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F.D. Menzies, D.A. Abernethy, L.A. Stringer, C. Jordan. A comparison of badger activity in two areas of high and low bovine tuberculosis incidence of Northern Ireland. *Veterinary Microbiology*, 2011, 151 (1-2), pp.112. 10.1016/j.vetmic.2011.02.033 . hal-00701902

HAL Id: hal-00701902

<https://hal.science/hal-00701902v1>

Submitted on 28 May 2012

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Accepted Manuscript

Title: A comparison of badger activity in two areas of high and low bovine tuberculosis incidence of Northern Ireland

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PII: S0378-1135(11)00114-3
DOI: doi:10.1016/j.vetmic.2011.02.033
Reference: VETMIC 5200

To appear in: *VETMIC*

Please cite this article as: Menzies, F.D., Abernethy, D.A., Stringer, L.A., Jordan, C., A comparison of badger activity in two areas of high and low bovine tuberculosis incidence of Northern Ireland, *Veterinary Microbiology* (2010), doi:10.1016/j.vetmic.2011.02.033

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A comparison of badger activity in two areas of high and low bovine tuberculosis
incidence of Northern Ireland

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44 **Abstract**

45

46 During 2005, a field survey of badger activity was carried out to evaluate differences
47 between two areas with different levels of bovine tuberculosis (annual herd incidences
48 of 16% and 4%) and to assess the awareness of herd keepers in relation to badgers. A
49 random selection of herd keepers was interviewed and their farm land surveyed for
50 the presence of badgers. The survey end point for each farm was the discovery of an
51 active badger sett. Participation was very high in both areas (>80%). Evidence of
52 badger activity was recorded on a higher proportion of farms in the area with a high
53 tuberculosis herd incidence. However, when the difference in quality of agricultural
54 land within each area was taken into account, a statistically significant association was
55 not demonstrated. This suggests that the quality of agricultural land is a major
56 determinant in the location of active badger setts. Nevertheless, the study did
57 demonstrate the potential for increased exposure of cattle to badgers in the high
58 incidence area. Herd keepers accurately identified the presence of badger setts on
59 their land (positive predictive value = 97%) but herd keepers reporting the absence of
60 badger setts/activities on their land were found to be less accurate. Overall, the
61 conclusions from this study tend to reflect the findings observed in other studies.

62

63

64 **Keywords:** Badgers, *Meles meles*, bovine tuberculosis, *Mycobacterium bovis*, farm
65 survey

66

66 **Introduction**

67
68 Despite the implementation of standard measures to control bovine tuberculosis, such
69 as annual routine tuberculin herd testing, eradication of *Mycobacterium bovis*
70 infection in cattle has proved problematical in Great Britain, Northern Ireland and in
71 the Republic of Ireland (Reviriego Gordejo and Vermeersch, 2006). The failure to
72 eradicate bovine tuberculosis from these countries has been partially attributed to the
73 endemic reservoirs of *M. bovis* infection in the European badger, *Meles meles* (Denny
74 and Wilesmith, 1999; Abernethy et al., 2006; Corner, 2006). In these countries,
75 infection rates of up to 40% have been reported in badgers (Delahay et al., 2001;
76 Abernethy et al., 2003; Corner, 2006).

77

78 Transmission of *M. bovis* infection from badgers to cattle has been demonstrated
79 experimentally (Little et al., 1982) and badger behaviour provides opportunities for
80 transmission of infection between badgers and cattle through their use of pasture to
81 feed on earthworms or through accessing cattle houses in search of food (Garnett et
82 al., 2002; Roper et al., 2003; Garnett et al., 2005). No experimental studies have been
83 published on transmission of *M. bovis* from cattle to badgers.

84

85 However, quantifying the role of badgers in the maintenance of bovine tuberculosis is
86 more problematical as studies have indicated conflicting results. A Northern Ireland
87 case control study concluded that badgers were associated with 40% of tuberculosis
88 breakdowns in large, closed dairy herds (Denny and Wilesmith, 1999). An earlier
89 study in Great Britain also showed a positive relationship between the risk of a herd
90 becoming infected and increased badger sett density (Wilesmith, 1983). In the
91 Republic of Ireland, a study to investigate and quantify associations between

92 breakdown herds and badger setts found contradictory results between two study
93 periods (Olea-Popelka et al., 2006).

94

95 Attempts to demonstrate spatial associations between badgers infected with *M. bovis*
96 and tuberculosis in cattle have also yielded inconsistent results. A study in the
97 Republic of Ireland failed to find any significant association between the number of
98 badgers with a given strain type of *M. bovis* and the risk of nearby cattle herds having
99 the same strain (Olea-Popelka et al., 2005). In contrast, a spatial association was
100 found between badger and cattle *M. bovis* isolates of the same spoligotype within
101 Great Britain (Woodroffe et al., 2005). An ongoing study in Northern Ireland has
102 shown that herds within 3 km of a badger carcass infected with *M. bovis* is more
103 likely to have experienced a bovine tuberculosis breakdown than herds within 3 km of
104 an unaffected badger carcass (Abernethy et al., 2003).

105

106 Badger culling trials have also provided information to fuel the debate on the role of
107 the badger in the maintenance of tuberculosis in the cattle population. Two badger
108 culling trials in the Republic of Ireland (the East Offaly area trial from 1989 to 1995
109 and the four area trial from 1997 to 2002) both demonstrated a significant reduction in
110 the bovine tuberculosis herd breakdown rate in proactively culled areas compared to
111 control/reactive culling areas (Ó Máirtín et al., 1998; Griffin et al., 2005). Although
112 areas where badgers were proactively culled in the randomised badger culling trial
113 carried out in Great Britain demonstrated a 19% lower incidence in cattle herd
114 breakdowns compared to the control areas, there was a 29% increased incidence in the
115 2 km area neighbouring the proactive culling areas, which was thought to be due to
116 perturbation effects (Donnelly et al., 2006). Differences in terms of badger density

117 and lack of geographical boundaries between the studies may account for the different
118 findings from the two studies. However, a previous GB intervention study did show
119 that the risk of herds having TB was lowered once badgers had been removed from
120 the area (Clifton-Hadley et al., 1995).

121

122 To complement this body of evidence and also increase the regional knowledge on the
123 possible role of the badger in the transmission of tuberculosis to cattle, a field survey
124 of badger activity was carried out in Northern Ireland. The main aims of the study
125 were to assess any differences between badger activity in two areas with different
126 levels of bovine tuberculosis and to assess the awareness of herd keepers to badgers
127 on their land through herd keeper telephone interview and field surveys on a random
128 sample of cattle farms.

129

130 **Materials and methods**

131

132 *Training*

133 The badger survey field work was undertaken during 2005 by four field members of
134 staff of the Department of Agriculture and Rural Development (DARD). They had
135 on-farm training over a two week period in the recognition of badger setts and
136 whether such setts were active or inactive, and in identifying signs of badger activity
137 (e.g. latrines, badger pads, badger hair, spoil heaps) by a DARD colleague
138 experienced in badger survey duties. No training was provided on categorising
139 badger setts by type (e.g. main, annexe, subsidiary) as this information was not
140 required as part of the study. Initially, the survey work was undertaken in pairs so
141 that the findings could be cross-validated. Queries were resolved by consultation with
142 the trainer.

143

144 *Herd selection*

145 All active cattle herds (n = 866) were included in the sampling frame for the high
146 tuberculosis herd incidence area (Figure 1). This area had an annual tuberculosis
147 cattle herd incidence of 15.8% in 2004. Herds were randomly selected in batches as
148 resources permitted, with a target of contacting 200 herd keepers within this area.
149 This sample size allowed for a 75% participation rate using a 95% confidence interval
150 with 80% power level and equal sample sizes from the two areas with the ability to
151 detect a minimum odds ratio of 2 whilst assuming that 50% of cattle farms within the
152 low incidence area would be shown to have signs of badger activity. An identical
153 process was used to randomly select herd numbers from a low tuberculosis herd
154 incidence area with a sampling frame of 445 herds (Figure 1). The annual
155 tuberculosis cattle herd incidence in 2004 was 3.7% in this area.

156

157 *Survey protocol*

158 The selected herd keepers were initially contacted by letter to alert them to the aims of
159 the survey along with information on what would be required from them if they chose
160 to participate. The letter was followed up by a telephone call, which sought
161 permission to survey the land owned or rented by the herd keeper, and a questionnaire
162 was completed in relation to badger and badger sett sightings by the herd keeper over
163 the previous two years. If the herd keeper agreed to participate, then a date and time
164 for the farm survey work was agreed.

165

166 The questionnaire used during the survey was pre-tested on four farms prior to
167 initiation of the survey. A copy of the questionnaire is available upon request from
168 the authors.

169

170 During the farm survey, the presence of badger setts was recorded and whether the
171 sett was active or inactive along with details of the evidence for declaring the sett as
172 active. The end point of a survey of a farm was the discovery of any active badger
173 sett. A time limit of one working day was placed upon the survey of any one farm
174 therefore if not active badger sett was found within the time limit, then the farm was
175 declared to have no active badger setts present. Where the farm contact knew of the
176 presence of any badger setts, these setts were examined prior to the initiation of any
177 systematic survey of the farm. Any badger setts that were observed were recorded
178 along with details of the sett location and map reference. Additional information was
179 recorded on other signs of badger activity such as the presence of latrines or badger
180 pads.

181

182 *Data management*

183 Returns from the survey were entered into a customised MS ACCESS database
184 (Microsoft Corporation, Redmond, WA, USA) and all the data were validated by
185 visual inspection and by cross-checks using database queries. Data summaries were
186 extracted using MS ACCESS and statistical analysis by the chi-squared test were
187 carried out using either web based software (Preacher, 2001) or by using a customised
188 MS EXCEL (Microsoft Corporation, Redmond, WA, USA) worksheet. Estimation of
189 crude and summary odds ratios using the Mantel-Haenszel procedure was carried out

190 using STATA 10/IC (StataCorp, College Station, Texas, USA). Statistical
191 significance was set at the 5% level.

192

193 *Misclassification bias*

194 Due to the time resource limitation placed on the survey of each farm, some farms
195 may have had an active badger sett but this was not found as not all of the farmland
196 may have been surveyed. During the following year, a continuation of farm surveys
197 which used the same methodology was carried out within in the two areas. Additional
198 information on the proportion of land not surveyed on each farm was recorded and
199 this information was used to evaluate the potential for misclassification of farms
200 where no active badger setts were found. Eighty-seven randomly selected farms were
201 surveyed with 23 farms reported as not having an active badger sett. The proportion
202 of land not surveyed on these 23 farms was totalled and divided by 87 to represent the
203 potential number of farms per 100 farms not surveyed that potentially had an active
204 badger sett. This was used to calculate the number of farms that were potentially
205 misclassified within the low incidence area (i.e. maximum number of farms on which
206 no active badger sett was found that could have been misclassified). This figure was
207 added to the total farms with active badger setts in the low incidence area and
208 deducted from the total farms with no active badger setts in the low incidence area.
209 The comparison between the proportion of farms with and without active badger setts
210 in high and low incidence areas was then re-analysed using the amended figures.

211

212 *Land classification*

213 The Irish National grid geographical co-ordinate system was used to identify the
214 locations of all farms and badger setts included in this study (OSNI, 2009). Farms and

215 setts were mapped using a geographical information system (GIS), ArcView version
216 3.2a (Environmental Systems Research Institute, Redlands, California, USA). The
217 GIS was used to create a database of information on the agricultural land class (ALC)
218 at various distances (buffer zones) around each farm and badger sett. The map of
219 ALC is based on the soil map of Northern Ireland (Cruickshank, 1997) and classifies
220 the soil into 7 classes numbered 1 (best), 2, 3A, 3B, 4A, 4B, and 5 (poorest). In the
221 ALC classification, class 1 represents the best quality agricultural land (land with no
222 or very minor limitations to agricultural use) while class 5 represents the poorest
223 quality land (land with severe limitations which restrict use to permanent pasture or
224 rough grazing). The full ALC classification scheme is detailed in Cruickshank (1997).
225 The distances between active badger setts found on the main farm and associated farm
226 buildings was calculated and summarised for the two areas under investigation.

227

228 Buffer zones were created at 0 and 500 metre radius around each farm and active
229 badger sett location where the map reference was known. These buffer zones were
230 overlaid on classification maps of ALC to extract the proportion of each ALC
231 classification, within each buffer zone, for each farm and sett. For each 0 metre
232 buffer zone, the number of farms or badger setts for each ALC within the two areas
233 was calculated and compared. For each 500 metre buffer zone, the proportion of ALC
234 was averaged separately of farms and active badger setts from the two areas and the
235 proportions were compared between the two areas. For statistical comparison
236 purposes, ALC were aggregated into three groups (very good/good,
237 moderate/moderately poor, poor/very poor/urban) or two groups where the numbers
238 within any cell was too small for valid analysis (very good/good/moderate and
239 moderately poor/poor/very poor/urban).

240

241 **Results**

242

243 There were a total of 225 herds drawn by random sample from the high incidence area

244 and 204 herds from the low incidence area. There were 193 and 168 positive

245 respondents respectively, giving response rates of 86% and 82%. The main reasons

246 given for non-participation were land already surveyed under an associated herd

247 number (19%), land rented out (18%) and inability to contact the herd keeper (10%).

248 However, no reason was given by 44% (n = 30) of non-respondents.

249

250 There was no statistically significant difference between the average farm size in the

251 high and low incidence regions (34.4 and 38.4 hectares, respectively) or in the herd

252 sizes (83 and 78 cattle, respectively). Median farmland size was 65 hectares (25th253 percentile = 40; 75th percentile = 100) for the high incidence area and 66 hectares (25th254 percentile = 38; 75th percentile = 110) for the low incidence area.

255

256 There were 193 telephone questionnaires completed for the high incidence area and

257 168 for the low incidence area. The high herd incidence area consistently showed

258 statistically significant higher rates of observation of badger activity ($P < 0.01$; Table

259 1). For example, one-third of herd keepers (37%) in the high incidence area reported

260 observing badgers on their land over the last two years compared to only 13% of herd

261 keepers in the low incidence areas.

262

263 In the high incidence area, 185 farms were surveyed and 162 farms in the low

264 incidence area (Table 2). There were significantly more farms in the high incidence

265 area where badgers setts were found ($P < 0.01$; 70% cf. 57%). Moreover, a higher

266 proportion of farms in the high incidence area had active badger setts ($P < 0.05$; 56%
267 cf. 43%). However, on farms with badger setts, there was no difference between the
268 two areas in the proportion of setts that were active or inactive (80% cf. 76%).

269

270 The evidence for active badger setts also varied between the two areas with the
271 presence of spoil heaps and fresh bedding being recorded more frequently in the high
272 incidence area while the presence of badger hair in the low incidence area was a more
273 common finding. Both areas showed the main farm to be the most common place to
274 find an active sett.

275

276 A significantly higher percentage of farms in the high incidence area revealed
277 evidence of badger activity (77% cf. 61%; $P < 0.01$) with the presence of badger pads
278 being the main evidence cited (>90%) for badger activity within both areas.

279

280 In the high incidence area, there were 245 badger setts identified on 130 farms, of
281 which 104 had an active badger sett. This compares with 211 badger setts identified
282 on 92 of the farms surveyed in the low incidence area, 70 of which had an active
283 badger sett.

284

285 The location of badger setts is shown in Table 3. A significantly higher proportion of
286 badger setts was found in hedges within the high incidence area (74% cf. 62%;
287 $P < 0.001$). This difference was still significant ($P < 0.001$) when active setts alone were
288 considered. Within the high incidence area, there was no significant difference
289 between the proportion of active and inactive badger setts within the different location
290 types, but there was a difference for the low incidence area ($P < 0.001$) with a higher

291 proportion of inactive badger setts being located in hedges (68% cf. 54%). However,
292 the difference in the low incidence was due to 'other' sett locations, which were
293 mainly locations within field boundaries and therefore were generally equivalent to
294 'hedge' locations. Taking this fact into consideration, the difference in sett location
295 was not significant (that is, comparing setts within field boundaries as opposed to
296 being located in woodland or rough ground).

297

298 Investigation of the potential for misclassification bias concluded that up to a
299 maximum of three farms were potentially misclassified within the low incidence area
300 (a maximum of 2.76 farms per 100 could have been misclassified as the proportion of
301 farmland not surveyed was 2.4 out of the 23 farms where no active badger setts were
302 found from the total surveyed in 2006 of 87). Re-analysing the adjusted figures for
303 the low incidence area (73 farms with active setts, 89 farms without active setts cf. 70
304 and 92, respectively), showed that the difference in the presence of active badger setts
305 between the two areas was still statistically significant ($P < 0.05$).

306

307 *DARD/Herd keeper comparison*

308 The results obtained from herd keepers during the telephone interview on the presence
309 of badger setts were badger sightings compared with the findings recorded by the
310 DARD field staff from their farm surveys. Signs of badger activity were assumed to
311 correlate with herd keepers observing badgers on their land. This indicated that herd
312 keepers were accurate at identifying badger setts (positive predictive value 97%) and
313 also for reporting sightings of badgers on their land (positive predictive value 95%).
314 However, reporting of negative findings was less accurate with respect to correctly
315 stating that badger setts were not present on their land (negative predictive values

316 30% and 43% for the high and low incidence areas, respectively) and correctly stating
317 that they had observed no signs of badger activity on their land (negative predictive
318 values 23% and 39% for the high and low incidence areas, respectively).

319

320 *Land classification*

321 The median (mean) distance between active badger setts and main farm buildings for
322 the low incidence area was 283 m (441 m) while the distance for the high incidence
323 area was 305 m (477 m) ($P>0.05$, t test).

324

325 There were highly significant differences ($P<0.001$) between the amount of ALC
326 surrounding farm buildings between the two areas at 0 m and 500 m buffer zones
327 (Tables 4 and 5). In the high tuberculosis herd incidence area, 63% of the land within
328 500 m of the farm buildings was classified as very good or good quality agricultural
329 land while only 7% of the land within 500 m of farm buildings in the low tuberculosis
330 herd incidence area was classified within these two categories. A similar finding was
331 seen in relation to active badger sett locations and land classification within 500 m
332 (63% and 6%, respectively). However, when ALCs were compared between farm
333 buildings and active badger setts within the same area at each of the two buffer zones
334 (0 m and 500 m), there was no statistically significant difference observed within any
335 of the comparisons.

336

337 Further examination of the relationship between presence of badger activity and
338 incidence area while controlling for land quality indicated that the adjusted odds ratio
339 (OR) was found to be not statistically significant (OR = 1.6 95% confidence interval
340 0.9 – 2.7). Thus when the effect of land quality was taken into account, the

341 relationship between badger activity and incidence area was no longer statistically
342 significant. However, the 95% confidence intervals for the adjusted measure of effect
343 did include the crude OR value, so this may be related to the power of the study rather
344 than to an absence of any association.

345

346 **Discussion**

347
348 The random sampling utilised for herd keeper selection and the good response rates
349 from herd keepers within the two areas enable valid conclusions to be drawn from the
350 information collected during the study. The issue of observer bias could not be
351 readily evaluated as each staff member normally covered distinct geographical areas.
352 However, various meetings with the staff suggested that the recording of information
353 would be factual. Moreover, the staff were in regular contact with each other which
354 again would assist in maintaining a standardised and balanced approach to completing
355 the returns. Misclassification bias arising from the lack of resource to survey all
356 farmland was investigated and was found to have no impact upon the findings of the
357 study.

358

359 Herd keepers within the high TB herd incidence area consistently reported more
360 sightings of badger activity (37% had seen badgers on their land, 8% had seen badgers
361 around the farm buildings while 40% had observed badger setts on their land)
362 compared to the low incidence area. Preliminary evaluation may conclude this
363 finding to indicate that the apparent increased level of badger activity and of badger
364 setts were correlated with increased TB incidence. However, a component of this
365 finding may be that herd keepers that have experienced a TB breakdown may be more
366 aware of the debate and possible links between badgers and the spread of TB to cattle

367 from this species and therefore such herd keepers would be more likely to recall
368 sightings of badgers and setts. The reverse may also be true for herd keepers in the
369 low TB incidence area i.e. they may have seen evidence of badger activity but have
370 not remembered about such sightings when questioned. Alternatively, the finding
371 may be factually correct which the authors would consider as the most likely option.

372

373 Indeed, the farm survey results did validate the above reports from herd keepers in
374 that there were significantly more farms with signs of badger activity in the high
375 incidence area (77% compared to 61%) and also badger setts were found more
376 frequently on farms in the high incidence area (70%) compared to the low incidence
377 area (57%). This finding would concur with some of the other studies that showed a
378 link between increased badger activity and/or sett density and increases in cattle TB
379 breakdowns (Wilesmith, 1983; Denny and Wilesmith, 1999), although other studies
380 were inconclusive in their findings (Olea-Popelka et al., 2006). It should be
381 remembered that farm size and herd size were similar across the two areas, which
382 adds further validation to the above finding.

383

384 The finding that there was a higher proportion of active badger setts on farms in the
385 high incidence area along with a lower average number of setts, was probably an
386 effect caused by the study design. The fact that the end point of each farm survey was
387 the disclosure of an active badger sett along with the finding that herd keepers in the
388 high incidence area were more aware of badger sett locations would have strongly
389 influenced this observation. Therefore no inference should be given to badger sett
390 proportions within this study. Additionally, no attempt was made to assess badger

391 density as the presence of an active badger sett was used only as an indication of
392 recent badger activity on the farm.

393

394 Similarly, the end point of disclosure of an active badger sett may have caused a non-
395 differential systematic bias in relation to the location of the badger setts (as the field
396 survey component of each farm was not completed randomly). The fact that the
397 positive predictive value for herd keepers identifying badger setts and badger activity
398 were very similar between the two areas would re-inforce the assumption that there
399 was no differential bias. Moreover, the fact that hedges were the main location of
400 badger setts on farm land in the island of Ireland and that active badger setts are more
401 commonly found on better quality agricultural land have been highlighted in other
402 studies (Feore, 1994; Smal, 1995; Feore and Montgomery, 1999; Reid et al., 2008).

403 These findings are also biologically plausible in that hedges do form the most
404 abundant type of cover for sett location on farm land and better quality agricultural
405 land normally provide both soil types that are easier for digging, have less tendency
406 for becoming water logged and provide a better potential food source for badgers.

407

408 The good response rate and high level of assistance freely given by herd keepers
409 during this voluntary survey is encouraging and should be taken into account for any
410 future work on badgers in the field. However, it should be remembered that herd
411 keepers were accurate at identification of presence of badger setts and sightings of
412 badgers on their land but a report of no sightings of setts and/or badgers on the land
413 cannot be relied upon.

414

415 Active badger setts were regularly found to be in relatively close proximity to farm
416 buildings (overall median 305 m) and there was also a preponderance for active
417 badger setts to be found on better-quality agricultural land. This has been found
418 previously by modelling of data collected during a national badger survey (Reid et al.,
419 2008), which indicated the suitability of land for badger setts was positively correlated
420 with improved land quality. This study (Reid et al., 2008) also recorded a direct
421 relationship between the number of badgers associated with a badger sett and the
422 higher the quality of the agricultural land. Both of these associations with land
423 classification are consistent with observing a higher level of badger activity in the
424 high tuberculosis herd incidence area. However, there was no statistical association
425 when the quality of agricultural land was controlled for. Nevertheless, even if land
426 quality is a major determinant in relation to badger sett location, this does not negate
427 the fact that this would increase the potential exposure of cattle in the high incidence
428 area to badgers.

429

430 **Conclusion**

431

432 In summary, this study has shown that there is evidence for increased badger activity
433 and setts in an area where the TB herd incidence is high. This would indicate the
434 potential for increased exposure of cattle in that area to badgers. However, the study
435 did not find a statistically significant association when the quality of agricultural land
436 was taken into account. Further work to examine these relationships in more detail is
437 indicated. The survey has also shown the willingness of herd keepers to assist with
438 future projects involving badger investigations.

439

440

441 **Acknowledgements**

442

443 The contribution of those involved in the field survey work is gratefully
444 acknowledged (Leo Black, John Coulter, Chris Hayes, Kathryn McBride, Elliott
445 Todd), particularly for completing the job so thoroughly and with such enthusiasm.
446 The expert technical and administrative input by Martina Monaghan and Charlie
447 Torbitt (document production, data entry and validation) was invaluable and greatly
448 appreciated. Statistical advice was obtained on the evaluation of misclassification
449 bias from Alan Gordon.

450

451 **Conflict of Interest Statement**

452

453 The authors have no conflict of interest.

454

455

456 **References**

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Table 1 - Summary of the main responses to badger sightings from the telephone questionnaire

Telephone Questionnaire Summary	High incidence area (193 farms)		Low incidence area (168 farms)		^Statistical Significance	Odds Ratio (95% CI)
	n	[%]	n	[%]		
Badgers seen on their farm land in last 2 years	72	[37.3%]	22	[13.1%]	***	3.95 (2.24 - 6.99)
Badgers seen around farm buildings in last 2 years	16	[8.3%]	1	[0.6%]	***	15.1 (2.28 - 636.8)
Badger setts seen on the farm land in last 2 years	77	[39.9%]	41	[24.6%]	**	2.04 (1.26 - 3.30)
If setts observed, how many are currently occupied#	36	[46.8%]	11	[26.8%]	N.S.	2.39 (0.98 - 5.94)

^* = P<0.05; ** = P<0.01; *** = P<0.001; N.S. = not statistically significant

45% (35) in the high incidence area & 61% (25) in the low incidence area did not know the status of the sett

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Table 2 - Summary of the main badger activity observations from the farm survey questionnaire

Farm Survey Questionnaire Summary	High incidence area (185 farms)		Low incidence area (162 farms)		^Statistical Significance	Odds Ratio (95% CI)
	n	[%]	n	[%]		
At least one badger sett located on farm	130	[70.3%]	92	[56.8%]	**	1.80 (1.13 - 2.87)
At least one active badger sett located on farm	104	[56.2%]	70	[43.2%]	*	
% farms with setts that had an active sett	104	[80.0%]	70	[76.1%]	N.S.	1.26 (0.63 - 2.51)
Evidence of active sett:						
Spoil heaps	104	[100%]	65	[92.9%]	**	Undefined
Fresh bedding	80	[76.9%]	43	[61.4%]	*	2.09 (1.02 - 4.29)
Badger hair	36	[34.6%]	41	[58.6%]	***	0.37 (0.19 - 0.73)
Latrines	28	[26.9%]	12	[17.1%]	N.S.	1.78 (0.79 - 4.08)
Other~	17	[16.3%]	25	[35.7%]	**	0.35 (0.16 - 0.76)
Active sett located on :main farm	78	[75.0%]	44	[62.9%]	N.S.	
: other farm	23	[22.1%]	26	[37.1%]		
: other	3	[2.9%]	0	[0.0%]		
Signs of badger activity	142	[76.8%]	98	[60.5%]	**	2.16 (1.32 - 3.53)
Evidence of badger activity:						
Latrines	40	[28.2%]	31	[31.6%]	N.S.	0.85 (0.47 - 1.54)
Badger pads	132	[93.0%]	89	[90.8%]	N.S.	1.33 (0.48 - 3.73)
Other	74	[52.1%]	65	[66.3%]	*	7.18 (2.56 - 24.69)

~ other signs were mainly pads/digs or old bedding

^ * = P<0.05; ** = P<0.01; *** = P<0.001; N.S. = not statistically significant

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Table 3- Badger sett locations within the high and low incidence areas

Sett Location	High incidence area: All setts		Low incidence area: All setts		High incidence area: Active setts		Low incidence area: Active setts	
	n	[%]	n	[%]	n	[%]	n	[%]
Woodland	19	[7.9%]	17	[8.1%]	16	[10.1%]	10	[10.8%]
Hedge	177	[73.8%]	129	[61.7%]	115	[72.3%]	50	[53.8%]
Rough ground	38	[15.8%]	38	[18.2%]	24	[15.1%]	13	[14.0%]
Other	6	[2.5%]	20	[12.0%]	4	[2.5%]	20	[21.5%]
Not stated	5		2		2		1	
Total	245		211		161		94	

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Table 4 - Percentage of farm buildings and active badger setts that were located within each agricultural land classification at a 0 metre buffer.

Land Quality Class	Farm buildings area		Badger sett area	
	High TB incidence	Low TB incidence	High TB incidence	Low TB incidence
Very good	7	6	7	6
Good	55	6	55	6
Moderate	3	76	3	76
Moderately poor	34	0	34	0
Poor/Other	1	13	1	13

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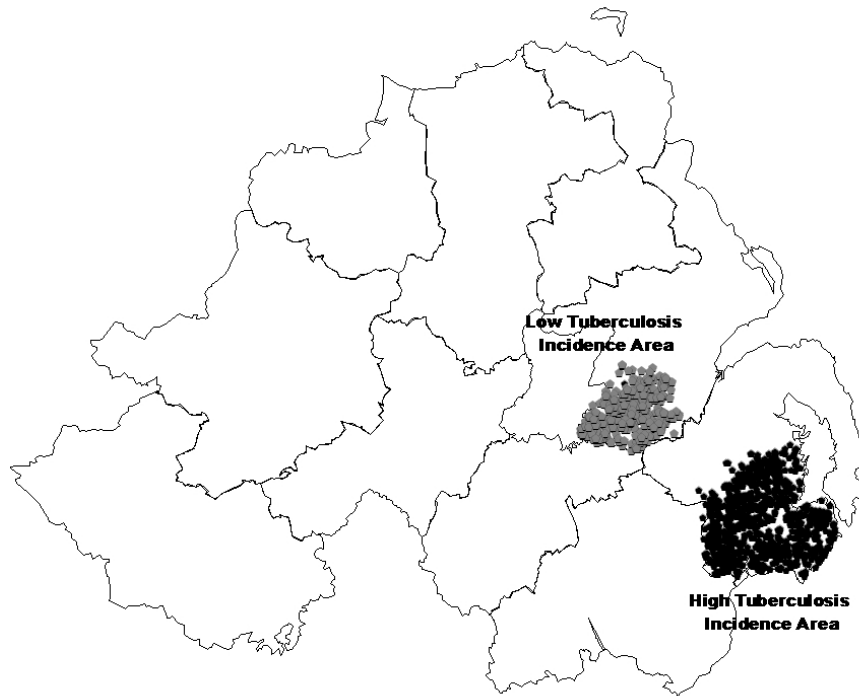
Table 5 - Percentage of farm buildings and active badger setts that were located within each agricultural land classification at a 500 metre buffer.

Land Quality Class	Farm buildings area		Badger sett area	
	High TB incidence	Low TB incidence	High TB incidence	Low TB incidence
Very good	3	5	3	4
Good	60	2	60	2
Moderate	5	87	5	87
Moderately poor	26	0	26	0
Poor	3	3	3	4
Very poor	3	3	3	3

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573 Figure 1 – Map showing the locations of the high and low tuberculosis herd incidence
574 areas used in the study
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