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Aspects of the ecology and behaviour of White-winged Fairy-wrens on Barrow Island

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Abstract. We studied White-winged Fairy-wrens (*Malurus leucopterus edouardi*) on Barrow Island (20°43'S, 115°28'E) during September and October 1998. Birds were most abundant (occurring every 1–2 ha of habitat) on ridges in upland areas where *Triodia wiseana* was the dominant vegetation and was interspersed with open areas. They were less abundant in foredune areas and on red dunes, and were rare in other habitats. Males were significantly larger than females in most morphological measurements. Reproductive males (those with enlarged cloacal protuberances) had significantly shorter tails than non-reproductive males (individuals without cloacal protuberances). Group size averaged 2.4 individuals ($n = 9$; range 2–3) with six of nine groups consisting of just one male and one female. In one of nine groups, the only male present was a completely brown male. Sex ratio of adults in these nine groups was 0.83 (males/females). The display vocalisation was nearly identical in structure to that of birds on the mainland. Three nests were each approximately 0.5 m high in a shrub adjacent to a *Triodia angusta* plant. In most aspects of their behaviour and ecology, White-winged Fairy-wrens on Barrow Island appear to be almost identical to birds on the mainland.

Introduction

The White-winged Fairy-wren (*Malurus leucopterus*) is one of the most widely distributed species of fairy-wren, occurring throughout the drier regions of the Australian mainland and on two offshore islands in Western Australia. Three subspecies are recognised: *M. l. leucopterus*, on Dirk Hartog Island; *M. l. edouardi*, on Barrow Island; and *M. l. leuconotus*, on the mainland (Rowley and Russell 1997). Both island subspecies are similar in appearance, with nuptial males exhibiting black and white plumage, but are strikingly different from the blue and white mainland subspecies. This colour variation is both dramatic and important. Both Dirk Hartog and Barrow Islands are closer to the mainland (approximately 2 km and 56 km, respectively) than they are to each other (approximately 600 km). The islands were connected to each other and to the mainland during the last ice age 8000–10 000 years ago. It is not known whether the black plumage of the island subspecies evolved independently on both islands after separation from the mainland, or whether black plumage is the ancestral condition in the species, and blue plumage evolved on the mainland after separation (Ford 1987).

While the mainland subspecies has received considerable study (Tidemann 1980, 1983, 1989; Tidemann and Marples 1987; Rowley and Russell 1995), the two island subspecies are virtually unknown, with information from Barrow Island limited to observations during early collecting trips (Whitlock 1919; Serventy and Marshall 1964), and notes on

the breeding season (Ambrose and Murphy 1994) and on diet (Wooller and Calver 1981). In this study we quantified aspects of behaviour and ecology of White-winged Fairy-wrens on Barrow Island and, although our study was short term, these data represent the first quantitative description of social organisation and ecology of this important subspecies.

Study Area and Methods

Study area

Barrow Island (20°43'S, 115°28'E) is a continental island off shore from central Western Australia. It is 234 km² in size, 56 km from the mainland and approximately 1300 km north of Perth. The climate is tropical arid, with seasonally extremely high temperatures (>45°C), and sporadic and highly variable rainfall, averaging 330 mm, with peaks from March to May during the coastal cyclone season. There are six major land forms/vegetation units: foredunes (characterised by white sand), red dunes (red sand), ridges (limestone), pans (clay), creek beds (red earth), and mangrove areas (tidal muds) (Buckley 1983). *Triodia* hummock grassland is the dominant vegetation type and *Triodia* spp. occurs over 93% of the island. *T. wiseana* dominates the vegetation in the uplands, with *T. angusta* dominating in the lowlands.

A total of 110 bird species has been recorded on Barrow Island and 32 species are known to breed there; the three most common breeding bird species, in order of their relative abundance, are the Singing Honeyeater (*Lichenostoma virescens*), the White-winged Fairy-wren, and the Spinifexbird (*Eremiornis carteri*) (Sedgwick 1978).

General field methods

Fieldwork was conducted each day from 18 September to 6 October 1998. We surveyed all areas of the island accessible by road (virtually

the entire island) for the presence of fairy-wrens and we attempted to quantify group size and composition. We define a 'group' as a group of birds (male[s] and female[s] plus possible juveniles) residing together on a territory and that exhibit pair-bonded behaviour (adult males and females). This definition coincides with that of 'sub-group' in Rowley and Russell (1995) (see Discussion).

Mist nets were set up in 14 fairy-wren territories and all or some of the groups members were caught. When birds were captured, morphological measurements were taken, moult was scored, and blood samples collected. Cloacal protuberances and testes (of birds collected) were measured in three dimensions, and their volumes (V) calculated using the formula

$$V = (L) [(W/2) (D/2)],$$

where L = length, W = width, and D = depth (Briskie 1993; Mulder and Cockburn 1993; Tuttle *et al.* 1996).

Five adult females, five adult males in nuptial plumage, and five brown or brown and white males were collected for dissection, examination of reproductive organs, and preparation of study skins. The study skins and tissue samples from these birds were accessioned into the collection at the Western Australia Museum.

Determination of sex

The sex of adult birds was determined in the field by the presence of a brood patch (females) or a cloacal protuberance (males). Presence of white scapular feathers and secondary coverts is diagnostic for males, but, in all cases, males with white feathers also had cloacal protuberances. Some completely brown birds had neither brood patches nor cloacal protuberances. For most of these, blood samples were collected and subsequently used to determine sex in the laboratory via analysis of sex-specific CHD genes (Griffiths *et al.* 1998). Briefly, a pair of primers (P2 and P8: Griffiths *et al.* 1998) were used in a polymerase chain reaction (PCR) to amplify sex-specific DNA fragments from the W and Z chromosomes. PCR products were run out on a 1.5% agarose gel at 105 V for 1 h. In fairy-wrens, this process produces a single band of approximately 375 base pairs in males, and two bands of approximately 350 and 375 base pairs in females. We used DNA samples from the individuals collected (and dissected) to confirm the accuracy of the DNA sexing technique applied to other individuals.

We refer to juveniles as individuals in brown plumage that showed no external sign of age or sex (brood patch, cloacal protuberance, wing and tail moult). On the basis of laboratory analysis of DNA, we determined that such individuals included both males and females. In all other studies of White-winged Fairy-wrens (Tidemann 1989; Rowley and Russell 1995; Pruett-Jones, unpublished data) males at least one year of age retained brown plumage but had an enlarged cloacal protuberance during the breeding season. We believe that the juveniles we captured resulted from breeding efforts in 1998 prior to the onset of our fieldwork. White-winged Fairy-wrens can breed on Barrow Island as early as May after cyclonic summer rains (Ambrose and Murphy 1994).

Nest watches

We observed one nest each morning during 3–5 October and quantified feeding visits to the nest by each member of the group. This group consisted of one brown male and two females (which were marked for individual identification). The plumage of the male was entirely brown (female-like) except for several dark feathers on its back and 1–2 white scapular feathers. Observations through binoculars were conducted from a car approximately 30 m from the nest between 0630 and 0830 each morning, for a total of 5 h. The weather each day was hot (approximately 35°C), clear, and windy.

Vocalisations

Several vocalisations were recorded in the field using a Sony digital audio tape-corder (Model TCD-D8) and a Sennheiser directional shotgun microphone (ME 66) with a foam windscreen. Vocalisations were recorded on 5 and 6 October from unidentified (unsexed) individuals during the pre-dawn chorus, generally within 20 m. Spectrograms were made from the digital recordings using Canary software (Cornell Laboratory of Bioacoustics).

Results

Morphology

We netted 33 individuals whose sex was determined either in the field or through DNA analysis: 22 males and 11 females. Reproductive males (males that had enlarged cloacal protuberances) were significantly larger than reproductive females (females with a brood patch) in mass, tarsus length and wing length (Table 1). Reproductive males had significantly shorter tails than did non-reproductive males (Table 1; cf. Swaddle *et al.* 2000). In the Appendix we list the reproductive and moult status of all males and females that we examined.

Of the 22 males, 8 were in completely brown plumage and did not have a cloacal protuberance. The sex of these individuals was evident only through analysis of their DNA (see Methods). The age of these individuals was unknown, but it is likely that they were juveniles. Males that had cloacal protuberances also had enlarged testes (Table 2) and there was a positive, statistically significant relationship between testis volume and volume of the male's cloacal protuberance (Fig. 1). Only one completely brown male (out of 9 that were examined) had a cloacal protuberance (Table 2). Comparing the males in full adult plumage with those in brown or partial adult plumage, there was no significant difference in the volume of their cloacal protuberance ($t_{12} = -0.96$, $P = 0.356$) or the mean volume of their testes ($t_8 = -1.18$, $P = 0.271$). Males in adult plumage (and thus presumably older) did not have larger testes or cloacal protuberances than did males in only partial adult plumage (and thus presumably younger).

Vocalisations

White-winged Fairy-wrens have at least five distinct vocalisations (Tidemann 1980): a typical *Malurus* reel, a harsh call, contact notes, high pips, and a juvenile vocalisation. The display call, given by both males and females, consists of a dry, raspy, sinusoidal series of rising and falling notes preceded by 3–5 chips (Tidemann 1980; Baker 1995; Rowley and Russell 1997).

We did not quantify all vocalisations of White-winged Fairy-wrens on Barrow Island, but during fieldwork we heard each of the vocalisations identified by Tidemann (1980) from mainland populations. A sonogram of the display call of *M. l. edouardi* from Barrow Island is shown in Fig. 2. In both structure and detail this sonogram is similar to the sonograms of *M. l. leuconotus* published in Tidemann (1980) and Baker (1995).

Table 1. Morphometrics of male and female White-winged Fairy-wrens on Barrow Island

Sex was determined by presence of either a brood patch or cloacal protuberance in the case of reproductive adults, or by DNA analysis in the case of non-reproductive individuals. Mass is measured in grams; all other measurements in millimetres. Key to statistical comparisons: R = reproductive; N = non-reproductive; m = males; f = females

Character	Reproductive						Non-reproductive						Statistical comparisons			
	Females			Males			Females			Males			$(P_{2\text{-tailed}} \text{ from } t\text{-tests})$			
	<i>n</i>	Mean	s.e.	<i>n</i>	Mean	s.e.	<i>n</i>	Mean	s.e.	<i>n</i>	Mean	s.e.	R_f-R_m	N_f-N_m	R_m-N_m	R_f-N_f
Mass	7	6.59	0.15	14	7.03	0.07	3	6.93	0.18	8	6.95	0.16	0.01	0.95	0.60	0.21
Wing	8	42.64	0.42	14	43.63	0.22	3	41.63	0.09	8	43.04	0.22	0.03	0.01	0.09	0.19
Tarsus	8	19.02	0.11	14	19.78	0.18	3	19.59	0.42	8	19.84	0.18	0.01	0.53	0.85	0.08
Tail	6	55.90	0.65	12	55.10	0.86	3	57.41	1.19	7	57.78	0.48	0.56	0.73	0.04	0.26
Culmen	8	11.40	0.06	14	11.57	0.08	3	11.40	0.25	7	11.38	0.13	0.18	0.26	0.23	0.98
Bill width	8	2.95	0.04	14	2.94	0.04	3	3.03	0.14	7	2.82	0.09	0.91	0.23	0.09	0.44
Bill depth	8	2.71	0.05	14	2.62	0.02	3	2.74	0.02	7	2.57	0.03	0.07	0.01	0.04	0.56

Table 2. Cloacal protuberance and average testis volumes in relation to plumage characteristics of male White-winged Fairy-wrens from Barrow Island

Mean testis volume is calculated as the mean of the two testis volumes for each male

Plumage status	Cloacal protuberance volume (mm ³)			Mean testis volume (mm ³)		
	<i>n</i>	Mean	s.e.	<i>n</i>	Mean	s.e.
Completely brown ^A	1	54.97	—	1	80.12	—
Brown, one or more white scapular feathers	5	120.58	19.23	3	179.99	8.00
60% black and white, rest brown	1	95.53	—	1	148.43	—
Full black and white	7	129.31	15.75	5	185.24	17.75
All males combined	14	118.47	11.30	10	169.47	13.62

^AEight other completely brown birds determined to be males via DNA analysis did not have cloacal protuberances and were not dissected.

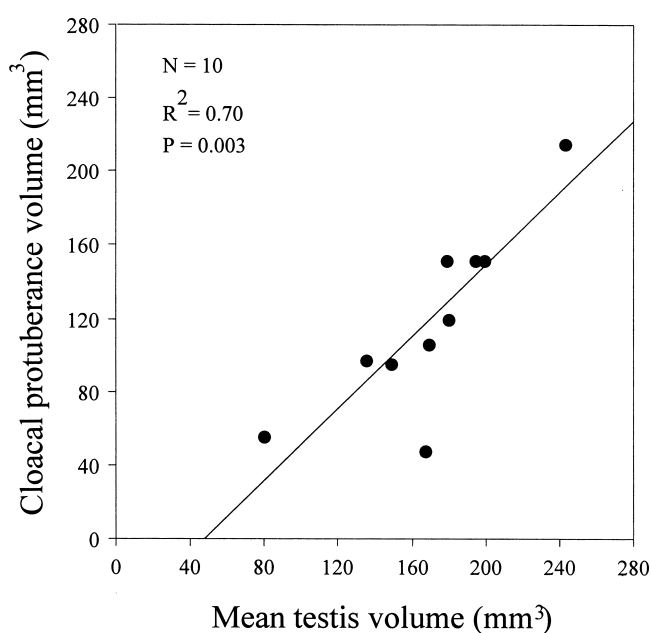
Group size and composition

We studied and/or netted nine family groups in sufficient detail to identify all individuals in the group. In total, 29 birds were identified in these groups (22 adults and 7 presumed juveniles). Sex ratio of all birds combined was 0.71 (males/females). Sex ratio of the 22 adults was 0.83 (males/females). Five groups had just two adults present (one male and one female); the other four groups had one secondary individual (either male or female) also present. Mean group size, excluding presumed juveniles, was 2.4 individuals (range 2–3). Eight of the nine groups had just one male in attendance; the other group had one black and white male and one brown male. Eight of the nine groups had either a black and white or partially-plumed male in attendance; in the other group, the only male present was a completely brown male. In six of the groups, just one female was present. A secondary female was present in the other three groups. Four groups had presumed juveniles present with the adults.

Habitat preferences

We surveyed all land forms/habitats on the island. Fairy-wrens were common and abundant on ridges and upland areas where *T. wiseana* was interspersed with open ground and taller shrubs. In road surveys, both from a vehicle and on foot, family groups of fairy-wrens were

encountered every 100 m or so in upland areas. The species was less abundant, but still common in foredunes and red dunes, being encountered every 200–300 m on road surveys

**Fig. 1.** Relationship between testis volume and cloacal protuberance volume in male White-winged Fairy-wrens on Barrow Island.

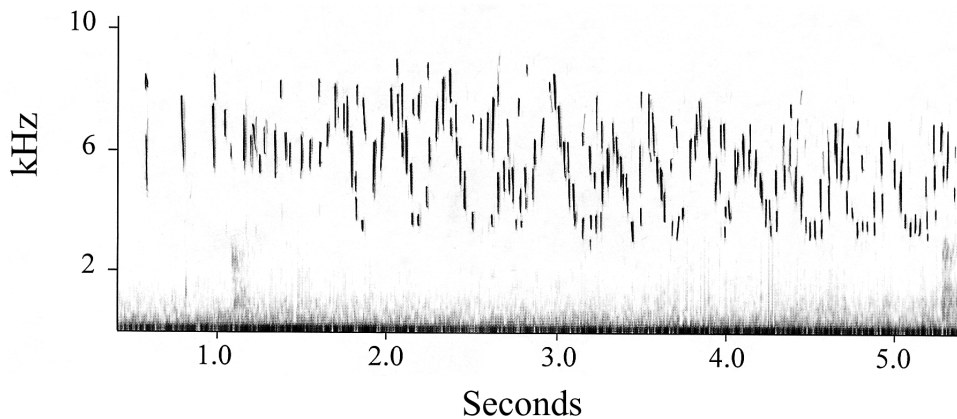


Fig. 2. Spectrogram of the display call of White-winged Fairy-wrens on Barrow Island.

in these habitats. Fairy-wrens were only sporadically found on clay pans and no birds were found in creek beds or mangrove habitats.

Description of nests

We found three nests, each a typical *Malurus* domed nest constructed of plant tendrils and dry grass blades, lined with dry grass blades without any feathers. Nest 'Surf Point' was discovered on 25 September with three fairy-wren eggs and one Horsfield's Bronze-cuckoo (*Chrysococcyx basalis*) egg present. The nest was 0.60 m high in a large *Solanum cleistogamum* shrub next to a large *T. angusta*; the entrance faced north. This nest was found preyed upon on 1 October. Nest P45 was found on 1 October with three nestlings approximately 8 days old. The nest was 0.53 m high in a *Melaleuca cardiophylla* shrub next to a large *T. angusta*; the entrance faced north-east. This nest was not visited again. Nest SP45 was found on 1 October with four young, approximately 2 days old; it was 0.48 m high in a *M. cardiophylla* shrub next to a large *T. angusta*; the entrance faced east.

Nest watches

In total, 178 feeding visits by the three group members were recorded at nest SP45, 71 (39.9%) by the male, 76 (42.7%) by the breeding female, and 31 (17.4%) by the secondary female. Overall, the male fed the nestlings at a rate of 14.2 times h^{-1} , the breeding female fed the nestlings at a rate of 15.2 times h^{-1} , and the secondary female fed the nestlings at a rate of 6.2 times h^{-1} . Each individual was remarkably consistent in its individual feeding rate across the three days. For example, the male fed the nestlings 14.5 times h^{-1} on 3 October, 13.5 times h^{-1} on 4 October, and 15 times h^{-1} on 5 October.

When feeding nestlings, each individual visited the nest alone, and usually flew directly to the nest, or first to a nearby bush or shrub before flying to the nest entrance. The breeding female was seen soliciting food (crouching in front of the individual and fluttering her wings) from both the male and the secondary female. In response to one such solicitation,

the male fed the breeding female at the nest entrance rather than deliver the food to the nestlings directly. After feeding the nestlings, the female occasionally remained on the nest, but never for more than 1 or 2 min. When not pursuing food, the male often perched above the nest or on an elevated site near to the nest, scanning the horizon and exhibiting vigilance behaviour.

Discussion

Our observations, coupled with those of Tidemann (1980, 1983) and Rowley and Russell (1995), suggest that White-winged Fairy-wrens on Barrow Island are extremely similar in behaviour and ecology to the mainland subspecies. Although habitat on Barrow Island is unique, with the extreme dominance of *Triodia*, the preference of fairy-wrens for areas with a combination of dense shrubbery and open areas on Barrow Island is similar to their habitat preferences on the mainland. Within preferred habitat, population density of the birds on Barrow Island also appears comparable with that of the mainland.

General aspects of social organisation of the birds on Barrow Island are also similar to those of populations on the mainland. The size of family groups that we observed is comparable to what was quantified by Rowley and Russell (1995), but smaller than that reported by Tidemann (1980) and in a population under study at Brookfield Conservation Park in South Australia (Pruett-Jones, unpublished data). Rowley and Russell (1995) describe the social organisation of White-winged Fairy-wrens as consisting of clans, in which a male in adult plumage associates with at least two sub-groups ('groups' as defined in this paper) and is paired with a female in one of the sub-groups. A clan type of social organisation was also indicated, but not stated explicitly, in the studies of Tidemann (1980, 1983). We did not observe clan behaviour in the birds on Barrow Island but acknowledge that the short-term nature of our observations may have precluded such observations.

We did not quantify details of social behaviour of the birds on Barrow Island, but our impression was that the

displays of males, and the manner in which they use their black and white plumage, are similar, if not identical, to those of birds on the mainland. Vocalisations of birds on Barrow Island were identical in overall structure to vocalisations of birds on the mainland (compare the sonagram in Fig. 2 with those in Tidemann 1980 and Baker 1995). As the *M. l. leucopterus* on Dirk Hartog Island has yet to receive detailed study, comparisons of the Barrow Island birds with those on Dirk Hartog Island are not yet possible.

Barrow Island is, in effect, a closed ecosystem for the resident fairy-wrens, although because of variation in habitat, population density varies across the island. It seems unlikely that fairy-wrens disperse off of Barrow Island, but they certainly could disperse considerable distances on the island itself. It would be interesting to know whether dispersal on the island is within or between habitat types. Reproductive success could easily vary with habitat on the island, and dispersal probabilities may not be equal across the entire island.

We observed one fairy-wren nest that was parasitised by Horsfield's Bronze-cuckoo. This species of cuckoo had previously been thought to breed on Barrow Island (Ambrose and Murphy 1994), but our observation of a cuckoo egg in a fairy-wren nest is the first confirmation of breeding. Horsfield's Bronze-cuckoo is a common parasite of White-winged Fairy-wrens on the mainland (Tidemann 1980; Brooker and Brooker 1989; but see Rowley and Russell 1995).

Sedgwick (1978) concluded that the White-winged Fairy-wren was the second most abundant breeding bird species on Barrow Island and estimated that there were 8150 individuals of this species on the island. Although this count must be regarded as an approximation, we believe that the count is reasonably accurate and agree with Sedgwick's placement of the fairy-wren as the second most abundant breeding species. This assessment of the species' relative abundance must, however, be placed in context of the habitat preferences of the fairy-wrens and the other resident species on Barrow Island. On ridges and in upland areas, the White-winged Fairy-wren was, in our assessment, the single most abundant breeding species, whereas in other areas it was far less common or did not occur at all.

This study suggests that the White-winged Fairy-wren on Barrow Island is nearly identical in its ecology and behavior to the mainland subspecies. Understanding of the dramatic plumage difference between birds on Barrow Island (and also Dirk Hartog Island) and those on the mainland must wait for a detailed genetic study. Such study will be essential to test hypotheses for the evolution of plumage variation in this species.

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Appendix. Reproductive and moult status of White-winged Fairy-wrens on Barrow Island in September and October 1998

Volume measurements are in cubic millimetres. np = cloacal protuberance not present; nd = bird not dissected; bp = brood patch. P = primaries; S = secondaries; Sc = secondary coverts; R = retrices; C = capital tract; B = body tracts (combined dorsal, scapulohumeral, femoral, and ventral tracts). U = upper bill; L = lower bill

ID	Plumage status/ brood patch	CP volume/ follicle size	Mean testis volume	Feathers or feather tracts in active moult	Bill colour	Sex confirmed or determined through DNA analysis
Males						
BW003	Completely brown	np	nd	Sc, R, C, B	U: brownish pink; L: pink	Yes
BW004	Completely brown	np	nd	Sc, R, C, B	U: brownish pink; L: pink	Yes
BW005	Full black and white	214.91	242.86	Sc, R	Black	
BW006	Full black and white	119.83	179.76	Sc, C, B	Black	
BW008	Full black and white	106.35	168.91	Sc, R	Black	
BW009	Full black and white	96.76	135.39	P, R, B	Black	
BW010	Completely brown	54.97	80.12	P, Sc, R	Pinkish brown; dark tip	
BW012	Completely brown	np	nd	C, B	Pinkish brown; dark tip	Yes
BW014	Full black and white	151.50	199.30	P, R, C, B	Black	
BW015	Completely brown	np	nd	P, S, R, C, B	not recorded	Yes
BW017	Completely brown	np	nd	Sc, C, B	U: brownish pink; L: pink; dark tip	Yes
BW018	Completely brown	np	nd	Sc, R, C, B	U: brownish pink; L: pink; dark tip	Yes
BW019	Completely brown	np	nd	Sc, R, C, B	U: brownish pink; L: pink; dark tip	Yes
BW021	Brown, 1 white scapular	47.57	166.75	C, B	U: brownish pink; L: pink	
BW023	Completely brown	np	nd	R, C, B	U: brownish pink; L: pink; dark tip	Yes
BW024	Partial black and white	95.53	148.43	S, Sc, C, B	Mottled black and horn; tip black	
BW027	Brown, 1 white scapular	120.02	nd	P, Sc, C, B	Mottled black and horn	
BW028	Full black and white	110.19	nd	S, C	Black	
BW029	Full black and white	105.63	nd	P, Sc, R, C, B	Black	
BW030	Brown, 2 white scapulars	131.88	nd	R, C, B	Mottled black and horn	
BW033	Brown, white scapulars	152.02	178.85	P, Sc, C, B	Mottled black and horn	
BW042	Brown, 2 white scapulars	151.42	194.38	S, R, C, B	Mottled black and horn	
Females						
BW001	Old bp	nd		Sc, R		Yes
BW002	No bp	nd		Sc, C, B		Yes
BW007	Vascular bp	1 g		R		
BW011	Beginning bp	nd		No moult		Yes
BW013	No bp	<1 mm		Sc, C, B		
BW016	Beginning bp	2 mm		S, Sc, R, C, B		
BW020	No bp	nd		Sc, C, B		Yes
BW022	Old bp	1–2 mm		P, S, Sc, R, C, B		
BW025	Old bp	1–2 mm		Sc, R, C, B		
BW026	Vascular bp	nd		R		
BW034	Vascular bp	nd		No moult		