Equine Veterinary Journal

Equine Veterinary Journal ISSN 0425-1644
DOI: 10.1111/evj.12573

Colic in a working horse population in Egypt: Prevalence and risk factors

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Summary

Reasons for performing study: Colic is an important health problem in managed horse populations. Currently, there is limited information about colic prevalence and risk factors for colic in working horse populations.
Objectives: To determine the prevalence of, and risk factors for, colic in a working horse population in Egypt and to describe management practices in this working horse population.
Study design: Cross-sectional survey.
Methods: Owners of 350 working horses were interviewed. Data about their horses, management and colic episodes in the preceding 12 months were collected. Dental examination was conducted on 342 horses and blood samples (n = 100) were collected for immunodiagnosis of tapeworm (*Anoplocephala perfoliata)* infection. Multivariable logistic regression analysis was used to identify risk factors for a history of colic in the preceding 12 months.
Results: The 12-month prevalence of colic was 54.6%. Severe and moderate tapeworm infection intensity was identified in 3% and 26% of horses tested, respectively. Horses that had severe dental disease (odds ratio [OR] 6.8, 95% confidence interval [CI] 1.9–24.3, P<0.001), that displayed stereotypic behaviour (OR 2.0, 95% CI 1.15–3.5, P = 0.013), were fed ground corn during the 'dry season' (OR 1.65, 95% CI 1.03–2.6, P = 0.035) or that had received an anthelmintic in the previous 6 months (OR 2.1, 95% CI 1.3–3.3, P = 0.003) were more likely to have a history of colic in the preceding 12 months. Horses fed on rice bran during the 'green season' (OR 0.47, 95% CI 0.26–0.9, P = 0.015) and that displayed geophagia/coprophagia (OR 0.19, 95% CI 0.05–0.73, P = 0.001) were less likely to have a history of colic.
Conclusions: Colic is common in this working horse population and this study has identified factors associated with altered likelihood of colic. The study provides important information that may be used to inform future prospective studies investigating colic in working horse populations and to assist development of preventive healthcare strategies.

The Summary is available in Chinese – see Supporting information

Keywords: horse; working horses; Egypt; colic; risk factors; prevalence

Introduction

Abdominal pain (colic) is common in horses and it is frequently associated with death or euthanasia in managed horse populations [1,2]. Based on estimates from the UK and the USA, colic has a reported incidence rate of 4–26 episodes per 100-horse-years-at-risk [3–6] and a case fatality rate of 6.7–11% [4,5]. At present, there is limited information about the prevalence and impact of colic in other countries, particularly where working equid populations predominate. Colic was reported as a significant welfare issue and of great concern among owners of working equids in Ethiopia [7,8]. A 12-month prevalence of 32.5% and a 5-month prevalence of 13.2% were reported by the owners of working equids in Romania and India, respectively [9,10]. A hospital case fatality rate of 27% was reported in Ethiopia [7].

Many horse- and management-level risk factors have been reported to be associated with an altered likelihood of colic. Identified risk factors in managed horse populations (predominantly in the USA and the UK) include: age, breed, previous colic episodes, crib-biting/windsucking behaviour, internal parasites, feeding practices and feed types changes, and exercise and turnout regimes [11]. This knowledge has been used to inform colic prevention strategies relevant to these equine populations. However, for working equid populations, such evidence is lacking. In addition, the information available from colic epidemiology studies based in the USA and Europe may not be directly relevant to working equids in developing countries as management practices, climatic conditions, diet and access to prophylactic veterinary care may vary. Intestinal obstruction and impaction due to eating coarse feed stuffs or nonfood substances such as polyethylene bags [7,12] and intestinal parasitism [13] were the common reported causes of colic in some working equine populations. Previously, a few case reports and experimental studies of colic [14–16] have originated from Egypt, but these may have limitations based on the number of cases involved and were largely drawn from a referral caseload and therefore were not able to provide estimates of the prevalence or risk factors of colic within the general population.

Therefore, the aims of this study were to determine the prevalence of, and risk factors for, colic in a working horse population in Egypt and to describe management practices in this working horse population.

Material and methods

Study population

A flow chart detailing recruitment of participants, data acquisition and reporting of results is given in Supplementary Item 1. The study population included working horses from 2 provinces in Egypt. Horses were recruited from 41 villages and 2 cities within 10 different regions in Al Sharquiya province and 3 different regions in Al Dakahliya province (Supplementary Item 2). Village selection was based on availability of a local veterinary surgeon or a village resident who was willing to assist in recruitment of horse-owners. A mobile clinic was used to visit the study areas and on arrival, announcements were made using a microphone. Horses of all ages, regardless of any history of dental examination or any concurrent medical conditions were eligible to be included in the study. Timing of the study was targeted between 27 September and 8 November 2014 that coincided with the end of the agricultural crop cycle in Egypt where there are seasonal differences in work and feed types that horses are exposed to between the green 'Berseem' season (November–May) and the dry 'rice' season (July–October).

Data collection

Owner questionnaire: A questionnaire (Supplementary Item 3) was constructed using information available from previous epidemiological studies on colic [11] and knowledge of management practices of working horses in Egypt. Questions were grouped into the following sections: horse identification; horse background; medical history including details of any previous colic episodes; horse behaviour; details of use; stabling and turnout regimen; nutritional management including types of feeds during green and dry seasons; and history of any dental and anthelmintic treatment.

The questionnaire was designed using Epi Info 7[a] software and question formats included closed and open-ended questions. The questionnaire was piloted and revised accordingly. Horse-owners completed the study questionnaire with one of the study team while the dental examination was conducted and blood samples were collected by a veterinary surgeon. In an attempt to validate owner-reported colic episodes, horse-owners were asked to describe clinical signs (behavioural alterations) that horses demonstrated during the colic episodes [3]. In order to record a second colic episode for a given horse, an intervening period of normal work and feed of at least 48 h had to be reported. For each colic episode reported, the horse-owner was asked to provide the following information: the date it occurred, whether a veterinary surgeon had attended, any treatments administered including pharmaceuticals and conservative/alternative therapies, an estimation of the duration of colic (in h) and the owners opinions about what they thought may have caused each colic episode. The data were entered into Epi Info 7[a].

Clinical examination: Horses underwent a full dental examination using a dental speculum, light source and dental mirror; horses were excluded from this part of the study if this could not be performed without sedation or if owners did not give consent for this to be performed [17]. Age estimation was based on history taken from the owner and examination of incisor morphology [18]. Weight and height were determined using a measuring tape (Easy-Measure)[b] and body condition score was evaluated on a 6-point scale of zero to 5 [19]. Ten ml of blood was collected from the jugular vein of each horse and was placed into EDTA (for measurement of packed cell volume and total plasma protein) or plain tubes (for serum isolation). Samples were transported in an ice pack to the clinical laboratory at Faculty of Veterinary Medicine, Zagazig University, Egypt, where packed cell volume was measured using the microhematocrit method and total plasma protein was determined using a refractometer. Sera samples were isolated following centrifugation and stored at -20°C prior to transport to the UK for immunodiagnosis of *Anoplocephala perfoliata* infection under appropriate licencing.

Immunodiagnosis of tapeworm (*A. perfoliata*) infection

One hundred serum samples were randomly selected using a random number generator to undergo testing for *A. perfoliata* infection. This excluded horses with a history of receiving an anticestodal drug (n = 18) in the previous 12-month period, and samples were divided equally between horses that did (n = 50) and did not (n = 50) have a history of colic in the previous 12 months. Samples were submitted to the Diagnosteq laboratories, University of Liverpool for testing using enzyme-linked immunosorbent assay (ELISA) optical density (OD) values specific for the 12/13 kDa excretory/secretory antigen of *A. perfoliata* [20]. Optical density values of <0.2, 0.2–0.7 and >0.7 were used to assign horses to zero or low, moderate and high infection intensity, respectively [20].

Data analysis

Using data collected from horses that were under their current ownership for ≥12 months, the 12-months prevalence of colic was calculated as number of horses that experienced one or more colic episodes divided by the total number of horses recruited into the study that were under current ownership for ≥12 months.

Preliminary descriptive analyses excluded any variables containing ≥30% missing data. Categorical variables containing few observations among some of the categories were condensed into fewer, biologically plausible groups. Unadjusted associations between explanatory variables and a history of colic in the previous 12 months as a dichotomous outcome variable was explored using univariable logistic regression. The functional form of the relationships between continuous predictor variables and the log-odds of the outcome variable were examined using generalised additive models [21] where nonlinearly associated variables were categorised using data-driven cut-off points. Pearson's correlation coefficient was used to test for collinearity between all explanatory variables prior to multivariable model building. If variables were highly correlated ($r > 0.9$), the most statistically significant or biologically plausible variable was selected [22].

Variables with a univariable likelihood ratio test P value <0.25 were considered for inclusion into a multivariable logistic regression model. The model was built using a forward stepwise selection approach whereby variables were added in succession and were retained if their inclusion resulted in significant changes in likelihood ratio test statistic ($P<0.05$) when nested models were compared. The final model was tested by forcing excluded variables back into the model to assess for confounding, this was defined as a 25% change in regression coefficient of any of the variables remaining in the model [23]. Two-way interactions between variables remaining in the final model were evaluated and model fit was assessed by the Hosmer–Lemeshow goodness-of-fit test statistic using 10 groups divided by deciles of fitted values. In order to test for influential observations, deviance residuals and δβs for each variable in the final model were examined graphically. Finally, a mixed effects model was built to explore random effects for the interviewer (3 interviewers) and for the horse (as multiple episodes of colic were reported for some horses) to assess for within-horse and within-interviewer clustering. This model was built using the lme4 statistical package version 1.1.7 [24] on R software environment version 3.2.0 [25].

A chi-squared test of independence was used to test for association between positive *A. perfoliata* ELISA results (OD>0.2) and colic history. Data analyses were performed using Epi Info 7[a], Stata (StataCorp 2005 Stata Statistical Software: Release 9)[c] and R software. The critical probability was set at 0.05 for all analyses.

Results

Study population

A total of 460 horses were presented to the mobile clinic. Of these, 350 horses had been under the present owners' care for ≥12 months and were eligible for inclusion. Dental examination was performed on 342 of these horses; horses that were either too aggressive to be examined without sedation (n = 3) or whose owners were unwilling to have the horses' mouths examined (n = 5) were excluded from dental examination. Horses included 239 (68.3%) females, 109 (31.1%) stallions and 2 (0.6%) geldings. Additional data on characteristics of the horse population are given in Supplementary Item 4.

Medical history and stereotypic behaviour

At least one medical problem was reported by owners over the preceding 12 months in 292 horses (83%). These were gastrointestinal disease (n = 192; 54.9%), skin lesions (n = 81; 23%), weight loss (n = 70; 20%), lameness (n = 43; 12.3%), fever and lethargy (n = 22; 6.3%), reproductive problems (n = 16; 4.6%), respiratory disease (n = 9; 2.6%), eye lesions (n = 2; 0.6%), tetanus (n = 3; 0.9%) and suspected pesticide toxicity (n = 2; 0.6%). Nine horses were previously admitted to a referral centre for surgical excision of a skin tumour (n = 3), pregnancy diagnosis (n = 2), pruritus (n = 2), fever (n = 1) and treatment of lameness (n = 1). Seventy (20%) horses were reported to exhibit crib-biting/windsucking stereotypic behaviour, 5.14% (n = 18) exhibited weaving behaviour and 0.6% (n = 2) exhibited box-walking behaviour.

Colic episodes

A total of 371 colic episodes in 191 horses were reported by the horse owners within the previous 12 months, contributing a 12-months colic prevalence of 54.6% (95% CI 49.2–59.9). Figure 1 shows the seasonal

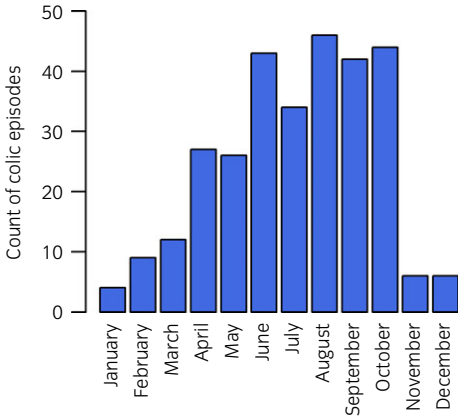

Fig 1: Seasonal distribution of owner-reported colic episodes in the previous 12 months.

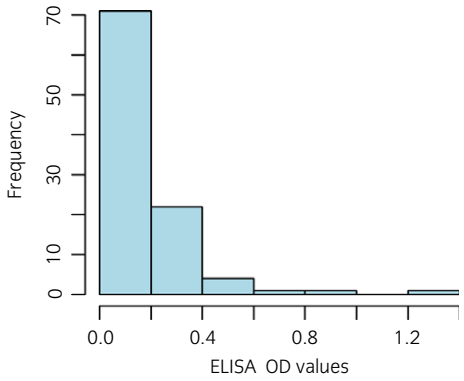

Fig 2: Histogram showing the distribution of enzyme-linked immunosorbent assay optical density (ELISA OD) values among 100 randomly tested blood samples.

distribution of these colic episodes suggesting that a higher frequency of colic occurred during the dry season (July–October). A single colic episode was reported for 89 horses; 69 had 2 colic episodes, 14 had 3, 10 had 4, 3 had 5, one horse had 7 and 4 horses had 10 colic episodes (data not recorded for the number of colic episodes in one horse). The most frequently reported clinical signs were: repeatedly getting up and down (82.7%), rolling (41.4%), pawing the ground repeatedly (25.7%), prolonged periods of lateral recumbency (11.5%) and kicking the abdomen (11%). Less frequent signs were sweating (4.2%), flatulence (3.7%), bruxism (1.8%), diarrhoea (1%) and a single report of dull demeanour.

Owners were able to provide some information about management and outcomes of 298 (80.3%) colic episodes. The signs of colic were confirmed by a veterinary surgeon in 43% (n = 127) of these episodes. Spontaneous recovery without any treatment was reported in 7.5% (20/266) of colic episodes while a range of treatments were sought on 246 (92.5%) occasions. Treatments administered included; alternative/conservative treatments (n = 78), pharmaceutical preparations (n = 109) and combinations of pharmaceutical preparations and alternative/conservative treatments (n = 59). The alternative/conservative treatments included: exercise (n = 119), which involved walking, trotting or working the horse; bathing the horse in a water canal (n = 4); a drench of barley water (n = 27), which comprised either human commercial products or boiled and sieved barely grains; removing feed (n = 10); a drench of commercial carbonated water (n = 9); and changing feeds e.g. offering hay or barley (n = 6). Pharmaceutical preparations comprised administration of a diuretic (furosemide; n = 66); anthelmintic (n = 7); nonsteroidal anti-inflammatory drugs (n = 8), which included diclofenac sodium, ketoprofen and flunixin meglumine; spasmolytic drugs (n = 26) including hyoscine butylbromide, atropine, dipyrone, tiemonium iodide; intravenous fluid therapy (n = 8) and oral administration of liquid paraffin (n = 3). Urinary catheterisation was performed by a veterinary surgeon in 7 horses with colic. Questions about rectal examination and findings were not asked. The owners were not able to specify drugs given on 63 colic occasions. The median reported time between veterinary examination and when signs of colic were first noticed by the owners was 6 h (range 1–192 h) and horses exhibited colic signs for a median duration of 8 h (range 1–360 h) prior to recovery.

Among 183 reports of what owners believed caused each colic episode, urine retention was the most commonly proposed cause (n = 74) followed by feeding excess dry feed in the form of roughage or grains with limited access to green feeds (n = 70). Other proposed causes of colic were silage overfeeding (n = 13), hard work (n = 11), internal parasites (n = 6), feeding young or wet clover (n = 5), constipation (n = 2), late pregnancy/abortion (n = 3), feeding from sandy ground (n = 1), and feeding spoiled feeds (n = 2). For the remaining colic episodes (n = 115) horse-owners did not give any opinion about the potential cause of colic.

Management practices

Details about use, stabling and turnout, feed and water supply, and prophylactic veterinary care are available in Supplementary Item 5. Details of the findings on oral examination in this horse population have been reported separately [17].

Immunodiagnosis of *A. perfoliata* infection

The ELISA OD values indicated that 3% (n = 3) and 26% (26) of the horses tested had high and moderate infection intensities respectively. Figure 2 shows the distribution of OD values. The prevalence of positive tapeworm infection (29%) did not vary between horses with and without a reported history of colic ($\chi^2 = 0.05$, P = 0.8).

Univariable and multivariable analysis

The results of univariable analysis of potential explanatory variables for risk of colic during the previous year are available in Supplementary Item 6. A final multivariable model is shown in Table 1. Horses with severe orodental disease during oral examination, those reported to exhibit stereotypic behaviour and those that had received anthelmintic in the previous 6-month period were more likely to have a 12-month history of colic. Increased likelihood of colic in the previous 12 months was also associated with feeding ground corn during the 'dry season' while horses fed on rice bran during the 'green season' and those reported to display pica (geophagia and coprophagia) were less likely to have a history of colic. No significant biologically plausible multiplicative interaction terms were found between variables in the final model. The Hosmer–Lemeshow test statistic suggested that the model was a good fit (P = 0.07) and no influential data points were identified. In the mixed model, the random effect of horse and of the interviewer was not significant and, therefore, these variables were not included within the final model.

Discussion

This study has documented the 12-month prevalence of colic in a working horse population in Egypt and identified factors that were associated with a history of colic. We have also provided information about management practices and owner perceptions about causes of colic. This information is an important first step in determining the impact of colic in a working population of horses and strategies that may be developed to minimise the likelihood of colic occurring.

The prevalence of colic (54.6%) in this working horse population exceeds the prevalence of colic reported for working horses in Romania (32.5%) [9] and the 12-month cumulative colic incidence of 5.8–6.5% reported for horse populations based in the USA and the UK [3,4]. These differences may be due to variation in horse types and management practices and different study designs. A greater frequency of colic episodes occurred from June to October. This apparent seasonal pattern differs from that previously reported for colic in the UK and the USA [3,4,26,27]. However,

TABLE 1: Multivariable logistic regression model of risk factors for owner reported colic in the previous 12-month period in a working horse population in Egypt

Variable	Coefficient	Standard error	Odds ratio	Lower 95% CI	Upper 95% CI	Likelihood ratio test P value
Severe orodental disease						
No	Ref.					
Yes	1.92	0.65	6.8	1.9	24.32	<0.001
Stereotypic behaviour						
No	Ref.					
Yes	0.7	0.3	2.0	1.15	3.5	0.01
Feeding ground corn during June–October						
No	Ref.					
Yes	0.5	0.24	1.65	1.03	2.6	0.04
Anthelmintic administered during the last 6 months						
No	Ref.					
Yes	0.7	0.24	2.1	1.3	3.3	0.003
Feeding rice bran during November to May						
No	Ref.					
Yes	-0.75	0.24	0.47	0.26	0.9	0.015
Geophagia/coprophagia (pica)						
No	Ref.					
Yes	-1.65	0.7	0.19	0.05	0.73	0.001

Number of observations in the final model are 339, the Hosmer-Lemeshow goodness-of-fit test statistic (χ^2 = 13.24, P = 0.07), ref. = reference category, CI = confidence interval.

this finding may also be related to recall bias with owners reporting colic episodes that occurred more frequently relative to the timing of questionnaire administration. In order to investigate whether there is a true seasonal pattern of colic in the study population, a prospective cohort study would be required.

In the current study, horses that were diagnosed with severe dental disease were more likely to have developed colic during the preceding 12-months compared with those diagnosed with no/mild or moderate dental disease. While the retrospective nature of the study and timing of the colic episode in relation to dental examination means that it is not possible to confirm a definitive association between the two, this finding is consistent with other studies. Horses with a history of dental disease were previously reported to be at greater risk of recurrent colic episodes [28] and those with a history of less frequent dental examinations were found to be at increased risk of simple colonic obstruction and distension colic [29]. Increased risk of large colon volvulus was also reported in horses that had a history of quidding [30]. Therefore, implementation of a programme of dental prophylaxis by appropriately trained veterinary surgeons might help to reduce the incidence of colic in this population of horses.

Stereotypic behaviours were significantly associated with a horse having a history of colic in the last 12 months and this is also consistent with previous reports [22,31,32]. The prevalence of crib-biting/windsucking stereotypic behaviour (20%) within this working horse population was greater than the prevalence (4.4–6.1%) reported for horse populations in the USA and the UK [33,34]. These behaviours were described by owners as horses grasping the wood of the carts without attempts to suck in air. If these behaviours were to be described as a wood chewing behaviour, our reported prevalence may be comparable with the prevalence (17.2%) of wood chewing behaviour in other horse populations [34]. There is a need to define and describe these behaviours more accurately in working horses.

The association between certain types of feeds and altered likelihood of colic identified in the current study is interesting. Previously, changes in feed or feeding practices rather than the actual feed types were more consistently reported as important components of the aetiopathogenesis of colic [35–37]. This study provides preliminary data that may be used to assist design of prospective cohort studies that investigate further any seasonal variation and relationship between likelihood of colic and feed types given in this type of equine population. Geophagia/coprophagia (pica) was associated with a reduced likelihood of a history of colic. This was unexpected as we consider that this may reflect nutritional or other management deficiencies that may increase the likelihood of colic. Pica may be a proxy measure for young age, previously reported to be associated with a reduced risk of colic [35]. However, within this equine population, age was not found to be a confounder. This finding requires further investigation to determine whether it is directly attributable to colic risk or whether it is a marker for other horse or management factors.

Horses that had been given anthelmintic treatment during the preceding 6 months were more likely to have had a colic episode within the previous year. This finding may initially seem counterintuitive compared with other studies reporting risk factors for colic [29,38]. Anthelmintic preparations may have been administered in response to colic occurring [39], or due to evidence of parasite-related colic, which makes it difficult to assess the underlying direction of this association. Furthermore, the efficacy of anthelmintic preparations used by owners, or the possible role of anthelmintic resistance within this population is largely unknown. A single pilot study, reporting anthelmintic susceptibility to ivermectin and fenbendazole found no evidence of resistance [40]. Further work is required to examine anthelmintic practices and efficacy of treatment within this working equid population.

The study, for the first time in Egypt, has identified a high seroprevalence of *A. perfoliata* infection of 29% in horses tested. This is comparable with the infection rate (34%) reported in working donkeys in Ethiopia [41], but is lower than the seroprevalence (56%) reported in other equine populations [42]. Frequency of positive infections did not differ between horses with or without a history of colic. The decision for the number of samples tested was based on available funding, and this may have reduced the power to detect any significant differences.

Urinary retention was a commonly perceived cause of colic reported by owners of working horses in this study. It is unclear whether this is a result of a physical inability to pass urine, as is the case in obstructive urolithiasis, often considered an infrequent clinical problem in horses and not always associated with signs of colic [43], or whether this observation could be associated with other aetiologies that are relevant to this working horse population, for example, dehydration. Behaviour may have been misinterpreted by owners and whatever the underlying aetiology, it is of note that urinary catheterisation and the use of diuretics were among the commonly reported treatments given by veterinary surgeons for colic. Other owner perceptions about causes of colic were in agreement with previous reports [5]. Further work is warranted to look at the aetiologies and clinical signs associated with colic in this population of working horses. This would assist development of training programmes for local veterinary surgeons and owners of working horses about colic prevention, diagnosis and treatment. The results of the current study will be disseminated via

social media to veterinary surgeons and veterinary schools in relevant areas to demonstrate areas where improved owner and veterinary student education is required.

In common with all retrospective cross-sectional studies, there may have been an element of recall bias, as no written/computer record of medical history was available for any of the examined horses. Almost all owners (98%) owned a single horse, which might have better enabled them to recall historical details. Furthermore, the ability to examine risk factors is limited as temporal associations between risk factors identified and colic cannot be ascertained within this cross-sectional format, and our reliance on horse-owners to classify cases with colic may have introduced misclassification bias. The findings from the current study do, however, provide useful insight into factors that require investigation in future longitudinal studies. Due to requirements to gain consent from local government and logistical issues relating to access to equine populations, the recruitment strategy was non-randomised and, therefore, it may not be appropriate to extrapolate the current results to other regions of Egypt. Additionally, our investigation of severe forms of colic that might have resulted in death or euthanasia of the animals was limited. Again, this highlights the need for future prospective studies that involve detailed clinical examination of horses with colic and where relevant, *post mortem* examination.

We have reported the 12-month prevalence of colic and associated risk factors in a population of working horses in Egypt. This information, together with details about management practices of horses and horse-owner perceptions about possible causes of colic can be used to inform educational and training programmes for horse-owners and veterinary surgeons in this region, and in similar populations. These data provide information that may be used as a basis for performing future prospective cohort studies to examine risk factors for colic further within this and other working equid populations.

Authors' declaration of interest

No competing interests have been declared.

Ethical animal research

This study was approved by the University of Liverpool Veterinary Research Ethics Committee (VREC247). Informed consent was obtained from all participating animal owners.

Source of funding

S.E. Salem's PhD studies are funded by the Egyptian Ministry of Higher Education.

Acknowledgements

Thanks to W. Refaai, M. Gomaa, I. Morsey and M. Marzouk from Zagazig University for assistance with the data collection. We thank the veterinary surgeons and the horse-owners who participated in the study.

Authorship

S.E. Salem was the main researcher and contributed to all aspects of the study. C.E. Scantlebury contributed to study design, data analyses and preparation of the manuscript. A.M. Abdelaal and E. Ezzat contributed to study design and data collection. D.C. Archer contributed to study design, interpretation of the data and preparation of the manuscript.

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Supporting Information

Additional Supporting Information may be found in the online version of this article at the publisher's website:

Summary in Chinese

Supplementary Item 1: A flow chart describing horses' recruitment, data collection and reporting of the results to the horse owners.

Supplementary Item 2: A map showing locations of visited villages.

Supplementary Item 3: The study questionnaire.

Supplementary Item 4: Characteristics of the studied Egyptian working equid population.

Supplementary Item 5: Workload, stabling and turnout regimes, feed and water and preventative veterinary care in Egyptian working equids.

Supplementary Item 6: Univariable analysis of risk factors investigated for association with history of colic in the previous 12-month period in an Egyptian working horse population.