

## **Effect of routine dentistry on faecal fibre length in Donkeys**

Johnson, C.; Williams, Jane; Phillips, Chelsie

*Published in:*

Journal of Equine Veterinary Science

*Publication date:*

2017

*The re-use license for this item is:*

CC BY-NC-ND

*This document version is the:*

Peer reviewed version

*The final published version is available direct from the publisher website at:*  
[10.1016/j.jevs.2017.06.002](https://doi.org/10.1016/j.jevs.2017.06.002)

**[Find this output at Hartpury Pure](#)**

*Citation for published version (APA):*

Johnson, C., Williams, J., & Phillips, C. (2017). Effect of routine dentistry on faecal fibre length in Donkeys. *Journal of Equine Veterinary Science*, 41-45. <https://doi.org/10.1016/j.jevs.2017.06.002>

1 **Effect of routine dentistry on faecal fibre length in Donkeys**

2 Claire Johnson<sup>1</sup>, Jane Williams<sup>1\*</sup>, and Chelsie Phillips<sup>1</sup>

3 <sup>1</sup>University Centre Hartpury, Gloucester, Gloucestershire, UK, GL19 3BE.

4 \*Corresponding author: [jane.williams@hartpury.ac.uk](mailto:jane.williams@hartpury.ac.uk); 0044 1452702640.

5

6 **Abstract**

7 Many donkeys are kept as companions in the UK and are not ridden or work, therefore dental  
8 pain can often go unnoticed by owners. Donkeys suffer from an increased frequency of dental  
9 pathology compared to horses and require regular dental treatment (rasping) to optimise their  
10 welfare. Faecal fibre length (FFL) has been suggested as a non-invasive method to assess when  
11 *Equidae* require dental treatment. This study aimed to identify FFL pre-rasping in donkeys  
12 requiring dental treatment and to evaluate how this changed over a 6-week period post-rasping.

13 Twenty adult donkeys of mixed sex and age, and subject to analogous management regimes  
14 were selected from the Donkey Sanctuary. Faecal samples were taken for FFL analysis pre-  
15 rasping (week 0) and post-rasping (weeks 1, 2, 3 and 6). Mean FFL, determined via laboratory  
16 analysis, was recorded for each donkey and the cohort each week. Repeated measures ANOVA  
17 with post-hoc Bonferroni analyses and a Bonferroni adjustment ( $P \leq 0.01$ ) examined if  
18 differences occurred in FFL between weeks.

19 The cohort's mean FFL was higher pre-rasping than for all weeks examined post-rasping.  
20 Significant reductions in mean FFL for the cohort were reported pre- and post-rasping for week  
21 0 to weeks 1, 2, 3 and 6, weeks 1 and 3, 1 and 6, weeks 2 and 3, and week 2 and 6 ( $P < 0.0001$ ).  
22 Pre-rasping FFLs  $> 3.3$ mm were associated with the presence of dental elongations in adult,  
23 companion donkeys. This suggest that FFL measurement is a useful non-invasive tool that  
24 could be used to assess the dental health of donkeys.

25

26 Key words: equine, rasping; prophylactic dentistry; welfare; dental pathologies

27

28 **Highlights:**

- 29 1. Donkeys experience a higher incidence of dental pathologies than horses.
- 30 2. Dental pain can be hard to diagnose in unriden companion donkeys.
- 31 3. FFL>3.3mm were associated with dental pathology in the donkeys examined.
- 32 4. FFL reduced after rasping for the 6 weeks examined.
- 33 5. FFL could be used as a non-invasive indicator of dental pathology in donkeys.

34

## 35 **1.0 Introduction**

36 Modern management regimens [1] and diets of domesticated *Equidae* often restrict access to  
37 forage and instead contain high concentrate rations [2]. These diets require reduced attrition  
38 and do not cause sufficient wear of the occlusal surfaces needed to maintain hypsodont  
39 dentition [3,4]. Subsequently, a higher prevalence of dental abnormalities is reported in  
40 managed *Equidae* compared to their free-living peers [5,6]. Domesticated horses and donkeys  
41 therefore require regular routine dental treatment (rasping) to facilitate functional mastication  
42 and digestion [7,8].

43 There are approximately 44 million donkeys worldwide [9] the majority of which are working  
44 animals [10]. In the UK, donkeys are often kept as companion animals (not ridden), which can  
45 result in dental pain not being identified by their keepers and donkeys receiving minimal or no  
46 regular dental treatment [11]. Dental pathologies are the second most common clinical  
47 condition reported in the domestic donkey [12] and have been widely associated with impaction  
48 colic cases [13,14]. Dental pathologies therefore represent a potential welfare issue in the  
49 donkey.

50 To date, the majority of dental care protocols used in the donkey have been adapted from those  
51 used in the horse [15]. Yet the assumption that the donkey and the horse are identical is an  
52 incorrect with differences between digestive physiology and dental anatomy reported [16, 17].  
53 Both species possess hypsodont dentition, with an annual eruption rate of 2-3mm reported  
54 [18,19]. Donkeys possess between 36- 44 teeth dependent upon age, sex and presence of non-  
55 functional wolf teeth [17], with the average adult animal presenting with 36 permanent teeth  
56 [8]. Donkeys have a greater degree of anisognathia than horses, 27% compared to 24%  
57 respectively [17] and a wider range of occlusal angles than the horse [20]. Changes to the  
58 masticatory cycle due to either discomfort or an inappropriate diet can produce a more  
59 pronounced vertical masticatory pattern resulting in increased occlusal surface angulation [14].  
60 Therefore, the normal cheek teeth angulation and anisognathia found in donkeys, combined  
61 with the impact of modern management regimes, predispose them to develop a higher  
62 incidence of dental pathologies than the horse [15].

63 Faecal fibre length (FFL) can be used as an indicator of oral health and masticatory efficiency  
64 in *Equidae* [21, 22] and could therefore be used to assess dental health status in donkeys. FFL  
65 >3.6mm have been proposed as an indicator of the presence of dental abnormalities in horses  
66 [18, 23]. Research in horses suggests that FFL does not significantly change after dental

67 treatment [24, 25]. However these studies used a technique (rubber ball to encourage fibre  
68 separation, followed by dry sieving) which could cause excessive attrition of faecal fibres  
69 producing measurements which are not representative of true FFL [22, 26]. The validation of  
70 FFL as an indicator of masticatory efficiency and digestion in the donkey could provide a  
71 monitoring tool informing frequency of routine rasping aiding in the maintenance of welfare  
72 in donkeys. Therefore, this study aimed to identify FFL in donkeys requiring dental treatment  
73 and to evaluate the effect of routine dental treatment on FFL in companion donkeys over a six-  
74 week period. It was hypothesised that a reduction in FFL would occur after rasping.

## 75 **2.0 Materials and Methods**

76 Twenty donkeys of mixed sex (16 Jacks; 4 Jennys) and age ( $7.6 \pm 2.8$  years), subject to the same  
77 management practices (group housed in a barn with turnout) and diet (haylage twice per day  
78 and *ad libitum* oat straw), resident at The Donkey Sanctuary, Woods Farm, Devon, UK were  
79 selected for inclusion in the study. All donkeys required routine dental treatment, as part of  
80 their ongoing, yearly health care. The study was authorised by the site manager and the  
81 management team. All procedures, including dental examinations and treatments were  
82 approved as adhering to animal welfare guidelines by the University of the West of England  
83 (Hartpury) Ethics Committee and were performed by a qualified equine dental technician  
84 (EDT) adhering to British Equine Veterinary Association (BEVA) guidelines [27]. Data  
85 collection took place from mid-October to the end of November 2013.

### 86 *2.1 Faecal sampling protocol*

87 An initial faecal sample was collected prior to any dental examination or treatment: week 0.  
88 Individual donkeys were separated from the herd, but they were still in visual contact with the  
89 rest of the herd to prevent putting them under undue stress, until they defecated. Faecal samples  
90 were then collected from the naturally dropped faecal matter, fifty grams were weighed using  
91 digital scales and placed into sealed plastic bags and frozen on the day of collection at  $-18^{\circ}\text{C}$ ,  
92 monitored using a digital thermometer. Each bag was labelled with the sample number and a  
93 letter which represented the individual donkey. Once a sample had been successfully collected,  
94 the donkey was moved back into the barn to prevent re-collection or sampling errors. The yard  
95 where the donkeys were held was cleared of any existing faeces prior to and during sample  
96 collection to avoid misidentification of the donkey the sample came from. Faecal sample  
97 collection was repeated post-dental treatment for weeks 1, 2, 3 and 6 using the same procedure.

98     2.2 *Dental treatment*

99     Dental examination and treatment was performed over two days after the first (week 0) faecal  
100     samples had been collected. All donkeys were treated by the same BEVA qualified EDT who  
101     was a member of the British Association of Equine Dental Technicians.. The onsite veterinarian  
102     assessed the donkeys and declared them fit to receive treatment and free from any pre-existing  
103     clinical conditions other than dental elongations that could be corrected by rasping  
104     accompanied by no further pathologies. The 20 donkeys were held in their normal yard whilst  
105     receiving dental treatment to minimise stress.

106     A full oral examination was performed, visualising all dental surfaces/structures and assessing  
107     all oral tissues. Donkey age, sex and dental diagnoses data were transcribed directly to a dental  
108     chart; dental disorders noted included sharp enamel points, focal overgrowths, shear mouth,  
109     step mouth, wave mouth, accentuated transverse ridges and diastema. Routine dental treatment  
110     (rasping) was undertaken to reduce overgrowths, remove sharp enamel points, increase lateral  
111     excursion, restore balance of the arcades and establish correct occlusal angles in accordance  
112     with BEVA guidelines (2009).

113     2.3 *Laboratory analysis of faecal fibre length*

114     Prior to laboratory analysis, the sampling period individual samples came from was blinded  
115     from the experimenter to prevent bias. Faecal samples were defrosted at room temperature (18-  
116     24°C) until the sample reached 4°C. Five grams of faecal matter, taken from multiple sections  
117     of the larger 50g sample to ensure a representative selection of fibre lengths, was weighed using  
118     digital scales. Each 5g sample was added to a glass beaker filled with 500ml of distilled water.  
119     The mixture was gently stirred to separate fibres from unwanted sediment. The mixture was  
120     then poured through a 0.5mm sieve to eliminate all fibres under 0.5mm from analysis. The  
121     remaining fibre mass was collected and gently spread over a foil square, labelled in indelible  
122     marker with the sample's identification letter. All 20 samples were placed in the oven at 150°C  
123     for 2 hours and once dried each sample was gently sieved through a 1cm sieve, using a soft  
124     bristle brush to encourage fibre separation whilst attempting to prevent attrition to the fibre  
125     length during the process. The separated dry fibres were re-sieved evenly over a 616 squared  
126     grid, sub-divided into four labelled quadrants: A, B, C and D, each of which was subdivided  
127     into 154 squares. One square from the 154 present in each quadrant was randomly selected for  
128     analysis (e.g. Quadrant A, square 101). Ten faecal fibres were measured from each of the four  
129     squares selected, providing a total of forty faecal fibres for each individual sample. Fibres were

130 removed from the grid using tweezers, placed on a separated white surface and were  
131 individually measured using Mitutoyo Absolute Digimatic Digital Vernier Callipers (Mitutoyo  
132 part number: 500 196-20, model: 500 196-20, accuracy  $\pm 0.01\text{mm}$ ). The mean, standard  
133 deviation, upper and lower and inter-quartile ranges were calculated for FFL of each sample  
134 using Microsoft Excel™ Version 2010 prior to statistical analysis. The FFL analysis procedure  
135 was repeated for each individual sample for weeks 0, 1, 2, 3 and 6.

#### 136 *2.4 Statistical Analysis*

137 Data were analysed using Statistics Package for Social Scientists (SPSS, Version 20). Data  
138 were parametric however whilst Pillai's Trace confirmed a highly significant difference in  
139 mean FFL it could not provide specificity ( $P=0.0001$ ) and Mauchly's test indicated that the  
140 assumption of sphericity within the data had been violated ( $P=0.002$ ). Therefore the degrees of  
141 freedom were corrected using Greenhouse-Geisser estimates of sphericity ( $\epsilon=0.57$ ) and one-  
142 tailed Repeated Measures ANOVA with a Greenhouse-Geisser correction was applied to  
143 determine if significant differences were present in mean FFL across the cohort [28]. Post hoc  
144 Bonferroni analyses were conducted with a Bonferroni correction applied, to adjust for  
145 repeated measures, resulting in a revised significance level of  $P\leq 0.01$ . These tests were  
146 performed to determine where statistical differences occurred in FFL between the data  
147 collection weeks for the entirety of the study.

### 148 **3.0 Results**

149 The cohort's mean FFL pre-rasping was higher than all weeks examined post-rasping (Table  
150 1). The majority of subjects recorded higher FFL (90%) pre-dental treatment compared with  
151 their FFL recorded post-dental treatment; the magnitude of FFL changes varied between  
152 individual donkeys as well as within the weeks evaluated (Table 2).

153 Significant changes in mean FFL (decreases) were found across the study period ( $P<0.0001$ ),  
154 however after subsequent post-hoc analysis and Bonferroni adjustment for repeated measures,  
155 this pattern was not repeated consistently for the entirety of the study period. Significant  
156 reductions in mean FFL for the cohort were reported pre- and post-dentistry for week 0 to  
157 weeks 1, 2, 3 and 6 ( $P=0.0001$ ) with further reductions reported between weeks 1 and 3, 1 and  
158 6, weeks 2 and 3, and week 2 and 6 ( $P=0.0001$ ). No significant changes in FFL length occurred  
159 between weeks 1 and 2, or between weeks 3 and 6 ( $P>0.05$ ).

160 Table 1: Faecal fibre lengths in millimetres (to 2 decimal places) across the cohort for the study  
 161 period.

<b>Faecal Fibre length (mm)</b>	<b>Pre- dentistry (week 0)</b>	<b>Post- dentistry (week 1)</b>	<b>Post- dentistry (week 2)</b>	<b>Post- dentistry (week 3)</b>	<b>Post- dentistry (week 6)</b>
<b>Mean</b>	4.37	3.03	2.80	1.95	1.93
<b>Standard deviation</b>	0.65	0.40	0.25	0.27	0.30
<b>Minimum</b>	3.32	2.50	2.32	1.46	1.35
<b>Lower quartile</b>	4.02	2.60	2.66	1.80	1.74
<b>Median</b>	4.27	3.05	2.77	1.97	1.89
<b>Upper quartile</b>	4.79	3.41	2.98	2.13	2.16
<b>Maximum</b>	5.55	3.81	3.25	2.47	2.43

162

163 Table 2: Individual faecal fibre length across the six weeks investigated in millimetres to 2  
 164 decimal places

<b>Donkey ID</b>	<b>Faecal fibre length (FFL) in millimetres (mm) post routine dental treatment</b>				
	<b>Week 0</b>	<b>Week 1</b>	<b>Week 2</b>	<b>Week 3</b>	<b>Week 6</b>
1	4.01	2.52	2.32	1.80	1.86
2	4.82	2.93	2.54	1.96	2.13
3	4.51	2.59	2.98	1.80	2.41
4	4.93	2.56	2.93	2.24	2.23
5	4.11	2.66	2.90	1.63	1.85
6	5.46	2.60	3.20	1.46	2.33
7	4.62	2.50	2.64	1.51	2.31
8	4.29	2.91	2.43	1.89	1.75
9	5.34	3.19	2.86	2.40	1.66
10	3.32	3.47	2.51	1.98	1.63
11	3.58	3.01	2.77	2.05	1.91
12	4.65	3.26	2.93	2.18	1.94
13	3.38	3.46	2.70	1.66	1.75
14	4.04	3.50	2.76	1.82	1.35



15	4.20	2.61	3.25	2.12	1.65
16	4.71	3.81	2.74	2.47	1.70
17	4.04	3.15	2.75	1.99	1.78
18	4.24	3.08	3.03	2.01	2.08
19	3.64	3.22	3.09	1.88	1.93
20	5.55	3.56	2.73	2.13	2.43
<b>Cohort</b>					
Mean	4.37	3.03	2.80	1.95	1.93
Standard deviation	0.65	0.40	0.25	0.27	0.30

165

#### 166 **4.0 Discussion**

167 At the start of the study, the majority of donkeys (90%) exceeded a FFL of >3.6mm the length  
168 proposed to indicate the presence of dental abnormalities in horses [26, 29]. The presence of  
169 dental pathologies were confirmed in these donkeys by EDT examination. However, EDT  
170 examination confirmed a further two donkeys, who returned FFL <3.60mm (3.32 and 3.38mm  
171 respectively), required dental treatment suggesting that the FFL level that is consistent with the  
172 presence of dental abnormalities may be shorter in donkeys than that proposed in the horse,  
173 however more research is required before this is confirmed. By week 3, the FFL for all donkeys  
174 appeared to stabilise at lengths <2.50mm. Our results suggest that FFL measurement is a useful  
175 non-invasive tool that could be used to assess the dental health of donkeys, with FFL >3.30mm  
176 indicating the presence of dental elongation in adult donkeys.

177 The FFL length of the majority of donkeys (90%) reduced a week after rasping, but 5 (25%)  
178 still presented with a FFL >3.3mm. However by week 2, all donkeys' FFL were >3.3mm and  
179 further reductions in FFL occurred up to week 6. Routine rasping removes dental pathologies,  
180 thus reducing restriction to occlusal contact allowing full excursion and improved attrition,  
181 facilitating more efficient mastication [30]. The variation reported here suggests that the more  
182 efficient attrition which occurs post rasping, generates a reduction in faecal particle size [31,  
183 32]. Kinematic and electromyographic evaluation of how the mastication cycle in horses  
184 changes post-rasping, suggests that the first week after dental treatment (rasping) represents a  
185 period where fluctuations occurs in the mastication cycle demonstrated by changes in lateral  
186 excursion and the power stroke [31] and masseter and temporalis muscle workloads [32]. This  
187 adaptation could explain why there appears to be a transition period of 1 to 2 weeks for some

188 donkeys before FFL reduces below 3mm. Interestingly, donkeys that recorded FFL >3.3mm  
189 presented with more severe dental elongations pre-rasping than their peers; therefore the rate  
190 of FFL reduction post-rasping, may also be influenced by the incidence and severity of dental  
191 pathologies present in the subject.

#### 192 *4.1 Limitations and further research*

193 The results of this preliminary study are promising; however, further work incorporating larger  
194 numbers of donkeys to confirm the results found here and to establish a standardised FFL  
195 indicator of dental pathologies in donkeys is required. The current sample considered adult,  
196 companion donkeys, therefore we would advocate repeating the study in working donkeys and  
197 across wider age ranges to evaluate if differences in FFL present between adult and geriatric  
198 samples.

### 199 **5.0 Conclusion**

200 Routine dental treatment resulted in significant reductions in FFL in donkeys, which suggests  
201 that rasping has improved the efficiency of mastication. Our results suggest that faecal fibre  
202 lengths of <3.3mm can be used as an indicator of the presence of dental pathologies in  
203 companion, adult donkeys. If a standardised FFL length can signpost the presence of dental  
204 pathologies, the measure has the potential to be implemented as a standard welfare indicator  
205 particularly for working donkeys globally.

206

### 207 **Acknowledgements**

208 We would like to thank the Donkey Sanctuary for their support and providing access to the  
209 donkeys during this study.

210

### 211 **Conflict of interest**

212 No conflicts of interest apply to this work.

213

### 214 **Funding**

215 This research did not receive any specific grant from funding agencies in the public,  
216 commercial, or not-for-profit sectors.

217

218 **References**

- 219 [1] Grinder, M.I., Krausman, P.I., Hoffman, R.S. *Equus Asinus*. *Mammal Spp* 2006 794: 1-9.
- 220 [2] McBride, S.D., Long, L. Management of horses showing stereotypic behaviour, owner  
221 perception and the implications for welfare. *Vet Record* 2001 148 (26): 799-802.
- 222 [3] Frape, D. *Equine nutrition and feeding (Fourth Edition)*. Oxford, UK: Wiley-Blackwell;  
223 2010. p. 300-366.
- 224 [4] Hannes, C. *Caring for the Horse's Teeth and Mouth*. United Kingdom: Kenilworth Press;  
225 2009. p. 33-37.
- 226 [5] Masey O'Neill, H.V., Keen, J., Dumbell, L. A comparison of the occurrence of common  
227 dental abnormalities in stabled and free-grazing horses. *Behav, Welfare and Health* 2010 4  
228 (10): 1697-1701.
- 229 [6] Lamoot, I., Callebaut, J., Demeulanaere, E. Foraging behaviours of donkeys grazing in a  
230 coastal dune area in temperate climate conditions. *Appl Anim Behav Science* 2005 92(1): 93-  
231 112.
- 232 [7] DuToit, N., Dixon, P.M. Common dental disorders in the donkey. *Equine Vet Ed* 2011  
233 24(1): 45-51.
- 234 [8] Klugh, D.O. *Principles of Equine Dentistry*. London: Manson Publishing Ltd; 2010. p. 11-  
235 26.
- 236 [9] Starkey, P., Starkey, M. Regional and world trends in donkey populations. pp 10-21 in:  
237 Starkey, P., Fielding, D. (eds). *Donkeys, people and development. A resource book of the*  
238 *Animal Traction Network for Eastern and Southern Africa (ATNESA)*. ACP-EU Technical  
239 Centre for Agricultural and Rural Cooperation (CTA), Wageningen; 2000. The Netherlands.  
240 247p. ISBN 92-9081-219-2. Paper available from <http://www.atnesa.org>
- 241 [10] Regan, F.H., Hockenhull, J., Pritchard, J.C., Waterman-Pearson, A.E., Whay, H.R.,  
242 Behavioural repertoire of working donkeys and consistency of behaviour over time, as a  
243 preliminary step towards identifying pain-related behaviours 2014 *PloS one*, 9(7), p.e101877.

- 244 [11] Cox, R., Burden, F., Proudman, C. J., Trawford, A. F., Pinchbeck, G. L. (2010)  
245 Demographics, management and health of donkeys in the UK. *Vet Record* 2010 166(18): 552-  
246 556.
- 247 [12] The Donkey Sanctuary, Dental care information for owners. 2009 Available from:  
248 <https://www.thedonkeysanctuary.org.uk/donkey-health-and-welfare> { Accessed on 25th April  
249 2017}.
- 250 [13] Cox, R., Proudman, C., Trawford, A.F., Burden, F.A., Pinchbeck, G.L. Epidemiology of  
251 impaction colic in donkeys in the UK. *BMC Vet Res* 2007 3(1): 1.
- 252 [14] Cox, R., Burden, F., Gosden, L., Proudman, C., Trawford, A., Pinchbeck, G. Case control  
253 study to investigate risk factors for impaction colic in donkeys in the UK. *Prev Vet Med* 2009  
254 92(3): 179-187.
- 255 [15] Du Toit, N., Burden, F.A., Dixon, P.M. Clinical dental examination of 357 donkeys in the  
256 UK. Part 1: Prevalence of dental disorders. *Equine Vet J* 2009 41: 390-394.
- 257 [16] Reece, W.O. *Functional Anatomy and Physiology of Domestic Animals*.(Fourth Edition).  
258 Oxford, UK: Wiley-Blackwell; 2009.
- 259 [17] Du Toit, N., Kempson, S., Dixon P. Donkey dental anatomy: Part one: Gross and  
260 computed axial tomography examinations. *Vet J* 2008 176(3): 338-344.
- 261 [18] Dixon, P.M. Dental anatomy. In: G.J., K.J. Easley, K.J., editors. *Equine Dentistry, USA*:  
262 Elsevier Saunders; 2005, p. 25-48.
- 263 [19] Du Toit, N. An anatomical, pathological and clinical study of donkey teeth. PhD Thesis,  
264 University of Edinburgh: UK; 2008.
- 265 [20] Brown, S., Arkins, S., Shaw, D., Dixon, P. Occlusal angles of cheek teeth in normal horses  
266 and horses with dental disease. *Vet Record* 2008 162: 807-810.
- 267 [21] Ralston, S.L., Foster, D.L., Divers, T., Hintz, H.F. Effect of dental correction on feed  
268 digestibility in horses. *Equine Vet J* 2001 33 (4): 390-393.
- 269 [22] Hummel, J., Fritz, J., Kienzle, E., Medici, E.P., Lang, S., Zimmermann, et al., Differences  
270 in fecal particle size between free-ranging and captive individuals of two browser species. *Zoo*  
271 *Biology* 2008 27(1): 70-77.

272 [23] Baker, G.J. Dental physiology. In Baker, G. and Easley, J. Equine Dentistry (Second  
273 Edition). London: Elsevier; 2005 p. 49-55.

274 [24] Carmalt, J., Allen, A. Effect of rostrocaudal mobility of the mandible on feed digestibility  
275 and fecal particle size in the horse. J Am Vet Med Assoc 2006 229(8): 1275-1278.

276 [25] Carmalt, J.L., Allen, A. (2008) The relationship between cheek tooth occlusal  
277 morphology, apparent digestibility, and ingesta particle size reduction in horses. J Am Vet  
278 Med Assoc 2008 233(3): 452-455.

279 [26] Uden, P., Van Soest, P.J. The determination of digesta particle size in some herbivores.  
280 Anim Feed Science and Tech 1982 7(1): 35-44.

281 [27] BEVA Equine Dental Procedures 2009. Available from:  
282 <https://www.beva.org.uk/Home/Resources-For-Vets/Guidance-For-Vets> [Accessed on 25th  
283 April 2017].

284 [28] Field, A. Discovering statistics using IBM SPSS Statistics. London: Sage Publications  
285 Ltd; 2013. p. 249-257.

286 [29] Gatta, D., Krusic, L., Casini, L., Colombani, B. Influence of corrected teeth on the  
287 digestibility of two types of diets in pregnant mares. In: Proceedings: 1st Symposium Horse  
288 Diss, 1995: 326-331.

289 [30] Dixon, P.M. The Gross, Histological, and Ultrastructural Anatomy of Equine Teeth and  
290 Their Relationship to Disease. In: Proceedings of the 49<sup>th</sup> Annual Convention of the American  
291 Association of Equine Practitioners 2002 48: 421-437.

292 [31] Johnson, C., Williams, J.M., Nankervis, K. (2013) Kinematic analysis of the equine  
293 mastication cycle pre and post prophylactic dental treatment. Vet Nurse 2013 4(4): 234-241.

294 [32] Williams, J.M., Johnson, C., Bales, R., Lloyd, G., Barron, L., Quest, D. (2014) Analysis  
295 of Temporalis and Masseter adaptation after routine dental treatment in the horse via surface  
296 electromyography. Comp Exer Physiol 2014 10(4): 223-232.

297

298

299