

RVC OPEN ACCESS REPOSITORY – COPYRIGHT NOTICE

This is the peer-reviewed, manuscript version of an article published in *Veterinary Record*.
The final version is available online via <https://doi.org/10.1136/vr.104956>.

The full details of the published version of the article are as follows:

TITLE: Colic in the British military working horse population: a retrospective analysis

AUTHORS: Tannahill, VJ., Cardwell, JM., Witte, TH

JOURNAL TITLE: *Veterinary Record*

PUBLISHER: BMJ Publishing Group

PUBLICATION DATE: 19 November 2018 (online)

DOI: 10.1136/vr.104956

1 **COLIC IN THE BRITISH MILITARY WORKING HORSE POPULATION – A RETROSPECTIVE**
2 **ANALYSIS**

3

4 **V.J. Tannahill BVMS CertAVP(EP)(VDI) MRCVS**

5 Royal Veterinary College, Hawkshead Lane, North Mymms, Hatfield, Hertfordshire AL9 7TA, United
6 Kingdom.

7 * Current Address: Weipers Centre Equine Hospital, School of Veterinary Medicine, University of
8 Glasgow, Bearsden Road, Bearsden, Glasgow G61 1QH.

9 victoria.tannahill@glasgow.ac.uk Tel: 0141 330 5999 Fax: 0141 330 6025

10

11 **J.M. Cardwell MA VetMB MSc(VetEd) PhD FHEA MRCVS**

12 Royal Veterinary College, Hawkshead Lane, North Mymms, Hatfield, Hertfordshire AL9 7TA, United
13 Kingdom.

14

15 **T.H. Witte BVetMed PhD FHEA DipACVS DipECVS MRCVS**

16 Royal Veterinary College, Hawkshead Lane, North Mymms, Hatfield, Hertfordshire AL9 7TA, United
17 Kingdom.

18

19 **WORD COUNT:** 4043

20

21 **KEYWORDS:** horse, colic, recurrent colic, signalment, incidence, mortality.

22 **ABSTRACT**

23 Colic is a common and potentially life-threatening condition of horses. Multiple risk factors have been
24 previously identified and it is known that a careful management routine can help to reduce colic rates.
25 The British military working horse population represents a unique cohort of horses that are
26 intensively managed with a strict regimen. This retrospective study examined the incidence and
27 mortality rate of colic within this population, as well as the signalment of affected horses, and
28 compared these with the general population. Data for 717 horses over a five-year period (2008-
29 2012) were analysed. Of these, 163 horses (22.7%) experienced 267 colic episodes and thirteen
30 horses (1.8%) died because of colic. Recurrent colic was experienced by 35% (57/163) of horses.
31 The incidence of colic was 11.1 episodes per 100 horse years and of colic-related death was 0.5
32 deaths per 100 horse years. Horses purchased from mainland Europe were more likely to suffer
33 from colic (OR4.6; $P<0.001$) and from recurrent colic (OR6.0; $P=0.005$) than horses purchased from
34 Ireland. Only 3% (8/267) of colic episodes were treated surgically. It was concluded that the
35 incidences of colic and colic-related deaths within the British military working horse population are
36 similar to those of the general horse population.

37 **INTRODUCTION**

38 Colic is an extensively described clinical syndrome in horses – numerous epidemiological studies
39 have described the age, sex and breed of horses suffering from colic, as well as the incidence and
40 mortality rate.¹⁻⁸ Further studies have evaluated the risk factors for colic including housing, feeding,
41 exercise and veterinary factors.^{3-4,7,9-14}

42

43 There are few studies investigating veterinary problems amongst military working horses. Putnam
44 *et al*¹⁵ recently described lameness within one subset of the British population while Laranjeira *et*
45 *al*¹⁶ detailed colic within a Brazilian population.

46

47 The British military working horse population represents a unique cohort of horses that are
48 intensively managed with strict regimens. They are divided into three distinct populations – the
49 Defence Animal Centre (DAC), the Household Cavalry Mounted Regiment (HCMR), and the King's
50 Troop Royal Horse Artillery (KTRHA). Horses are routinely stabled or stalled, undertake a minimum
51 of an hour of exercise on six days per week, and have a period of pasture rest for several weeks at
52 least once yearly. Roughage (hay or haylage) and concentrate feeding (generally chaff and fibre
53 nuts) are tailored to each individual horse's needs based on their exercise intensity and body
54 condition. All horses have access to fresh water from an automatic drinker or bucket when stabled
55 or stalled, and from a water trough when grazing. Stabling consists of a loose box where the horse
56 may move around freely. Stalling consists of an area where the horse is tethered by a headcollar
57 and retractable rope such that it may reach the floor to eat or drink, may lie down or may reach round
58 to groom itself, but it may not turn around completely within the stall. They are routinely vaccinated
59 against equine influenza and tetanus, and regularly de-wormed following a military-wide, rotational,
60 synchronized anthelmintic schedule. Dental examinations and treatment are conducted annually by
61 a veterinary surgeon or registered equine dental technician; those horses that require more frequent
62 treatment are afforded this as necessary. Veterinary care at each site is provided by a dedicated
63 veterinary surgeon and veterinary technician. All personnel involved in horse care are given regular
64 instruction regarding the signs of colic and the immediate action to be taken for cases of suspected
65 colic.

66

67 There are several features of the British military horse's regimen that may contribute to an increased
68 risk of colic; for example, stalling and reduced access to pasture,¹¹ exercising more than once per
69 week¹⁰ and having more than one care-giver.^{2,12} There are also some features of their management
70 that could contribute to a reduced colic rate; for instance, regular anthelmintic treatment and careful
71 dietary changes.¹⁰⁻¹¹

72

73 The aims of this retrospective cohort study were to describe the incidence and mortality rate of colic
74 within the British military working horse population, as well as the signalment of those horses
75 suffering from colic, and to compare these outcomes to the general horse population.

76 **MATERIALS AND METHODS**

77 Ethical approval for the retrospective collation of data from clinical records was obtained from the
78 Royal Veterinary College's Social Science Research Ethical Review Board. Permission to collate
79 and analyse the data was obtained from the Director Army Veterinary and Remount Services prior
80 to the start of the study. Data from the clinical records of horses that undertook military work at any
81 time between 1st January 2008 and 31st December 2012 were recorded. Records of those horses
82 that remained in military work were accessed from the veterinary clinics of the three populations.
83 Records of horses that concluded their military work (either through retirement, euthanasia or death)
84 during the study period were accessed from archived records.

85

86 Details of the horses' year of birth, sex, breed, country of purchase and population subset were
87 recorded. Country of purchase was categorised as: 'Ireland', meaning Northern Ireland and Republic
88 of Ireland; 'GB' (Great Britain), meaning England, Scotland and Wales; and 'Europe', meaning
89 mainland Europe. Population subset was categorised as: 'DAC' (Defence Animal Centre), 'HCMR'
90 (Household Cavalry Mounted Regiment), or 'KTRHA' (King's Troop Royal Horse Artillery). Each
91 horse's total time at risk during the study period (months) was calculated from its date of entry into
92 and date of exit from military work; for ease of calculation, one month was counted for each whole
93 month or part thereof that the horse was in military work. The number of colic episodes suffered by
94 the horse during the study period, and if the horse died or was euthanased because of colic, were
95 recorded. A horse was deemed to have suffered from a colic episode if either: a) an event of 'colic'
96 was recorded by the attending veterinary team, or b) clinical signs of colic including, but not limited
97 to, rolling, pawing, flank watching, kicking the abdomen or prolonged recumbency, with or without
98 reduced faecal output or reduced appetite, were recorded by the attending veterinary team. A colic
99 episode was deemed to have resolved when either: a) the veterinary team recorded that the horse
100 had 'returned to normal' or was 'discharged', or words to that effect, or b) when ≥ 48 hours had
101 passed before the next entry was made in the clinical record. For each colic episode, the month and
102 year of the episode, as well as the age of the horse at the time of the episode, and the treatment
103 received (medical or surgical), were recorded. Age (in years) was calculated on the assumption that
104 each horse was born on January 1st of its birth year, and the month of the colic episode was counted

105 as a whole month regardless of the day the colic episode occurred. Horses were deemed to have
106 died of colic when the clinical signs of colic directly preceded death. Horses were deemed to have
107 been euthanased due to colic when the veterinary surgeon's decision to euthanase the horse was
108 directly related to the colic episode.

109

110 Colic episodes were defined as being recurrent if ≥ 48 hours passed between colic episodes, during
111 which time no further abnormalities that may be associated with colic were recorded. The time at
112 risk (months) for horses with recurrent colic was calculated from the date of the first episode of colic
113 until the date of exit from military work.

114

115 Data were analysed using Stata® version 13 (StataCorp LP, College Station, Texas, USA).
116 Categorical variables (sex, country of purchase, population subset, month, year, treatment) were
117 summarised using number and percentage. Incidence rates were calculated by dividing the number
118 of episodes or deaths by the total time at risk (years) and multiplying by 100. Relationships between
119 sex, country of purchase and population subset of horses suffering from colic and recurrent colic
120 were examined using cross-tabulations and tested for significance using a univariable logistic
121 regression model. Variables with a univariable P -value of ≤ 0.1 were taken forward to multivariable
122 analysis. Models were built using a manual forward step-wise approach, with a likelihood ratio test
123 value of $P < 0.05$ used as the threshold for retention. Outliers were checked for data entry errors and
124 retained in the model. It was considered that there were no biologically plausible interactions. The
125 final fit of the final model was tested using the Hosmer-Lemeshow goodness-of-fit test. Exact
126 (Clopper Pearson) 95% confidence intervals were calculated around morbidity and mortality
127 estimates. Continuous variables (time at risk, total colic episodes, age) were tested for normality
128 using the Shapiro-Wilk test and were not found to follow a normal distribution. These were
129 summarised using median, minimum and maximum values. Significance was set at $P < 0.05$.

130 **RESULTS**

131 A total of 766 horses were identified as being in military work during the study period however 49
 132 clinical records, representing 6.4% of the eligible horses, were inaccessible and so were excluded
 133 from the study. Of the 717 horses that were included, 505 (70.4%) were geldings, 211 (29.4%) were
 134 mares and one (0.1%) was a colt. A total of 35 different horse breeds were recorded and 493 (68.8%)
 135 horses had no breed listed. The three most common horse breeds were Irish Sport Horse and
 136 associated cross-breeds (n=115; 16.0%), Irish Draught and associated cross-breeds (n=34; 4.7%)
 137 and KWPN (n=12; 1.7%). The majority of horses (n=511; 71.3%) were purchased from Ireland, 181
 138 (25.2%) were from GB and 25 (3.5%) were from elsewhere in mainland Europe. Just over half
 139 (n=378; 52.7%) of horses were from the HCMR, 176 (24.5%) were from the KTRHA and 163 (22.7%)
 140 were from the DAC. The total time at risk was 28,750 months (2395.8 years; range 1-60) and 266
 141 (37.1%) horses were at risk for the entire study period (60 months).

142
 143 A total of 163 (22.7%; 95%CI 19.7-26.0) horses suffered colic during the study period and there were
 144 267 colic episodes in total. The majority of horses (n=106; 65.0%) that suffered colic only had one
 145 episode during the study period. The maximum number of episodes suffered by any horse was
 146 thirteen (Figure 1). The incidence of colic was 11.1 episodes per 100 horse years. The median age
 147 of horses experiencing a colic episode during the study period was 9.8 years (range 3.7-23.8). The
 148 number of colic episodes per month and per year are shown in Figure 2. Most colic episodes (n=259;
 149 97.0%) were treated by medical means while eight (3.0%) cases underwent surgical treatment.
 150 Univariable and multivariable relationships between recorded variables and occurrence of colic are
 151 summarised in Table 1.

152
 153 **Table 1 – Univariable and multivariable associations with occurrence of colic in a**
 154 **population of British military working horses (n=717).**

		Colic				Univariable			Multivariable		
		No		Yes		Crude OR	95% CI	P-value	Adjusted OR	95% CI	P-value
		n	%	n	%						
Sex	<i>Male</i>	389	76.9	117	23.1	ref					
	<i>Female</i>	165	78.2	46	21.8	0.9	0.6 – 1.4	0.7			
Country of Purchase	<i>Ireland</i>	399	78.1	112	21.9	ref			ref		
	<i>GB</i>	143	79.0	38	21.0	0.9	0.6 – 1.4	0.8	1.1	0.7 – 1.7	0.7
	<i>Europe</i>	12	48.0	13	52.0	3.9	1.7 – 8.7	0.001	4.6	2.0 – 10.5	<0.001

Population	HCMR	279	73.8	99	26.2	ref			ref		
	KTRHA	142	80.7	34	19.3	0.7	0.4 – 1.0	0.08	0.6	0.4 – 1.0	0.08
	DAC	133	81.6	30	18.4	0.6	0.4 – 1.0	0.05	0.6	0.4 – 0.9	0.02

155 OR = odds ratio. CI = confidence interval. Ref = reference variable.

156

157 Fifty-seven horses (35%; 95%CI 27.7-42.8) suffered from recurrent colic and they experienced 104
 158 episodes of colic. The total time at risk was 1901 months (238.5 years; range 2-60). The incidence
 159 of recurrent colic was 65.7 episodes per 100 horse years. The median age of horses experiencing
 160 a recurrent colic episode during the study period was 8.8 years (range 5.8-21.4). The number of
 161 recurrent colic episodes per month and per year are shown in Figure 3. Most recurrent colic episodes
 162 (n=100; 96.2%) were treated medically however four (3.8%) cases underwent surgical treatment.
 163 Univariable and multivariable relationships between recorded variables and occurrence of recurrent
 164 colic are summarised in Table 2.

165

166 **Table 2 – Univariable and multivariable associations with occurrence of recurrent colic in a**
 167 **population of British military working horses suffering from colic (n=163).**

		Recurrent Colic				Univariable			Multivariable		
		No		Yes		Crude OR	95% CI	P-value	Adjusted OR	95% CI	P-value
Sex		n	%	n	%						
Sex	Male	81	69.2	36	30.8	ref			ref		
	Female	25	54.3	21	45.7	1.9	0.9 – 3.8	0.08	2.2	1.0 – 4.5	0.04
Country of Purchase	Ireland	78	69.6	34	30.4	ref			ref		
	GB	24	63.2	14	36.8	1.3	0.6 – 2.9	0.5	1.4	0.6 – 3.1	0.4
	Europe	4	30.8	9	69.2	5.2	1.5 – 17.9	0.01	6.0	1.7 – 21.4	0.005
Population	HCMR	68	68.7	31	31.3	ref					
	KTRHA	20	58.8	14	41.2	1.5	0.7 – 3.4	0.3			
	DAC	18	60.0	12	40.0	1.5	0.6 – 3.4	0.4			

168 OR = odds ratio. CI = confidence interval. Ref = reference variable.

169

170 Thirteen horses died or were euthanased due to colic during the study period giving an overall
 171 mortality rate of 1.8% (95%CI 1.0-3.1) in the entire study population (n=717) and an incidence of 0.5
 172 deaths per 100 horse years. Amongst those horses experiencing a colic episode (n=163), the
 173 mortality rate was 8.0% (95%CI 4.3-13.2). Nine horses (69.2%) were geldings and four (30.8%) were
 174 female. The majority (n=11; 84.6%) were purchased from Ireland with only one (7.7%) from GB and
 175 one (7.7%) from the rest of mainland Europe. Most (n=11; 84.6%) were from the HCMR with only
 176 one horse (7.7%) from each of the KTRHA and DAC. The median age of horses dying from colic
 177 during the study period was 12.5 years (range 5.7-21.8).

178

179 Seven horses with recurrent colic died or were euthanased during the study period giving an overall
180 mortality rate of 1.0% (95%CI 0.4-2.0) in the entire study population (n=717). Amongst those horses
181 experiencing recurrent colic episodes (n=57), the mortality rate was 12.3% (95%CI 5.1-23.7) and
182 the incidence was 4.4 deaths per 100 horse years. There were four female horses (57.1%) and three
183 geldings (42.9%). The majority of horses (n=6; 85.7%) were from Ireland with only one (14.3%) from
184 GB. Most (n=6; 85.7%) were from the HCMR with only one (14.3%) from the KTRHA. The median
185 age of horses dying from recurrent colic during the study period was 14.2 years (range 8.1-17.8).

186

187 Seven out of eight horses (87.5%; 95%CI 47.3-99.7) that underwent surgery at an equine referral
188 hospital were euthanased, including all four horses undergoing surgical treatment for recurrent colic.
189 In three cases a large colon abnormality was identified but the colon ruptured during surgery. One
190 further horse was euthanased on the operating table with a diagnosis of septic peritonitis. The
191 remaining three horses survived surgery but were subsequently euthanased due to post-operative
192 colic or ileus. Due to the small numbers of horses that died or were euthanased, further statistical
193 analyses were not conducted.

194 **DISCUSSION**

195 The results of this retrospective cohort study have defined the signalment, incidence and mortality
196 rate of colic within the British military working horse population.

197

198 The incidence of colic in this study population was 11.1 episodes per 100 horse years. Published
199 incidence rates of the general horse population in temperate climates vary from 3.5-26.0 cases per
200 100 horse years.^{2-3,6-8,14} This population is therefore within the mid-range of previously established
201 figures. Hillyer *et al*² recognised that the true incidence of colic is likely to be underestimated by
202 practice-based surveys. The current figure is therefore likely to be closer to a true incidence than
203 other studies because every episode of colic in this population is reported to the veterinary team and
204 recorded in the clinical record, regardless of the severity of the colic episode or the treatment
205 undertaken.

206

207 Only two previous studies estimate the overall mortality rate of colic in the general population:
208 Kaneene *et al*¹⁷ found that 0.6% (10/1818; 95%CI 0.3-1.0) of horses died from colic, while Higuchi's¹⁸
209 study reported an estimate of 2.0% (306/15,208; 95%CI 1.8-2.2). In this study population the result
210 was 1.8% with a 95% confidence interval of 1.0-3.1%. Published estimates of the mortality rate
211 amongst horses suffering from colic^{2-3,6-7,17,19} (excluding studies examining referral equine
212 populations) range from 6.3% (32/509; 95%CI 4.3-8.8)² to 13.0% (10/77; 95%CI 6.4-22.6),³ which
213 is again comparable with our estimate of 8.0% (95%CI 4.3-13.2). Finally, in our study the incidence
214 of mortality was 0.5 cases per 100 horse years, which is comparable with published values of
215 between 0.24 and 0.7 cases per 100 horse years.^{1-3,6} We therefore concluded that the occurrence
216 of colic-related deaths in British military working horse population does not differ significantly from
217 that of the general population.

218

219 In our study, sex was not associated with the likelihood of suffering a colic episode. There is a single
220 study in which geldings were found to have a reduced risk of colic³ and another that found geldings
221 have an increased risk of colic,²⁰ but the current findings fit with the majority of studies which state
222 that the risk of colic does not vary by sex.^{1,4-7,9,12,19,21-22}

223

224 Given that the majority of horses had no specific breed listed in their documentation, the country of
225 purchase was investigated as an alternative parameter which may give some indication of breed-
226 associated relationships. Horses purchased from mainland Europe had a higher rate of colic than
227 those from Ireland or GB. Most of the military working horses that originate from mainland Europe
228 may be classified as warm blood types as opposed to the Irish and GB horses which would generally
229 be classed as cold blood types. These results are therefore in accordance with previous studies
230 identifying higher rates of colic in Warmbloods and Thoroughbreds than in cold blood breeds.^{1,11}

231

232 Although all British military working horses are managed in a highly structured manner, there are
233 some substantial differences between the three populations, depending on their role. For instance,
234 the horses at the DAC are more likely to undertake schooling work and are all stabled whereas the
235 HCMR horses primarily undertake road work and are mainly stalled. The lower occurrence of colic
236 in the DAC than in HCMR horses observed in this study may be explained by DAC horses having
237 more ready access to pasture¹¹ and more regulated care-giving^{2,5} compared with the HCMR horses.

238

239 Previously reported median/mean ages of horses experiencing colic episodes range from 4.8 to 10.3
240 years.^{1,3-5,12,20-21} Some studies report an increased risk of colic with increasing age^{1,5,18} whilst others
241 report no association.^{19,21} The median age of 9.8 years in our study population was therefore at the
242 higher end of the range of other studies. British military working horses are typically selected for
243 purchase at around five years of age and consequently there were only a small number of younger
244 horses in the current study population. We also found that the median age of horses dying from colic
245 (12.5 years) was greater than for horses experiencing colic in general; it is also often stated that the
246 risk of colic-related mortality increases with age.^{1,3,5,18}

247

248 There are variable reports of the seasonality of colic although most reports find an increase in the
249 spring.^{2,6-7,18-19} The highest number of colic episodes during this study were in November and
250 June/July. These months coincide with the tail-end of the busiest periods of ceremonial activities,
251 with multiple parade rehearsals and disruption to the horses' daily routine in the weeks running up

252 to these times, followed by a complete change in routine as the horses are moved to grass turnout
253 for a number of weeks over the summer or winter. Conversely, December and January are a quiet
254 time in the ceremonial calendar for the horses; their regimen is more strictly adhered to and more
255 horses are at pasture thereby resulting in fewer colic episodes at this time of year. Although we did
256 not analyse the occurrence of colic across years, Egenvall *et al*¹ found no pattern of colic incidence
257 across the six years of their study.

258

259 Only 3% of the study population were referred for surgery at an equine referral hospital which is
260 comparable to published estimates ranging from 1.4 to 17.0%.^{2-3,7} Reported estimates of mortality²⁻
261 ^{3,5,20-22} of horses undergoing colic surgery range from 30.8% (4/13; 95%CI 9.1-61.4)³ to 58.0%
262 (195/336; 95%CI 52.6-63.4)²² with a grave prognosis (between 97.3²² and 100%⁵ mortality) for
263 horses whose viscera rupture during surgical manipulation. The surgery mortality rate in our study
264 population was high (87.5%; 95%CI 47.3-99.7), probably because the management of colic cases
265 within barracks went beyond what would be expected of a normal primary care veterinary surgeon
266 and horses were only referred for surgery when their condition deteriorated, by which time the overall
267 prognosis for survival had already reduced. However, because of the very small numbers of horses
268 that underwent surgery in our study population the confidence intervals are very wide, and they do
269 overlap with published estimates of surgical mortality rates.

270

271 Multiple studies briefly document the number of horses experiencing more than one colic episode
272 during their study period,^{2,3,6,13,19} however few studies specifically examine recurrent colic.²³⁻²⁵ The
273 definition of recurrent colic differs between these studies; most recently Scantlebury *et al* (2011)
274 defined it as a subsequent episode of colic that occurred “on the proviso that the horse had been
275 free from colic signs, eating a normal diet and passing normal faeces for a full 48 hours since the
276 end of the previous colic episode”. Due to the variety of detail contained within the clinical records
277 of this population, it was not always explicitly stated that an episode of colic had resolved. We
278 therefore defined an episode of colic as being recurrent if at least 48 hours passed between colic
279 episodes, during which time the clinical record recorded no further abnormalities that may be
280 associated with colic and we took this to mean that the horse had returned to normal feeding and

281 faecal output. Based on this assumption, we found that 35% of horses (95%CI 27.7-42.8) suffering
282 from colic experienced recurrent colic episodes and that the incidence of recurrent colic was 65.7
283 recurrent episodes per 100 horse years. Reported estimates of recurrent colic vary from 3.9% (7/179;
284 95%CI 1.6-7.9)¹⁹ to 53.4% (102/191; 95%CI 46.1-60.6)¹³ with the most recent study²⁴ documenting
285 an estimate of 36.5% (38/104; 95%CI 27.3-46.5) and an incidence of 50 episodes per 100 horse
286 years which is broadly similar to our findings. Scantlebury *et al's* study²⁴ also recorded a recurrent
287 colic mortality rate of 10.5% (4/38; 95%CI 2.9-24.8) and an incidence of death from recurrent colic
288 of 3.37 deaths per 100 horse years. These findings are also similar to our own which were 12.3%
289 (95%CI 5.1-23.7) and 4.4 deaths per 100 horse years respectively.

290

291 We found that female horses were more likely to suffer from recurrent colic than male horses; this is
292 in contrast to Scantlebury's study²⁵ which found no relationship with sex. Signs of colic are not always
293 linked to gastrointestinal pain and female horses may experience colic episodes attributable to
294 reproductive tract pain, either in relation to seasonal behaviour or reproductive tract abnormalities.

295

296 As we found with all colic episodes, horses from Europe were more likely to suffer from recurrent
297 colic than horses purchased from Ireland. A previous report found no association with breed²⁵
298 however this may again be explained by the country of purchase relating to breed type, as previously
299 discussed.

300

301 The median age of horses suffering from recurrent colic episodes in our population was 8.8 years
302 which is slightly younger than previously reported (11 years)²⁴ however no association of age with
303 occurrence of recurrent colic has been documented.²⁵ The median age of horses dying from
304 recurrent colic in this study was 14.2 years however there are no previously recorded findings to
305 compare this figure to.

306

307 The highest number of recurrent colic episodes occurred in November, which was also the peak time
308 for all colic episodes. The least recurrent colic episodes occurred in January and June; January was
309 also a quiet time for colic in the whole population however June and July were the second busiest

310 months for colic. Season is not discussed in any of the publications regarding recurrent colic²³⁻²⁵ so
311 it is difficult to draw any worthwhile conclusions. The highest number of recurrent colic episodes
312 occurred in 2011 and 2012 which is also similar to the occurrences of all colic episodes, however
313 there was a much lower number of recurrent colic episodes in 2008, in contrast to the number of
314 colic episodes overall. This may represent either an increase in the number of horses experiencing
315 recurrent colic or increased identification of subtle colic signs in horses that were prone to recurrent
316 colic episodes.

317

318 Four (3.8%) episodes of recurrent colic were treated surgically in comparison to Scantlebury *et al's*
319 study²⁴ in which 12.5% underwent surgery. Our estimate may represent more horses experiencing
320 low grade, mild colic that did not require surgical treatment. Cases of colic may also have been
321 recognised sooner, especially in horses that were known to be prone to colic, enabling prompt
322 effective treatment before the case required surgical intervention.

323

324 In any study describing a disease process, the results obtained are dependent on the specific study
325 design and population. This is accentuated when considering equine colic studies where data may
326 be gathered from owners, primary care vets, referral hospitals or insurance statistics, and the study
327 population ranges across many different countries and specific horse groups. Although this study
328 has detailed yet another cohort of horses, the intensive nature of their day-to-day management is
329 not dissimilar to other strict horse management regimens (e.g. police horses, racehorses) therefore
330 these results may be applicable to such populations.

331

332 Despite their intensive management, British military working horses do not seem to experience a
333 higher rate of colic or colic-related death than the general equine population. We did not attempt to
334 establish specific risk factors in this population due to the variety of detail recorded in the clinical
335 records and due to non-availability of details regarding factors such as daily exercise, pasture turnout
336 and stereotypical behaviours. However, some previously identified risk factors are pertinent in this
337 population, for example stalling and reduced access to pasture,¹¹ exercising more than once per
338 week¹⁰ and having more than one care-giver.^{2,12} Equally, some features of the management of these

339 horses are likely to contribute to a reduced colic rate, for instance regular anthelmintic treatment and
340 careful dietary changes.¹⁰⁻¹¹ Risk factors for recurrent colic include stereotypical behaviours (crib-
341 biting,²⁴⁻²⁵ windsucking²⁴⁻²⁵ and weaving²⁵) as well as known dental abnormalities,²⁴ and increased
342 time at pasture is associated with a reduced risk.²⁵ It is not possible to comment on the association
343 of stereotypical behaviour on the risk of recurrent colic in this population as the clinical records do
344 not note such behaviours. Further studies would be required to identify and quantify the risk factors
345 within this unique population including, but not limited to: dietary management, stereotypical
346 behaviours, access to pasture and daily exercise regimen/ceremonial parade schedule.

347

348 The biggest limitation of this study was the retrospective analysis of data. Further description of each
349 colic episode to determine investigatory procedures, diagnosis, treatment given, and potential risk
350 factors was not possible due to a lack of specific clinical notes relating to these parameters in many
351 cases. The limited nature of this population is also recognised with only small numbers of young (<5
352 years old) and geriatric (>20 years old) horses, and of entire male horses.

353

354 This retrospective cohort study concludes that, despite their intensive management regimen, the
355 occurrence of both colic and colic-related deaths within the British military working horse population
356 are similar to those of the general horse population.

357 **COMPETING INTERESTS**

358 V.J. Tannahill is a serving Reserve Veterinary Officer in the Royal Army Veterinary Corps. J.M.
359 Cardwell and T.H. Witte have no competing interests to declare.

360

361 **ACKNOWLEDGEMENTS**

362 We are grateful to Lt Col M. Morrison RAVC for his help in reviewing the final manuscript.

363

364 **FUNDING**

365 None to declare.

366

367 **AUTHORSHIP**

368 V.J. Tannahill contributed to all aspects of the study. J.M. Cardwell contributed to analysis and
369 interpretation of data, manuscript preparation, and final approval. T.H. Witte contributed to study
370 design, manuscript preparation and final approval.

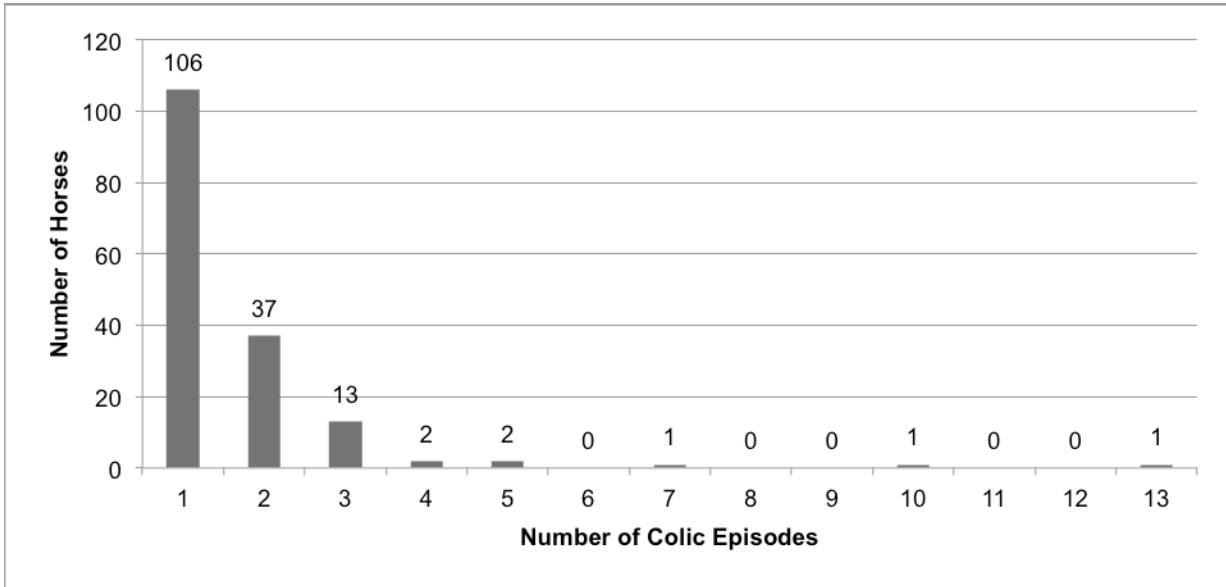
371 **REFERENCES**

- 372 1. Egenvall, A., Penell, J., Bonnett, B.N., Blix, J. and Pringle, J. (2008) Demographics and Costs
373 of Colic in Swedish Horses. *J Vet Intern Med* **22**,1029-1037.
- 374 2. Hillyer, M.H., Taylor, F.G.R. and French, N.P. (2001) A cross-sectional study of colic in horses
375 on Thoroughbred training premises in the British Isles in 1997. *Equine Vet J* **33**,380-385.
- 376 3. Kaneene, J.B., Miller, R., Ross, W.A., Gallagher, K., Marteniuk, J. and Rook, J. (1997) Risk
377 factors for colic in the Michigan (USA) equine population. *Prev Vet Med* **30**,23-36.
- 378 4. Mehdi, S. and Mohammad, V. (2006) A Farm-Based Prospective Study of Equine Colic
379 Incidence and Associated Risk Factors. *J of Equine Vet Sci* **26**,171-174.
- 380 5. Reeves, M.J., Gay, J.M., Hilbert, B.J. and Morris, R.S. (1989) Association of Age, Sex and
381 Breed Factors in Acute Equine Colic: A Retrospective Study of 320 Cases Admitted to a
382 Veterinary Teaching Hospital in the USA. *Prev Vet Med* **7**,149-160.
- 383 6. Tinker, M.K., White, N.A., Lessard, P., Thatcher, C.D., Pelzer, K.D., Davis, B. and Carmel,
384 D.K. (1997) Prospective study of equine colic incidence and mortality. *Equine Vet J* **29**,448-
385 453.
- 386 7. Traub-Dargatz, J.L., Koprak, C.A., Hillberg Seitzinger, A., Garber, L.P., Forde, K. and White,
387 N.A. (2001) Estimate of the national incidence and operation-level risk factors for colic among
388 horses in the United States, spring 1998 to spring 1999. *JAVMA* **219**,67-71.
- 389 8. Uhlinger, C. (1992) Investigations into the incidence of field colic. *Equine Vet J* **13**,16-18.
- 390 9. Archer, D.C., Pinchbeck, G.L., Proudman, C.J. and Clough, H.E. (2006) Is equine colic
391 seasonal? Novel application of a model based approach. *BMC Vet Res* **2**,1-11.
- 392 10. Cohen, N., Gibbs, P. and Woods, A. (1999) Dietary and Other Management Factors
393 Associated with Equine Colic. *AAEP Proceedings* **45**,96-98.
- 394 11. Hudson, J.M., Cohen, N.D., Gibbs, P.G. and Thompson, J.A. (2001) Feeding practices
395 associated with colic in horses. *JAVMA* **219**,1419-1425.
- 396 12. Reeves, M.J., Salman, M.D. and Smith, G. (1996) Risk factors for equine acute abdominal
397 disease (colic): Results from a multi-center case-control study. *Prev Vet Med* **26**,285-301.
- 398 13. Salem, S.E., Scantlebury, C.E., Ezzat, E., Abdelaal, A.M. and Archer, D.C. (2017) Colic in a
399 working horse population in Egypt: Prevalence and risk factors. *Equine Vet J* **49**,201-206.

- 400 14. Tinker, M.K., White, N.A., Lessard, P., Thatcher, C.D., Pelzer, K.D., Davis, B. and Carmel,
401 D.K. (1997) Prospective study of equine colic risk factors. *Equine Vet J* **29**,454-458.
- 402 15. Putnam, J.R., Holmes, L.M., Green, M.J. and Freeman, S.L. (2014) Incidence, causes and
403 outcomes of lameness cases in a working military horse population: a field study. *Equine Vet*
404 *J* **46**,194-197.
- 405 16. Laranjeira, P.V.E.H., Almeida, F.Q. de, Pereira, M.J.S., Lopes, M.A.F., Campos, C.H.C. de,
406 Caluby, L., C. de A.B. and Souza, P.N.B. de. (2009) Profile and distribution of equine colic
407 syndrome in three military units in Rio de Janeiro, Brazil. *Cienc Rural* **39**,1108-1115.
- 408 17. Kaneene, J.N., Ross, W.A. and Miller, R. (1997) The Michigan equine monitoring system. II.
409 Frequencies and impact of selected health problems. *Prev Vet Med* **29**,277-292.
- 410 18. Higuchi, T. (2006) A Retrospective Survey of Equine Acute Abdomen in a Breeding Region of
411 Japan based on Agricultural Mutual Relief Insurance Data. *J Equine Sci* **17**,17-22.
- 412 19. Proudman, C.J. (1991) A two-year prospective survey of equine colic in general practice.
413 *Equine Vet J* **24**,90-93.
- 414 20. Abutarbush, S.M., Carmalt, J.L. and Shoemaker, R.W. (2005) Causes of gastrointestinal colic
415 in horses in western Canada: 604 cases (1992 to 2002). *Can Vet J* **46**,800-805.
- 416 21. Sutton, G.A., Ertzman-Ginsburg, R., Steinman, A. and Milgram, J. (2009) Initial investigation
417 of mortality rates and prognostic indicators in horses with colic in Israel: A retrospective study.
418 *Equine Vet J* **41**,482-486.
- 419 22. Christophersen, M.T., Dupont, N., Berg-Sørensen, K.S., Konnerup, C., Pihl, T.H. and
420 Andersen, P.H. (2014) Short-term survival and mortality rates in a retrospective study of colic
421 in 1588 Danish horses. *Acta Vet Scand* **56**,20.
- 422 23. Hillyer, M.H. and Mair, T.S. (1997) Recurrent colic in the mature horse: A retrospective review
423 of 58 cases. *Equine Vet J* **29**,421-424.
- 424 24. Scantlebury, C.E., Archer, D.C., Proudman, C.J. and Pinchbeck, G.L. (2011) Recurrent colic
425 in the horse: Incidence and risk factors for recurrence in the general practice population.
426 *Equine Vet J* **43**(Suppl.39),81-88.

427 25. Scantlebury, C.E., Archer, D.C., Proudman, C.J. and Pinckbeck, G.L. (2015) Management and
428 horse-level risk factors for recurrent colic in the UK general equine practice population. *Equine*
429 *Vet J* **47**,202-206.

430 **FIGURE LEGENDS**

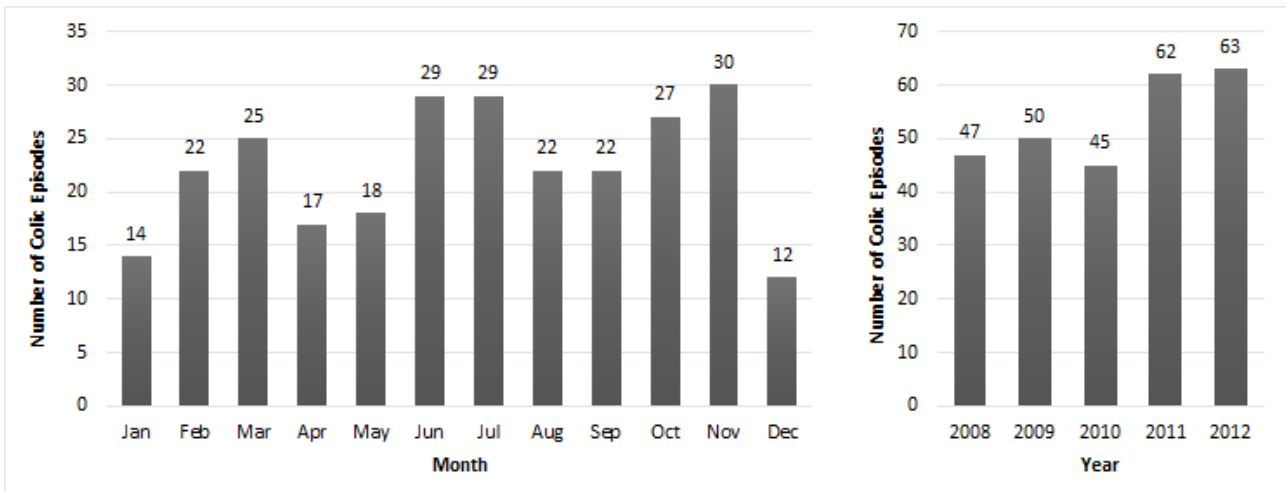


431
432 **Figure 1** – Number of colic episodes for each horse experiencing colic.

433

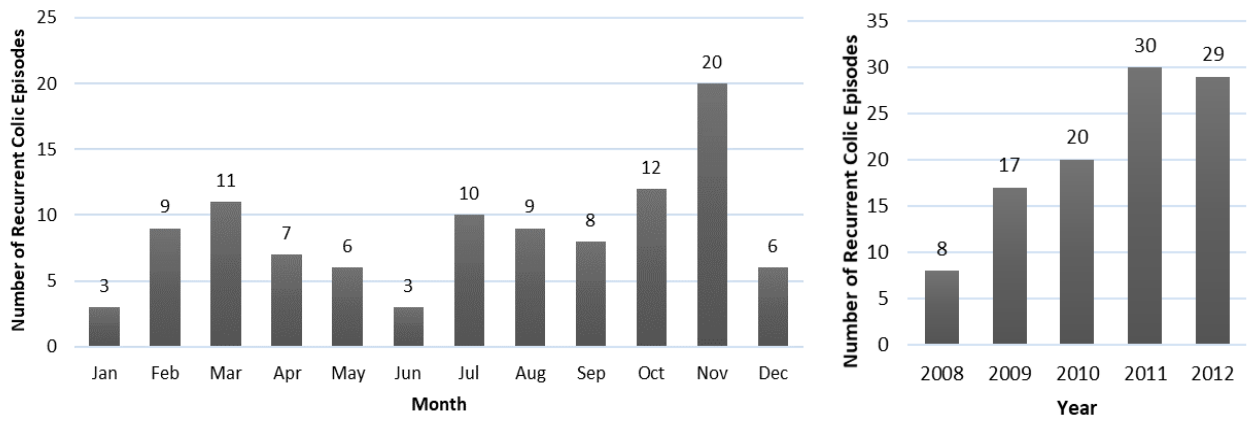
434

435



436
437 **Figure 2** – Number of colic episodes per month and per year.

438



439

440 **Figure 3** – Number of recurrent colic episodes per month and per year.