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1 **Skin disease in captive bats: results of an online survey of zoos and**
2 **rehabilitators in Europe, North America and Australasia**

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17
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23 Veterinary College for trialling the questionnaire.

24 Running title: Skin disease in captive bats

25 **Abstract**

26 **Background** - Bats may be held captive in zoos and breeding programmes, and for
27 rehabilitation due to illness, abandonment or injury.

28 **Objectives** - To describe the frequency and characteristics of skin disease in captive
29 bats.

30 **Methods** – Zoos (n=164) in Europe, America, Australia and New Zealand, Wildlife
31 Disease Association members and rehabilitators were invited to complete an online
32 questionnaire on skin lesions and housing. Associations between lesion type and
33 site, frequency, species, age, suspected cause and season, and their association
34 with housing in zoos were tested using chi-squared and 2-sample z-tests.

35 **Results** – Skin lesions were seen by 38.5% (15/39) of responding zoos and more
36 frequently by rehabilitators (66.7%, 18/27; $p=0.024$). Of the total of 153 lesions of
37 any type reported by zoos and rehabilitators, almost two thirds occurred on pinnae
38 (49/153, 32%) or wing-membranes (45/153, 29%). Amongst pinnal lesions, crusting
39 (27%), swelling and redness (25%) and necrosis (20%) were most frequent. In zoos,
40 pinnal ($p=0.001$) and wing lesions ($p=0.045$) were associated with 'season', being
41 more common in winter. Pruritus was rare but more often reported from rehabilitation
42 (12/77 observed lesions) than from zoos (1/76) ($p=0.0015$). Lesions most often
43 affected adult and geriatric bats in zoos, and juveniles and adults in rehabilitation.
44 Eight respondents reported that skin disease necessitated euthanasia in individual
45 bats. Type of housing and lesions were not correlated.

46 **Conclusion** - Pinnal and wing lesions were common in captive bats often with
47 necrosis. Further research into the causes is needed to improve health and welfare
48 in captive bats.
49

50 Introduction

51 Bats are the second largest order of mammal with around 1240 species described
52 worldwide. Approximately 25% of bat species are threatened with extinction and as
53 part of endangered species recovery plans, bats may be brought into captivity.^{1,2}
54 They may also be kept in captivity for public display, for research or while
55 undergoing rehabilitation following rescue. Megachiroptera are large bats found in
56 the Old World tropics which usually eat fruit and flowers, while microchiroptera are
57 small bats found worldwide with a varied diet including insects, fruit, fish and blood.³
58 Their practical needs differ substantially and facilities for captive bats vary from
59 large, professional organisations such as zoos to small cages for occasional casualty
60 bats cared for by an individual layperson.

61 Skin disease in bats can have serious functional consequences such as loss of flight,
62 where it affects the delicate membranes of the wings, or loss of echolocation where
63 the ear-flap (pinna) is damaged.² In addition, skin disease is an important welfare
64 issue and can cause debility resulting in the need for euthanasia. Apart from white
65 nose syndrome (WNS), a fungal disease affecting the skin and wing membranes of
66 hibernating bats leading to over a million fatalities since it was first recognised in
67 2006,⁴ little has been reported on bat skin disease. Individual cases of skin disease
68 are described in captive bats held in zoos⁵ and for rehabilitation⁶ including reports on
69 alopecia, atopic dermatitis, vitiligo and fungal dermatitis.^{5,7-10} Necrotic disease of the
70 pinna was reported in a translocation project in New Zealand short-tailed bats
71 (*Mystacina tuberculata*).² However, little has been reported on the overall burden of
72 skin disease amongst captive bats.

73 This study aimed to describe the frequency and occurrence of skin disease in
74 captive bats as observed by zookeepers and rehabilitators.

75 Materials and Methods

76 Identification and recruitment of participants

77 Zoos in Europe, North America, Australia and New Zealand with captive bats were
78 identified through publicly available mammal inventories.^{11,12} Effort was concentrated
79 in these geographical areas since they were considered most likely to have zoos
80 with dedicated health staff and good record keeping. One hundred and sixty-four
81 zoos were e-mailed directly with a link to an electronic questionnaire, inviting them to
82 participate in the survey. Members of the Wildlife Disease Association, Wildlife
83 Veterinary Section, were contacted through an invitation circulated to their June
84 2015 mailing list (Appendix S1). In addition, open invitations were distributed via
85 social media groups dedicated to bat rehabilitation,^{13,14} whose members are mostly
86 UK and USA based, and through the UK Bat Conservation Trust bat carer's bulletin
87 to people involved in rescue and rehabilitation of bats. Directly invited participants
88 were sent one reminder e-mail after one month.

89 Questionnaire design and administration

90 An electronic questionnaire (Appendix S2) was designed using Smart Survey
91 (Smartsurvey.co.uk), and translated into English, French, Spanish and German. A

92 link to the survey was sent to all recruited zoos and rehabilitators. The questionnaire
93 comprised both closed and open (free text) questions on three sections relating to:

- 94 (i) *bat populations and husbandry* including number and species of bats
95 kept at their establishment, primary purpose of the captive bat
96 population and housing facilities (type, heating, access to sunlight and
97 potential for flight),
- 98 (ii) *types and distribution of skin lesions* including species and age-group
99 most commonly affected, season of occurrence (respective season in
100 the respondent's country), frequency (never seen, one or two cases,
101 several per year, most bats affected), treatment and outcome (as free
102 text),
- 103 (iii) *suspected or confirmed causative factors* such as parasites, trauma,
104 temperature, housing, and bacteria isolated.

105 Multiple answers were allowed for lesion types seen, sites affected and housing
106 type. Lesion-type and site terminology was chosen appropriate for lay people, i.e.
107 blister to include pustules and vesicles, and toe and claw to indicate digits. All
108 questions referred to the zoo or rehabilitator's captive bat population as a group
109 rather than pertaining to individual bats. Zoos were asked to provide estimations of
110 bat numbers as they were describing stable populations, but rehabilitators were
111 commenting on populations that changed throughout the year due to admissions and
112 releases.

113 [Statistical analysis](#)

114 Questionnaire responses were collated in Microsoft Office Excel 2013 (Version;
115 15.0.4833.1000). Responses were anonymized but participants could voluntarily add
116 their contact details for further clarification. All statistical analyses were performed in
117 SPSS 22.0.0.1. Descriptive statistics were calculated for all variables and chi-square
118 tests were used to identify significant associations between X and Y. A p-value of
119 0.05 was considered significant for all analyses. A two sample z-test was used to
120 analyse the difference in frequency of reporting of skin lesions and pruritus by zoos
121 and rehabilitators.¹⁵

122 This study had been approved by the Royal Veterinary College Clinical Research
123 Ethical Review Board (CRERB) URN 2015 1332.

124 [Results](#)

125 Responses were received from a quarter of zoos (24 %; n/N = 39/164) and from 27
126 rehabilitators. Zoos responded from the United States and Canada (n=12), Australia
127 and New Zealand (n=10), continental Europe (n=10) and the United Kingdom (n=7);
128 rehabilitators were mainly from the UK (n=17), but also from the United States (n=6),
129 Canada (n=1), Australia (n=1), South Africa (n=1), and Austria (n=1).

130 [Bat populations and housing](#)

131 Information from zoos referred to a total of approximately 4500 bats of 26 species,
132 with colony sizes varying from 1 to 1650 (median = 14). The most common captive
133 species was *Rousettus aegypticus* housed by 23 % of zoos, although the most

134 numerous was *Carollia perspicillata* with 3000 bats in six colonies (Table 1).
135 Responses from rehabilitators included information on at least 1250 bats of 33
136 species with number of bats per rehabilitator varying from 1 to 200 (median=2). The
137 most common rehabilitating species in the UK and Europe were pipistrelles
138 (*Pipistrellus pipistrellus* and *P. pygmaeus*) and in North America, *Eptesicus fuscus*.
139 Bats were kept exclusively for research at one establishment and for research and
140 captive breeding at one other. Most facilities had more than one type of housing with
141 regard to flight opportunities and temperature control. In addition, five zoos and 25
142 rehabilitators reported the use of hospital cages, while seven facilities allowed full
143 hibernation and six allowed periods of torpor.

144 Observed skin disease

145 Skin or pinnal lesions had been noted by half of all respondents (50%; n/N = 33/66)
146 and were reported significantly less frequently from zoos (38.5%; n/N = 15/39) than
147 by rehabilitators (66.7%; n/N = 18/27) ($p=0.024$). The frequency of occurrence of
148 skin or pinnal disease was reported to be one or two cases per year by around a half
149 of the 33 respondents (skin disease 55%; n/N = 18/33, pinnal disease 45%; n/N =
150 15/33, zoos and rehabilitators combined), and several cases per year by up to a
151 quarter of respondents (skin disease 27%; n/N = 9/33, pinnal disease 12%; n/N =
152 4/33).

153 Not all respondents commented on seasonal distribution. From the completed
154 answers, almost two-thirds of skin lesions were reported as non-seasonal by zoo
155 keepers and rehabilitators combined (60 %; n/N = 15/25). Pinnal disease was
156 reported to occur in winter (44 %; n/N = 7/16) or as non-seasonal (38 %; n/N = 6/16)
157 but there was no significant association between season and occurrence of skin or
158 pinnal disease either with ($\chi^2 p = 0.497$) or without ($\chi^2 p = 0.721$) non-seasonal
159 occurrences included. However, for zoos alone, ten of which reported skin disease
160 and 8 of which reported pinnal disease, there was a significant association between
161 wing lesions and season (30%; n/N = 3/10) ($\chi^2 p=0.045$), and between pinnal lesions
162 and season (50%; n/N = 4/8) ($\chi^2 p=0.001$) with a tendency for winter to be the
163 season most often associated with lesions. Three respondents reported in free text
164 that lesions occurred during hibernation.

165 Of the 26 different species held in zoos, 15 had never been observed with skin
166 disease. Livingstone's fruit bat (*Pteropus livingstonii*) and the New Zealand lesser
167 short-tailed bat (*Mystacina tuberculata*) were the species recorded most frequently
168 with skin disease (Table 1). Information on numbers of rehabilitating bats with skin
169 disease could not be related to species due to the questionnaire design and
170 fluctuating bat populations at rehabilitator facilities. Rehabilitators in the UK and
171 Europe reported as free text that they felt skin lesions were most often seen in
172 pipistrelles and mouse-eared bats (*Myotis spp.*), whereas pinnal lesions were
173 particularly seen in serotines (*Eptesicus serotinus*), brown long-eared (*Plecotus*
174 *auritus*) and noctule bats (*Nyctalus noctula*). In North America, *Carollia perspicillata*
175 and the pallid bat (*Antrozus pallidus*) were affected with skin lesions. In Australasia,
176 in rehabilitation, the fruit bats *Pteropus conspicillatus* and *P. Alecto*, and in zoos
177 *Mystacina tuberculata*, were especially affected by pinnal lesions.

178 A total of 153 lesions of any type were reported by zoos and rehabilitators with
179 almost two-thirds (61.4%; n/N = 94/153) occurring on either the wing-membrane or
180 pinna (Table 2). Lesions occurred least frequently on digits (12%; n/N = 18/153).
181 There was no significant association between lesion site and bats being either in
182 zoos or rehabilitation (χ^2 p = 0.846).

183 The lesion type reported most frequently by all respondents was crusting (20%, n/N
184 = 31/153) and this was seen at all sites. Swelling and redness, and necrosis, were
185 also frequently reported by both zookeepers and rehabilitators, but necrosis was only
186 reported on the wing, ear flap and digit (Table 2). Pinnae and wing membranes
187 experienced the widest range of lesion types. Pruritus was reported significantly
188 more frequently by rehabilitators (16% n/N = 12/77) than in zoos (2% n/N = 1/76)
189 (p=0.0015), and blisters were reported on the wing membrane by zoos (31% n/N =
190 8/26) but never by rehabilitators. Additionally, two rehabilitators reported as free text
191 that facial scent glands had become impacted and abscessed in some species such
192 as pipistrelles and *Eptesicus fuscus* and two rehabilitators in USA reported lesions
193 and scarring compatible with WNS. There was a significant association between
194 lesion type and lesion site, both in zoos (χ^2 p = 0.003) and in rehabilitation (χ^2 p =
195 0.001).

196 Age categories were given for 64 occurrences of skin and pinnal disease seen by
197 zookeepers and rehabilitators. Adult bats were most frequently reported as affected
198 by both respondent groups (61 %; n/N = 39/64) but age group was not significantly
199 associated with occurrence of skin or pinnal disease (χ^2 p = 0.791). Skin disease
200 was reported to occur in juveniles (23 %; n/N = 9/40), and in the free text four
201 respondents related this to soiling with milk replacer and mealworm juices, which
202 was a particular problem in pipistrelles.

203 In zoos, for the variables type of heat ('artificial heat', 'ambient temperature'),
204 'sunlight' and flight ('full flight', 'restricted flight', 'no flight'), there was no significant
205 association with the presence or absence of lesions for each body site.

206 [Description of suspected causes, treatment and outcome of skin disease](#)

207 Twenty-six respondents completed the question on suspected causes for skin
208 disease (multiple answers allowed) and 20 respondents on causes for pinnal
209 disease, resulting in nine causes suspected by all respondents. Sixteen respondents
210 provided a suspected cause for skin or pinnal disease in the free text box: humidity
211 (44%; n/N = 7/16), poor hygiene (31%; n/N = 5/16), cage trauma leading to wing
212 injuries (25%; n/N = 4/16), poor diet (19%; n/N = 3/16), and WNS (6%; n/N = 1/16).
213 Suspected causes for skin disease were distributed to four main causal factors (type
214 of housing (27 %; n/N = 7/26), external parasites (23 %; n/N = 6/26), trauma (23 %;
215 n/N = 6/26) and other (19 %; n/N = 5/26)) while extreme cold (8% n/N = 2/26) was
216 rarely suspected. Conversely, cause of pinnal disease in particular was attributed to
217 external parasites (25 %; n/N = 5/20), type of housing (20 %; n/N = 4/20) and
218 extreme cold weather (20 %; n/N = 4/20), with other causes and trauma in the
219 remainder. No instances of either skin or pinnal disease were attributed to extreme
220 hot weather. There was no significant association between different suspected
221 causal factors and occurrence of skin and pinnal disease (χ^2 p = 0.724).

222 Twenty-two respondents completed the question on bacteria isolated from skin
223 lesions and 18 on pinnal lesions. For skin lesions, bacteria were isolated from four
224 (18%; n/N = 4/22), not isolated from 10 (45%; n/N = 10/22) and eight were not tested
225 (36%; n/N = 8/22). For pinnal lesions bacteria were isolated from four (22%; n/N =
226 4/18), not isolated from four (22%; n/N = 4/18) and 10 were not tested (56%; n/N =
227 10/18). Four respondents reported the bacteria isolated, two of which were
228 coagulase-negative staphylococci, one was *Staphylococcus aureus* and one
229 reported *Proteus mirabilis*, *Pseudomonas aeruginosa*, *Enterococcus spp*, alpha-
230 haemolytic *Streptococcus*, *Providencia rettgeri* and *Morganella morganii*.

231 Reported treatments included husbandry changes, hygiene measures, ectoparasite
232 control and topical therapies (emollients and antimicrobials). In severe cases,
233 systemic antimicrobial treatment (15%; n/N = 10/66) and amputation of affected
234 extremities (6%; n/N = 4/66) were reported.

235 Eight respondents (six zookeepers and two rehabilitators) reported that euthanasia
236 had become indicated in individual bats as a result of skin disease, with general
237 debility (8%; n/N = 5/66) or loss of wing membrane (3%; n/N = 2/66) stated as
238 specific causes. One zookeeper reported closing their bat colony of insectivorous
239 pallid bats (*Antrozus pallidus*) due to medical problems including skin disease.

240 Discussion

241 The findings of this study suggest that skin disease, in particular involving the wing
242 membrane and pinna, is common in captive bats and more likely to be seen in
243 rehabilitation than zoos. Necrosis was reported frequently, whereas pruritus was only
244 reported by rehabilitators. There was a significant association of skin disease with
245 season in zoos and, anecdotally, some species association in both zoos and
246 rehabilitation.

247 Online surveys are an inexpensive, rapid and efficient way of obtaining data from
248 specific groups of people, in this case bat carers. However, limitations such as
249 language barriers, access to a computer or self-exclusion, for example by those who
250 had not seen skin disease, may have created a biased sample.¹⁶

251 The quality of the data gathered here is limited by factors such as the quality of
252 record keeping by respondents and the questionnaire design, which aimed to be
253 short and easily answered, but which may, as a result, have sacrificed statistical
254 robustness.

255 Some questions were asked which were likely to produce highly subjective answers
256 which repeated prevailing wisdom. However, it appears that some species are over-
257 represented in the reports of pinnal lesions and, if genuine, this finding warrants
258 further investigation. Likewise, most carers reported that skin disease was “not
259 seasonal”, but in zoos there was a significant association between wing and pinnal
260 lesions and season, with a tendency for winter to be the most common season.
261 However, in both cases the sample sizes were small and those reporting these
262 associations all housed bats at ambient temperatures. It is possible that the
263 remaining zoos would not have noticed a seasonal association because artificial
264 heating removes most temperature seasonality for the bats.

265 Rehabilitators were significantly more likely to have seen skin or pinnal disease than
266 zoos, which is not unexpected since young, sick and injured bats are often
267 immunocompromised by being freshly captive, and subjected to handling and
268 medication.¹⁷ These bats are also more likely to be immobile and less able to groom
269 properly, hence reducing skin health and defence against infection. In addition,
270 rehabilitators report that the need to confine injured bats in plastic containers, or to
271 wrap pups in fabric can result in high humidity and wing membrane infections.⁹ The
272 practical difficulties of hand-feeding orphaned baby bats is reported to lead to soiling
273 of the fur and subsequent skin disease.⁷ In addition, providing a normal diet to
274 insectivorous bats in captivity is challenging.¹⁸ In contrast, zoo colonies usually are
275 predominantly healthy, active bats kept in enclosures which allow more normal skin
276 and pelage function, and providing correct nutrition to fruit bats is far less
277 problematical than for insectivorous bats.

278 The distribution of lesion type and lesion site was broadly similar in both groups,
279 however it is unclear why rehabilitators reported pruritus whereas zoos did so
280 infrequently, and zoos reported blisters on wing membranes whereas rehabilitators
281 did not. Pruritus has previously been reported in a single case of presumptive atopic
282 dermatitis in a captive Malayan flying fox (*Pteropus vampyrus*).⁵ Alopecia has been
283 previously reported in both captive and free-ranging bats.^{7,19,20} These authors
284 suggested that causes of alopecia were androgen activity, nutritional imbalance and
285 metabolic stress due to pregnancy and lactation or anthropogenic pressures. A role
286 for nutrition in the development of alopecia in bats, as suspected by several
287 respondents in this study based on hair regrowth following improved diets, is
288 plausible but has not been discussed in the published literature.

289 Necrosis was reported only on the wing, pinna, and digit. In bats, the wing distal to
290 the carpus is particularly at risk of necrosis due to the anatomical paucity of collateral
291 circulation.⁸ The skin of the wing membrane is extremely thin with a histologically
292 indistinguishable hypodermis reported in thin areas,²¹ which may render them less
293 able to withstand ischaemia due to microthrombi or damage by bacterial or other
294 toxins.²² Vasculitis is a recognised cause of skin and pinna necrosis in dogs and
295 other species, which is thought to involve type III hypersensitivity reactions, often
296 associated with underlying causes such as infections, drug reactions, or food
297 hypersensitivity.²³ In contrast and by comparison, porcine ear pinnal necrosis
298 syndrome rarely involves vasculitis and the involvement of staphylococcal toxins has
299 been proposed as a cause.²⁴ For bats, an association with cold has been proposed
300 by bat workers in Australia for ear lesions in black flying foxes at the southern end of
301 their range; pinnal lesions in free-ranging bats in Germany were ascribed to 'frost
302 damage' in winter roosts²⁵ although the evidence for this remains scant.
303 Cryoglobulinaemia in humans can result in skin necrosis and a case of cold-
304 associated cryoglobulinaemia in a dog which resulted in pinnal necrosis has been
305 reported.²⁶ Further studies are needed to elucidate the nature of the necrotic lesions
306 reported in this study.

307 The observations reported in this online survey suggest that skin disease affects a
308 substantial number of captive bats, that pinnae and wing membranes are
309 predisposed to skin disease, and that some species may be more susceptible than

310 others. As for other nondomestic animals, husbandry and housing are likely to be
311 contributing to some skin disease. Although this survey does not provide information
312 about the aetiology of skin disease in captive bats, it represents a starting point in
313 understanding the frequency and type of skin disease affecting bats. To assist those
314 caring for bats, better diagnostics and more research into the different aetiologies of
315 skin disease are needed to provide prognoses, targeted treatment, and better
316 welfare and conservation for captive bats.

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387

388 [Tables](#)

389 Table 1: Frequency of skin and pinnal disease in different species of captive bats in zoos (shading = disease present)

Genus	Species	Total number in captivity	Number of zoos with colonies	Number of zoos reporting skin disease (%)	Number of zoos reporting pinna disease (%)
Bats with Skin Disease					
<i>Antrozous</i>	<i>pallidus</i>	41	2	1 (50)	
<i>Carollia</i>	<i>perspicillata</i>	3000	6	2 (33)	1 (17)
<i>Macroderma</i>	<i>gigas</i>	13	2	1 (50)	1 (50)
<i>Mystacina</i>	<i>tuberculata</i>	42	2	2 (100)	2 (100)
<i>Pteropus</i>	<i>giganteus</i>	52	5	1 (20)	1 (20)
	<i>livingstonii</i>	56	2	2 (100)	2 (100)
	<i>lylei</i>	64	2	1 (50)	
	<i>poliocephalus</i>	136	6	1 (17)	
	<i>rodricensis</i>	39	4	1 (25)	1 (25)
	<i>vampyrus</i>	17	3	1 (33)	
<i>Rousettus</i>	<i>aegypticus</i>	700	9	2 (22)	
Bats With No Reported Skin Disease					
<i>Artibeus</i>	<i>jamaicensis</i>	1	1		
<i>Desmodus</i>	<i>rotundus</i>	145	2		
<i>Eidolon</i>	<i>helvum</i>	113	4		
<i>Glossophaga</i>	<i>soricina</i>	91	3		
<i>Leptonycterus</i>	<i>curasoae</i>	20	1		
<i>Noctilio</i>	<i>leporinus</i>	3	1		
<i>Phyllostoma</i>	<i>discolor</i>	1	1		
	<i>hastatus</i>	15	1		
<i>Pteropus</i>	<i>alecto</i>	2	1		
	<i>hypomelanus</i>	5	1		
	<i>pumilis</i>	8	2		
	<i>scapulatus</i>	21	4		
	<i>voeltzkowi</i>	1	1		
<i>Rousettus</i>	<i>lanosus</i>	55	1		
<i>Tadarida</i>	<i>brasiliensis</i>	1	1		

391 Table 2. Lesion types reported in bats suffering from skin disease on the face, body, wing membrane, ear flap, and toe and claw by
 392 15 zoos and 18 rehabilitators in response to a questionnaire.

Lesion Type	Number of times lesion type was reported at any site (%)		Number of times lesion reported at site (%)									
			Head and face		Body		Pinna		Wing membrane		Toe and claw	
	Zoo	Rehab	Zoo	Rehab	Zoo	Rehab	Zoo	Rehab	Zoo	Rehab	Zoo	Rehab
Crusting	16 (21)	15 (20)	2 (25)	1 (13)	1 (13)	2 (12)	6 (26)	7 (27)	4 (15)	3 (16)	3 (27)	2 (29)
Swelling & redness	17 (22)	12 (16)	2 (25)	1 (13)	2 (25)	nr	6 (26)	6 (23)	4 (15)	3 (16)	3 (27)	2 (29)
Necrosis	13 (17)	16 (21)	nr	nr	nr	nr	5 (22)	5 (19)	5 (19)	9 (47)	3 (27)	2 (29)
Blisters	10 (13)	2 (2)	nr	nr	nr	nr	2 (9)	2 (8)	8 (31)	nr	nr	nr
Alopecia	9 (12)	12 (16)	2 (25)	3 (38)	5 (63)	9 (53)	1 (4)	nr	1 (4)	nr	nr	nr
Discharge of pus	7 (9)	2 (2)	2 (25)	nr	nr	1 (6)	3 (13)	1 (4)	nr	nr	2 (19)	nr
Itchiness	1 (2)	12 (16)	nr	3 (38)	nr	4 (23)	nr	2 (8)	1 (4)	3 (16)	nr	nr
Depigmentation	3 (4)	6 (8)	nr	nr	nr	1 (6)	nr	3 (11)	3 (12)	1 (5)	nr	1 (13)
Totals	76 (100)	77 (100)	8 (100)	8 (100)	8 (100)	17 (100)	23 (100)	26 (100)	26 (100)	19 (100)	11 (100)	7 (100)

393 nr: not reported

394

Appendix S1. Invitation to Wildlife Disease Association, Veterinary Division members to complete the survey.

Message uploaded to WDA VD mailing list:

Survey on skin disease and ear flap disease in captive bats: Request for assistance from all involved in keeping bats in captivity. To assess the incidence and type of skin and ear flap disease in captive bats we would appreciate it if you would complete the online survey about your experience of any problems in your bats. Replies are anonymous. It is useful for us to know if you do not see any skin disease and your reply will only take a few minutes. I am particularly interested to hear from anyone seeing bats which lose part of the ear flap as a result of disease.

Appendix S2. Questionnaire; “Skin disease in captive bats”.

1. Introduction

This survey was designed by (identifying information removed). The results of the survey will provide valuable data about the type and incidence of skin disease in captive bats. Responses to this survey are anonymous and will be used for research purposes only (Data Protection Act 1998). Should you provide any contact details these will be held in a secure database in order to contact you regarding our research and will not be used for marketing or passed to any third parties.

2. About your bats

Tell us about the bats you have, and how and why you keep them.

1. What is the purpose of your captive bat population?

- Zoo Exhibit
- Rescue and Rehabilitation
- Captive Breeding
- Research

2. Which species of bat do you keep in your collection? (Please estimate numbers for each species)

3. In which type of housing are your bats kept?

	Ambient temperature	Artificial heat	Access to full sunlight
Full flight enclosure	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Restricted flight enclosure (some flight possible)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
No flight enclosure (flight not possible)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Hospital cage	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Other factors eg hibernation allowed?

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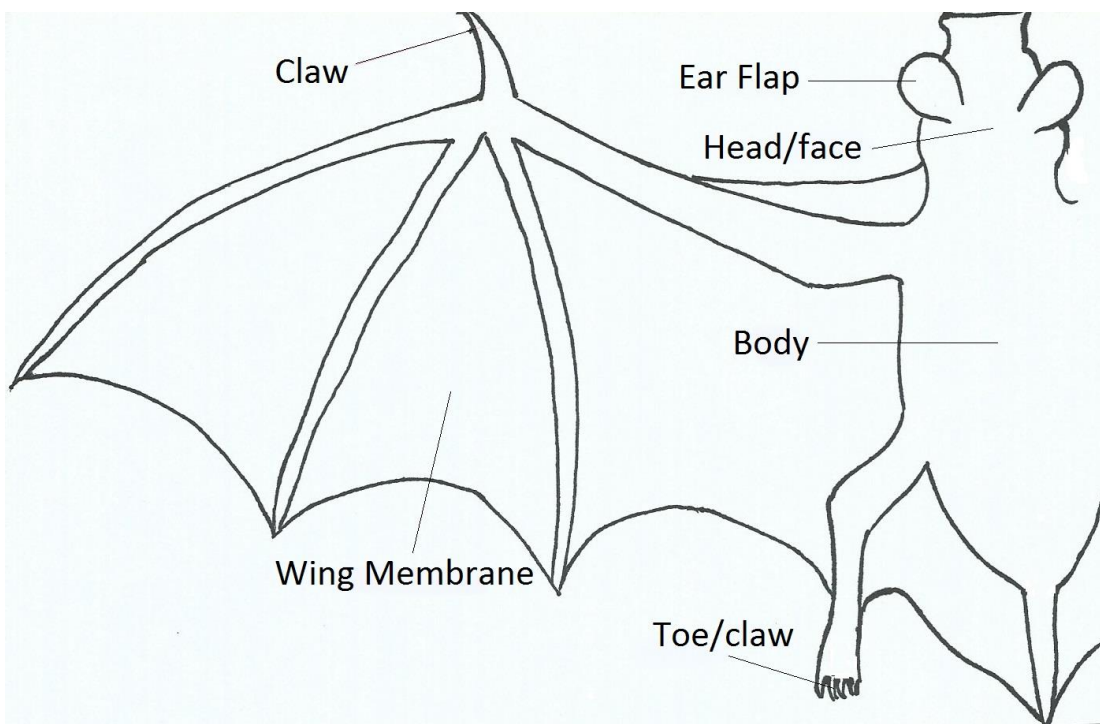
3. Skin Disease and Ear Flap Lesions

Types of skin disease you see and which bats are affected

4. Have you seen skin disease or ear flap disease in any of your bats? *

Yes

No



5. Which area of the skin has been affected? *

Body

Wing membrane

Toes/claws

Ear Flap

Head/face

6. Which type of skin changes or behaviour changes have you seen in each area?

	Body	Wing membrane	Toe/claw	Ear Flap	Head/face
Alopecia (loss of hair)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Crusting	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

	Body	Wing membrane	Toe/claw	Ear Flap	Head/face
Blisters	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Necrosis (death of tissue)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Swelling and Redness	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Discharge of pus	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Itchiness	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Other (Please describe)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Please describe any other skin changes seen.

7. How often have you seen skin disease and ear flap disease?

	Skin Disease	Ear Flap Disease
One or two cases	<input type="checkbox"/>	<input type="checkbox"/>
Several cases per year	<input type="checkbox"/>	<input type="checkbox"/>
Most bats affected	<input type="checkbox"/>	<input type="checkbox"/>
Never	<input type="checkbox"/>	<input type="checkbox"/>

8. Are any species more often affected by skin disease than others?

9. In which species do you see ear flap disease?

10. How old are bats which have skin disease and ear flap disease?

	Skin Disease	Ear Flap Disease
Neonate (0-2 weeks)	<input type="checkbox"/>	<input type="checkbox"/>
Juvenile (2wks-1 year)	<input type="checkbox"/>	<input type="checkbox"/>
Adult (1 year-15 years)	<input type="checkbox"/>	<input type="checkbox"/>
Geriatric (<input type="checkbox"/>	<input type="checkbox"/>
Other (Please specify)	<input type="checkbox"/>	<input type="checkbox"/>

Other comments about the age of bats affected

11. Did the skin disease or ear flap disease result in the need for euthanasia of the affected bat?

	Skin Disease	Ear Flap Disease
Yes	<input type="checkbox"/>	<input type="checkbox"/>
No	<input type="checkbox"/>	<input type="checkbox"/>

Please describe why euthanasia was necessary

4. Causative Factors

Any factors which have been suspected or confirmed as the cause of skin disease or ear flap lesions. (What do you or your vet think is the cause)

12. Were skin disease and ear flap disease associated with any cause?

	Skin Disease	Ear Flap Disease
External parasites	<input type="checkbox"/>	<input type="checkbox"/>
Trauma including fighting	<input type="checkbox"/>	<input type="checkbox"/>
Extreme hot weather	<input type="checkbox"/>	<input type="checkbox"/>
Extreme cold weather	<input type="checkbox"/>	<input type="checkbox"/>
Type of Housing (Please specify)	<input type="checkbox"/>	<input type="checkbox"/>
Other (Please specify)	<input type="checkbox"/>	<input type="checkbox"/>

Type of housing or other causes:

13. Have any bacteria been isolated from cases of skin or ear flap disease?

	Skin Disease	Ear Flap Disease
Yes	<input type="checkbox"/>	<input type="checkbox"/>
No	<input type="checkbox"/>	<input type="checkbox"/>
Not tested	<input type="checkbox"/>	<input type="checkbox"/>

Which bacteria were isolated? (Please state site)

14. Are skin disease or ear flap disease seen at a particular time of year?

	Skin Disease	Ear Flap Disease
Spring	<input type="checkbox"/>	<input type="checkbox"/>
Summer	<input type="checkbox"/>	<input type="checkbox"/>
Autumn (Fall)	<input type="checkbox"/>	<input type="checkbox"/>
Winter	<input type="checkbox"/>	<input type="checkbox"/>
Not Seasonal	<input type="checkbox"/>	<input type="checkbox"/>

Any other information on the time of year lesions occur

5. More Information

15. Would you be willing to provide more information on the skin disease seen in your bats?

If so please enter an e-mail address so that we may contact you.

The e mail address will remain confidential and will not be passed to any third party.