zoology* 245: 473–482.

Williams, M. 2017. Weights and measurements of *Anas superciliosa* in New Zealand. *Notornis* 64: 162–170.

Wilson, R.E. & McCracken, K.G. 2008. Specimen shrinkage in Cinnamon Teal. *The Wilson Journal of Ornithology* 120: 390–392.

Winker, K. 1993. Specimen shrinkage in Tennessee Warblers and "Traill's" Flycatchers. *Journal of Field Ornithology* 64: 331–336.

