

**Supplementary material**

1 **Appendix 1**

2

Study Topic	1985-	1985-	1990-	1990-	1995-	1995-	2000-	2000-	2005-	2005-	2010-	2010-	2015-	2015-
	89	89	94	94	99	99	04	04	09	09	14	14	17	17
	n	prop.	n	prop.	n	prop.	n	prop.	n	prop.	n	prop.	n	prop.
migration	6	0.05	16	0.06	58	0.15	106	0.17	133	0.16	344	0.24	248	0.29
foraging	15	0.12	44	0.17	63	0.16	146	0.23	167	0.20	275	0.19	154	0.18
home range and habitat use	20	0.16	38	0.14	41	0.10	73	0.12	132	0.15	257	0.18	142	0.16
survival	18	0.15	29	0.11	52	0.13	56	0.09	88	0.10	106	0.07	69	0.08
effects	17	0.14	31	0.12	43	0.11	47	0.08	59	0.07	62	0.04	30	0.03
dispersal	9	0.07	17	0.06	23	0.06	17	0.03	51	0.06	59	0.04	27	0.03
breeding	5	0.04	11	0.04	20	0.05	33	0.05	36	0.04	44	0.03	37	0.04
swimming / diving	4	0.03	25	0.09	27	0.07	39	0.06	43	0.05	22	0.02	19	0.02
technique or technology	14	0.11	17	0.06	26	0.07	20	0.03	34	0.04	33	0.02	23	0.03
flight / navigation	4	0.03	4	0.02	8	0.02	21	0.03	27	0.03	62	0.04	36	0.04
energetics	7	0.06	20	0.08	21	0.05	30	0.05	34	0.04	17	0.01	3	0.00
risk assessment	1	0.01	1	0.00	4	0.01	14	0.02	25	0.03	57	0.04	24	0.03
social behaviour	2	0.02	5	0.02	6	0.02	7	0.01	8	0.01	36	0.03	17	0.02
released birds	0	0.00	7	0.03	5	0.01	7	0.01	14	0.02	20	0.01	22	0.03
other	0	0.00	1	0.00	2	0.01	7	0.01	1	0.00	21	0.01	14	0.02

3

4 Table A1. Number (n) and proportion (prop.) of studies addressing major topics by five-year period 1985 – 2017.

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Landbirds, Short					
Model	Duration (LS)				
n	236				
AIC	267.52				
Parameter	Category	Comparator	Estimate	SE	Significance
%ma			-0.005	0.036	
att	backpack harness	back	0.193	0.483	
att	implant	back	0.961	0.824	
att	leg	back	-16.230	909.000	
att	leg-loop harness	back	0.296	0.422	
att	neck	back	1.342	0.696	
att	tail	back	-0.539	0.607	
year			-0.108	0.020	***
bma			0.000	0.000	
num			-0.007	0.004	

Model	Landbirds, Long Duration (LL)				
n	298				
AIC	405.16				
Parameter	Category	Comparator	Estimate	SE	Significance
%ma			0.122	0.112	
att	backpack harness	back	-1.339	1.200	
att	implant	back	-0.637	1.581	
att	leg	back	0.482	1.670	
att	leg-loop harness	back	-1.072	1.211	
att	neck	back	-1.058	1.219	
att	tail	back	-0.675	1.274	
year			-0.047	0.015	**
bma			0.000	0.000	
num			0.000	0.001	

Parameter	Category	Comparator	Estimate	SE	Significance
Seabirds, Short					
Model	Duration (SS)				
n	570				
AIC	663.99				
%ma			0.097	0.078	
att	backpack harness	back	0.550	0.508	
att	implant	back	0.937	0.548	
att	leg	back	-0.115	0.368	
att	subcutaneous anchor	back	0.721	0.665	
att	swallowed	back	-2.662	1.042	*
att	tail	back	-1.051	0.342	**
year			-0.064	0.013	***
bma			0.000	0.000	
num			-0.001	0.003	

Model	Seabirds, Long Duration (SL)				
n	194				
AIC	204.92				
Parameter	Category	Comparator	Estimate	SE	Significance
%ma			0.828	0.205	***
att	backpack harness	back	1.202	0.793	
att	implant	back	1.062	0.782	
att	leg	back	1.803	0.642	**
year			0.061	0.032	
bma			0.000	0.000	
num			0.002	0.003	

Parameter	Category	Comparator	Estimate	SE	Significance
Model	Waterbirds, Short Duration (WS)				
n	115				
AIC	135.97				
%ma			0.254	0.144	
att	backpack harness	back	1.447	0.698	*
att	implant	back	1.504	0.814	
att	leg-loop harness	back	0.464	1.102	
att	subcutaneous anchor	back	0.708	0.722	
att	tail	back	-16.800	1189.000	
year			-0.069	0.027	*
bma			0.000	0.000	
num			0.002	0.004	

Model	Waterbirds, Long Duration (WL)		Estimate	SE	Significance
n	192				
AIC	261.98				
Parameter	Category	Comparator	Estimate	SE	Significance
%ma		backpack	0.234	0.131	
att	implant	harness	-0.105	0.404	
att	leg	backpack			
att	leg	harness	-1.038	0.570	
att	leg-loop harness	backpack			
att	leg-loop harness	harness	-1.332	0.656	*
att	neck	backpack			
att	neck	harness	-0.635	0.823	
att	subcutaneous anchor	backpack			
att	subcutaneous anchor	harness	0.090	0.700	
year			-0.020	0.029	
bma			0.000	0.000	
num			0.002	0.002	

12

13 Table A2a-f. Probability of an effect being reported for the variables %ma+ att + dur + year + group +  
14 bma + num for the six models. Abbreviations: Maximum % Device Mass (%ma), Device Attachment  
15 Method (att), Year of Publication (year), Average Bird Mass (bma), and Number of Birds Marked  
16 (num). Significance codes: \*\*\*< 0.001; \*\*<0.01; \*< 0.05.

17

Birds Marked	1 – 10	11 - 25	26 – 50	51 – 100	>100
Records	601	498	420	279	269
Proportion Effects Reported	0.39	0.39	0.35	0.31	0.43

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19 Table A3. Proportion of records reporting effects by number of birds marked.

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## 21 **Text A1**

### 22 **Data Collection and Categorisation**

23 The following information was extracted from each publication, and summarised as described  
24 below:

25 1. Year of publication

26 2. Identity of species marked.

27 Species were aggregated into three ecological groups, Landbirds, Seabirds and Waterbirds,  
28 with Ratites excluded.

29 Landbirds included members of the families: Accipitridae, Aegothelidae, Apodidae,  
30 Bucerotidae, Cacatuidae, Caprimulgidae, Cathartidae, Columbidae, Coraciidae, Cracidae,  
31 Cuculidae, Falconidae, Megapodidae, Meropidae, Numididae, Odontophoridae, Otididae,  
32 Pandionidae, Phasianidae, Picidae, Podargidae, Psittacidae, Psittaculidae, Ramphastidae,  
33 Steatornithidae, Strigidae, Strigopidae, Trochilidae, Tytonidae, Upupidae, and all  
34 Passeriformes.

35 Seabirds included members of the families: Alcidae, Diomedeidae, Fregatidae, Hydrobatidae,  
36 Laridae, Pelecanoididae, Phaethontidae, Phalacrocoracidae, Procellariidae, Spheniscidae,  
37 Stercorariidae and Sulidae.

38 Waterbirds included members of the families: Alcedinidae, Anatidae, Ardeidae, Burhinidae,  
39 Charadriidae, Ciconiidae, Dromadidae, Gaviidae, Gruidae, Haematopodidae, Pelecanidae,  
40 Phoenicopteridae, Podicipedidae, Rallidae, Recurvirostridae, Scolopacidae and  
41 Threskiornithidae.

42 3. Countries where birds were marked

43 4. Devices used for each species marked, and whether single or multiple devices were  
44 attached. Multiple devices comprised 11% of the data, and analyses were repeated with

45 single device only to check for any influence on outcomes; only small changes were  
46 observed (see results). Devices were categorised as per the inclusion criteria.

47 5. Device attachment methods were assigned to one of the following 10 categories:

48 Back: attached to the skin or feathers of the back with glue or cable ties, with or without a  
49 supporting pad or plate.

50 Backpack harness: All types of harness with the device positioned on the back except leg-  
51 loop harnesses

52 Implant: Devices surgically implanted into a body cavity, not just subcutaneously. Where a  
53 transmitter was attached in this way it normally required attaching a percutaneous antenna.

54 Leg: Attached to the leg using a metal or plastic leg ring or flag.

55 Leg-loop harness: Figure-8 harness as first described by Rappole & Tipton (1991), with the  
56 device positioned above the synsacrum using two loops around the bird's thighs.

57 Neck: All types of attachment resulting in the device being positioned dorsally or ventrally  
58 on the neck, including collars, harnesses and ponchos.

59 Swallowed: Devices required to be swallowed by the bird and housed in the stomach with or  
60 without anchoring

61 Subcutaneous Anchor: Device held in position, usually on the back, with one or more wire  
62 anchors, inserted subcutaneously, usually with sutures and/or glue

63 Suture: Device held in position, usually on the back, by suturing through the epidermis and  
64 tying to the device or intervening pad or plate

65 Tail: Attached dorsally or ventrally to one or more rectrices with a clip, cable ties or tubing  
66 and/or glue

67 Thirty records with rarely used attachment methods were excluded from the model  
68 analyses.

69 6. Whether single or multiple attachment methods were used per device

- 70 7. The main topic(s) of the study, (often obtainable from keywords), which were grouped into  
71 15 categories, including device effects where this was a major topic (see Figure 3).
- 72 8. The number of birds of each species marked with each device and attachment method.
- 73 9. Whether fledged birds and/or chicks were marked, and for fledged birds if males, females or  
74 both were marked, or no sexing information was given.
- 75 10. The maximum duration of attachment of the devices for data recording purposes. Thus, the  
76 timing of birds returning with functioning or non-functioning devices, or being observed with  
77 the device in place but not recaptured would all be included. On the other hand, times  
78 when birds still retained functioning or non-functioning devices beyond the last date of data  
79 collection were excluded.
- 80 Two categories of maximum duration were used:
- 81 Short: up to and including 3 months
- 82 Long: longer than 3 months
- 83 11. Maximum mass of each device used, including attachments for each device and attachment  
84 method. Where individual birds carried more than one device the device mass was treated  
85 as the sum of the masses of the devices in all subsequent analyses.
- 86 12. Maximum percentage device mass with respect to each species marked and attachment  
87 method.
- 88 In cases where device mass was given, but no percentage mass, typical male and female bird  
89 masses were obtained from Dunning (2008), and a figure for maximum percentage mass  
90 obtained for fledged birds only, according to the sex or sexes marked.
- 91 13. All effects as reported, or if none were, whether they had been looked for, or their potential  
92 presence acknowledged, or if no information was available.
- 93 Effects were placed in eight categories, listed here with typical manifestations:
- 94 Breeding: interpreted widely to include clutch and brood size, hatching and fledging success  
95 and timing, nest abandonment, egg breakage, chick growth, breeding timing and duration,

96 display, singing and ability to attract a mate, breeding propensity, nest sites and territory  
97 size, quality and defence  
98 Foraging: composition of diet, time spent on this activity, efficiency, location  
99 Locomotion: flying, walking, running, hopping, gait, swimming, diving, time spent on these  
100 activities, speed  
101 Migration: distance, timing, direction, stopover location and duration  
102 Mortality: arising directly or indirectly from device attachment or removal procedure, the  
103 burden of having the device in place, or increased risk of predation and evidenced by corpse  
104 retrieval, return rates following migration or dispersal, unexplained disappearances,  
105 required euthanasia  
106 Social Behaviour: flocking, roosting, preening, dominance and other social behaviours  
107 Physical / Pathological: abrasion, callousing and other lesions, infection, necrosis, feather  
108 loss, movement, damage to or removal of device, entanglement, foreign body attachment,  
109 myopathy  
110 Physiology: enzymatic and hormonal effects, blood composition, heart rate, respiration,  
111 body mass, energy expenditure  
112 14. If effects were reported or looked for, whether an internal or relevant external control group  
113 was present. Comparison groups, (e.g. comparing groups of birds with a device attached by  
114 two different methods), were excluded.  
115 Effects that were tested for by comparing treatment and control groups were placed in the  
116 same categories as reported effects.

117 No information was collected on device dimensions, or whether devices were streamlined or  
118 otherwise modified in shape, because such data were not given for most of the studies.

119

120 **References**

- 121 Dunning, J.B., Jr. 2008. CRC handbook of avian body masses, 2<sup>nd</sup> edn. - CRC Press, Boca Raton.
- 122 Rappole, J.H. and Tipton, A.R. 1991. New harness design for attachment of radio transmitters to
- 123 small passerines. - Journal of Field Ornithology 62: 335-337.

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