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ONLINE FIRST

Tropical Animal Health and Production

ISSN 0049-4747

Trop Anim Health Prod
DOI 10.1007/s11250-019-02172-x

Springer

Tropical Animal Health and Production
https://doi.org/10.1007/s11250-019-02172-x

REGULAR ARTICLES

Applicability of teeth examination as a tool for age estimation in a semi-arid cattle production environment in Namibia

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Received: 27 June 2019 / Accepted: 1 December 2019

Abstract

Regression analysis was used to evaluate teeth examination as a tool for estimating age in beef and dairy cattle at Neudamm farm, Namibia, in 2018. There was a significant difference in age (months) between the overall mean actual age (M=60, SD=4.57) and the mean estimated age (M=57, SD=4.52 months) in beef cattle; t(74) = 3.61, *p*<0.001. There was no significant difference between the overall mean estimated age and the mean actual age (M=42.5, SD=5.18) and (M=41.3, SD=5.21 months) in dairy cattle; t(30) = 1.45, *p*=0.16. There was a very strong positive relationship between the overall teeth examination-estimated age and actual age in beef cattle [r (74) = 0.98, p<0.001]. There was a very strong positive relationship between the overall teeth examination-estimated age and actual age in dairy cattle [r (30) = 0.99, p<0.001]. A very strong positive relationship was also evident between the teeth examination-estimated age and actual age in beef cattle aged 45 months and below [r (37) = 0.93, p<0.001]. There was a very strong positive relationship between the teeth examination-estimated and actual age in dairy cattle aged 45 months and below [r (20) = 0.97, p<0.001]. There was a very strong positive relationship between the teeth examination-estimated age and actual age in beef cattle aged over 45 months [r (35) = 0.93, p<0.001]. There was a very strong positive relationship between the teeth examination-estimated age and actual age in dairy cattle aged over 45 months [r (8) = 0.97, p<0.001]. It was therefore concluded that under the given conditions of the study and the range of ages and the breeds under study, age estimation through teeth examination is reliably applicable for aging cattle in general. Age estimation through teeth examination was found to be more accurate in dairy than in beef cattle.

Keywords teething · beef · dairy · age · estimation · Namibia

Introduction

There are several methods available for age determination in cattle which include birth records (Lawrence *et al.* 2001; Pace & Wakeman 2003), teeth examination (Best 2014; Parish & Karisch 2014), horn ring or bone examination (Lawrence *et al.* 2001; O'Connor 2006; Raines *et al.* 2008), tail brush length measurement (Best 2014), post mortem lens weight measurements (Raines *et al.* 2008) as well as measurement of tendon thermal stability (Horgan 1991).

Birth records are the most reliable means of age determination, however, in reality, communal farmers and start-up farmers in the developing world do not always keep accurate birth records due to multiple ownership of animals and animals changing hands several times (Ortegon 2013; Pace & Wakeman 2003). In addition, some of the above-mentioned techniques can only be used at post mortem (Best 2014) or are not reliable or may not be possible to carry out in remote areas because of lack of expertise and/or lack of equipment.

Use of teeth examination to determine the age of cattle has been practised since time immemorial (Huidekoper 1903; Whiting *et al.* 2013). The canine teeth of cattle have migrated forward to join the incisors (Brown *et al.* 1960) and are anatomically indistinguishable from incisors and are thus referred to as fourth incisors (Whiting *et al.* 2013). The teeth examination method uses eruption and attrition of incisors (Attwell 1980; Parish 2013) which, however, are also influenced by several factors such as disease (Hobbs & Merriman 1962; Shupe & Alther 1966), sex (Carles & Lampkin 1977; Lawrence *et al.* 2001; Mellado *et al.* 2005), breed (Hearnshaw *et al.* 1996; Whiting *et al.* 2013), nutrition type (Müller *et al.* 2014; Wells

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Published online: 18 December 2019

2016), plane of nutrition (Brookes & Hodges 1979; Steenkamp 1970), geographical location (Gedminas 2016), and season of birth (Wiener & Forster 1982). Despite these potential confounding factors, teeth examination is considered the next best method for age determination in cattle (Best 2014; Torell *et al.* 1998; Whiting *et al.* 2013).

In Namibia and the world over, the correct age of an animal is required for identification in order to facilitate evaluation of the productivity of the individual animal or herd, to determine appropriate timing of routine management procedures such as weaning, dehorning, castration, breeding, vaccination, harvesting, culling and marketing (Best 2014; Graham & Price 1980; Silver 1969). Livestock auctioneers, middlemen and farmers need to know the exact ages of animals before they can buy or sell them (Best 2014). It is known that the value of an animal decreases with advancing age (Whiting *et al.* 2013). Moreover, abattoirs also need to know the ages of animals for carcass quality determination (Parish & Karisch 2014). In developed countries, the age of an animal has also been used to support eligibility of individual animals for show purposes, supporting age documentation for bovine spongiform encephalopathy exclusion (USDA 2019) and for determination of the onset of growth hormone treatment (Whiting *et al.* 2013).

There is a paucity of literature on cattle aging using dental examination and the last 4-5 decades has seen little activity on this subject. The majority of literature is found in the form of lecture notes, project reports (Miller 2004), training/extension manuals and guidelines (Ortegon 2013; Pace & Wakeman 2003), although a limited number were actual studies (Andrews 1975; Brookes & Hodges 1979; Carles & Lampkin 1977; Graham & Price 1982; Lawrence *et al.* 2001). To make matters worse, a number of the well-structured published studies are quite old (Andrews 1975; Brown *et al.* 1960; Huidekoper 1903; Silver 1969; Steenkamp 1970) with only a few well-structured studies on dental examination as a tool for aging cattle from more recent times (Parish & Karisch 2014; Whiting *et al.* 2013), some of which are doctoral dissertations (Best 2014; Gedminas 2016; Parish & Karisch 2014). Of these reports, only Best (2014), critically investigated the validity of age estimation under different circumstances.

Although dental examination is a widely-used tool in cattle production and marketing in Namibia, protocols for age estimation in current use were developed from elsewhere and have not been tested under Namibian cattle production conditions. It is thus imperative that appropriate evaluation of this tool be carried out under cattle production conditions in Namibia to justify its continued use. Therefore, this study was designed to determine the correlation between actual age of animals (as determined by birth records) and age estimation by visual dental examination in beef and dairy cattle at Neudamm farm in the semi-arid Khomas Region in order to test the suitability of teeth examination as a tool for age estimation in Namibia.

Materials and methods

Study area

This study was conducted at Neudamm farm, 30 km east of Windhoek within the Khomas region of Namibia. Neudamm farm is located at an elevation of 1,963 meters above sea level and lies between 22°31'0" S and 17°15'0" E in the highland Savannah of the country. The area receives an average annual rainfall of about 340-400mm with ambient temperatures of around 25 degrees Celsius.

Study animals and study design

Neudamm farm is a commercial farm that rears both beef (398 Afrikaner, 194 Nguni and 54 Simmental) and dairy (118 Friesian-Holstein breed) cattle. The beef herd of 646 cattle consists of 30 mature males, 162 mature females, 293 immature males and females and 161 steers. The dairy herd consists of 2 mature bulls, 49 mature cows (19 of them lactating), 42 immature females and 25 immature males. The sample size of beef cattle (n=76) was determined by using the sample size formula below (Daniel 1999), at 95% confidence level and 90% confidence interval whereby the population of interest was 353 cattle comprising of steers mature male and female cattle older than 12 months of age:

$$n = N^{*}X/(X + N - 1),$$

where,

$$X = Z_{\alpha}/2^{2^{*}}p^{*}(1-p)/MOE^{2}$$

The researchers chose not to use teething to age cattle below 12 months of age as this produces inconsistent and thus unreliable results. A simple random sampling method was used to select the individual beef and dairy animals. The 353 beef cattle of interest were each assigned a number between one and 353 then 76 animals were randomly chosen using an online random number generator (Randomness and Integrity Services Ltd. 2019). Since sex (male) and breed (Afrikaner, Nguni and Simmental) were not equally represented, the study did not investigate the accuracy of teething based on these categories. For dairy cattle, the calculated sample size of 32 was randomly chosen out of the eligible population of 51 cattle at 95% confidence level and 90% confidence interval. Though different paddocks are used, beef animal husbandry is primarily on pasture year-round with *ad lib* access to summer and winter licks (Feedmaster®) throughout the year. Bulls are kept in bull pens to facilitate selective breeding. Beef cattle are grazed on drier scrubland with considerable browse, whilst dairy cattle are grazed on well preserved greener scrubland pasture with limited browse. Dairy cattle receive 12kg (16% crude protein) of dairy meal daily (Feedmaster®). The beef

Table 1: Guidelines for estimation of age by teeth examination in cattle (Torell *et al.* 1998).

Age Category	Guidelines
≤ 1 month	Two or more of the temporary incisor teeth present. Within first month, entire 8 temporary incisors appear.
2 years	As a long-yearling, the central pair of temporary incisor teeth or pinchers is replaced by the permanent pinchers. At 2 years, the central permanent incisors attain full development.
2-1/2 Years	Permanent first intermediates, one on each side of the pinchers, are cut. Usually these are fully developed at 3 years.
3-1/2 Years	The second intermediates or laterals are cut. They are on the same level with the first Intermediates and begin to wear at 4 years.
4-1/2 Years	The corner teeth are replaced. At 5 years the animal usually has the full complement of Incisors with the corners fully developed.
5 to 6 Years	The permanent pinchers are levelled, both pairs of intermediates are partially levelled, and the corner incisors show wear.
7 to 10 Years	At 7 or 8 years the pinchers show noticeable wear; at 8 or 9 years the middle pairs show noticeable wear; and at 10 years, the corner teeth show noticeable wear.
>10 years	After the animal has passed the 6th year, the arch gradually loses its rounded contour and becomes nearly straight by the 12th year. In the meantime, the teeth gradually become triangular in shape, distinctly separated, and show progressive wearing to stubs. These conditions become more marked with increasing age.

enterprise operates a 20% cow replacement program (culled cows are auctioned or slaughtered at the farm for local marketing), though beef cows are sometimes kept in production for up to 16 years. The researchers and personnel involved in this study were all vaccinated against rabies and were well-informed about rabies as a deadly zoonotic disease.

Data collection and statistical analysis

Dairy and beef cattle were subjected to the same management and husbandry (nutritional and housing) regime. The estimation of age by teeth examination was done using the guidelines by Torell et al. (1998) as shown in Table 1. Three veterinarians with no prior access to birth records and also not involved in the sampling procedure independently estimated the ages of the sampled cattle within a two-week period. The three outcomes were compared and any disparities were collectively resolved by the three researchers. To remove any further bias, age estimates were then compared to the actual ages by a fourth veterinarian who had not been involved in the teething process. The overall estimated and actual age data collected for this study showed a normal distribution (Table 2).

A summary of the descriptive statistics of the proportional distribution of the estimated and actual beef and dairy cattle age-groups was calculated using Microsoft Excel 2013. A linear regression model was used to determine the correlation between estimated and actual ages in beef and dairy cattle. A Pearson correlation coefficient was also computed to investigate disparities in the accuracy of the teething method brought about by advanced age in animals by separating the study animals into two age groups based on the median age (45 months) of the study animals. The inferences on strength of correlations were made based on the descriptions shown in Table 3.

Scatter plots correlating the estimated beef or dairy cattle ages (independent variable) to the actual beef or dairy cattle ages (dependent variable) were drawn in Microsoft Excel 2013. The mean estimated and actual ages of the cattle were compared using the Paired Samples t-test. The Statistical Package for Social Sciences (SPSS) version 25 was used for regression analysis and t-test where $p \leq 0.05$ was considered significant.

Results

As shown in Table 4, there was a significant difference in age (months) between the overall mean actual age (M=60, SD=4.57) and the mean estimated age (M=57, SD=4.52 months) in beef cattle; $t(75) = 3.61$, $p<0.001$. There was no significant difference between the overall mean estimated age

Table 2: Shapiro-Wilk test scores (W) of the estimated and actual beef and dairy cattle ages from Neudamm farm in 2018

Parameter	Shapiro-Wilk score (W)	R^2
Beef cattle estimated age	0.95	0.91
Beef cattle actual age	0.94	0.88
Dairy cattle estimated age	0.92	0.85
Dairy cattle actual age	0.93	0.87

Table 3: Descriptions assigned to the ranges of the values of correlation coefficients (R)

R value	Description
0 to 0.19	very weak
0.2 to 0.39	Weak
0.4 to 0.59	Moderate
0.6 to 0.79	Strong
0.8 to 1.0	very strong

and the mean actual age [(M=42.5, SD=5.18) and (M=41.3, SD=5.21 months)] in dairy cattle; t(31) = 1.45, p=0.16.

As shown in Figure 1, there was a very strong positive relationship between the overall teeth examination-estimated age and actual age in beef cattle at Neudamm [r (74) = 0.98, p<0.001]. There was a very strong positive relationship between the overall teeth examination-estimated age and actual age in dairy cattle at Neudamm [r (30) = 0.99, p<0.001].

As shown in Figure 2, there was a very strong positive relationship between the teeth examination-estimated age and actual age in beef cattle at Neudamm aged 45 months and below [r (37) = 0.93, p<0.001]. There was a very strong positive relationship between the teeth examination-estimated age and actual age in dairy cattle at Neudamm aged 45months and below [r (20) = 0.97, p<0.001].

There was a very strong positive relationship between the teeth examination-estimated age and actual age in beef cattle at Neudamm aged above 45months [r (35) = 0.93, p<0.001]. There was a very strong positive relationship between the teeth examination-estimated age and actual age in dairy cattle at Neudamm aged above 45months [r (8) = 0.97, p<0.001].

Discussion

This study showed that there was a significant agreement between the teeth-estimated ages and the actual ages in both beef and dairy cattle. The results also showed that teeth examination had a high positive correlation with the actual age in beef cattle aged up to 152 months and in dairy cattle aged up to 119 months.

Table 4: Descriptive statistics of beef and dairy cattle at Neudamm farm in 2018

Descriptive statistic	Beef cattle	Dairy cattle
Mean estimated age±SEM (Months)	57±4.52	41.3±5.21
Mean actual age±SEM (Months)	60±4.57	42.5±5.18
Minimum estimated age (Months)	10	10
Minimum actual age (Months	13	8
Maximum estimated age (Months)	156	115
Maximum actual age (Months)	152	119

The implications of these findings are that other factors that also affect teeth eruption and attrition, such as disease (Shupe & Alther 1966), sex (Mellado *et al.* 2005), breed (Whiting *et al.* 2013), nutrition type (Wells 2016), plane of nutrition (Brookes & Hodges 1979; Steenkamp 1970), geographical location (Gedminas 2016), and season of birth (Wiener & Forster 1982) are only collectively responsible for between 2.4-4.9% of the variation, and are thus insignificant.

These results suggest that local veterinarians, animal production scientists and farmers can confidently age their animals using teeth examination using the protocols developed and tested elsewhere in the world (Lawrence *et al.* 2001; Ortegon 2013; Torell *et al.* 1998), without any need for adjustments.

The high positive correlation between teeth examination estimated age and actual age observed in young cattle (below 45 months) has also been investigated by a previous study (Best 2014) which reported that teeth examination was most accurate in younger cattle below 5 years than in cattle over 6 years of age. Other studies have also supported the findings that the accuracy of aging cattle decreases with increasing actual age (Parish 2013; Parish & Karisch 2014; Wells 2016). The increased accuracy of estimation of age observed in beef cattle over 45 months in this study has not been previously reported and is difficult to explain.

There are conflicting reports on the influence of genetics (breed) on teeth eruption in cattle, with some studies claiming a lack of relationship (Brown *et al.* 1960), while others claim the existence of a positive correlation (Brookes & Hodges 1979; Hearnshaw *et al.* 1996; Whiting *et al.* 2013; Wiener & Forster 1982) and yet still others declaring inconclusive results (Graham & Price 1982). Whiting and co-workers analysed the effect of breed on teeth eruption in different dairy and beef breeds of cattle and concluded that the permanent premolars of dairy breeds erupted earlier than those of beef breeds (Whiting *et al.* 2013). The age estimations of dairy breeds in the study by Whiting and co-workers were thus actually less correlated to actual age than in beef breeds. From that point of view, their results are in contrast to the findings of the current study. Results from this study suggested that teeth examination was more accurate in a dairy breed than in beef cattle. Such results have not been reported elsewhere. Perhaps, a similar study may need to be repeated using larger numbers of cattle from other parts of the country to substantiate this claim.

Although this study was able to vindicate the usage of teeth examination as a method of aging cattle in Namibia, the current study was not without its own limitations. The number of beef and dairy cattle at the farm limited the size of the sample. The study was only carried out at one farm, which might limit its wider applicability. In addition, the types of herds that the farm keeps might have also imposed limitations on equal representations

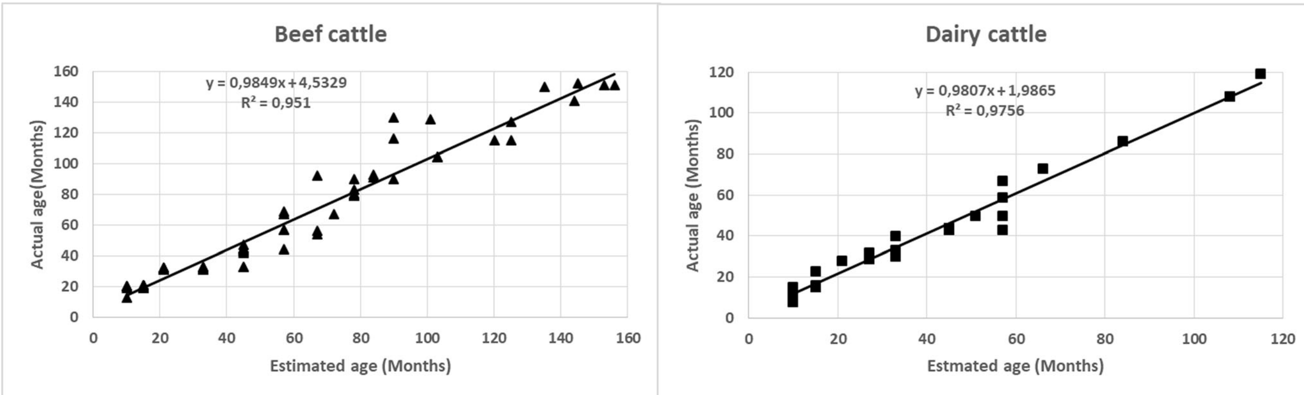

Fig. 1 Overall correlation of teething and actual age in beef and dairy cattle at Neudamm farm

of breeds and sexes of the animals used. In addition to the imbalance of breeds, the beef herd had fewer males older than 1.5 years. Similarly, the dairy unit does not keep significant numbers of males compared to females. The results from this study may differ with those of investigations done under different pedology, edaphology, feeding regime and vegetation type. Furthermore, farmers and non-veterinary stakeholders should be warned about the danger of using this method in areas where rabies is endemic because of the higher risk of contracting this disease.

The authors concluded that there was a very good positive correlation between teeth-examination-estimated-age and the actual age in cattle when protocols developed outside Namibia were used to estimate age in both beef (Afrikaner, Nguni and Simmental) and dairy (Friesian-Holstein) cattle at this farm.

Ethical issues The University of Namibia guidelines for animal handling and restraint were adhered to during the execution of this study and no invasive or painful procedures were employed. Animal handling and restraint was performed by trained and experienced animal handlers and veterinarians.

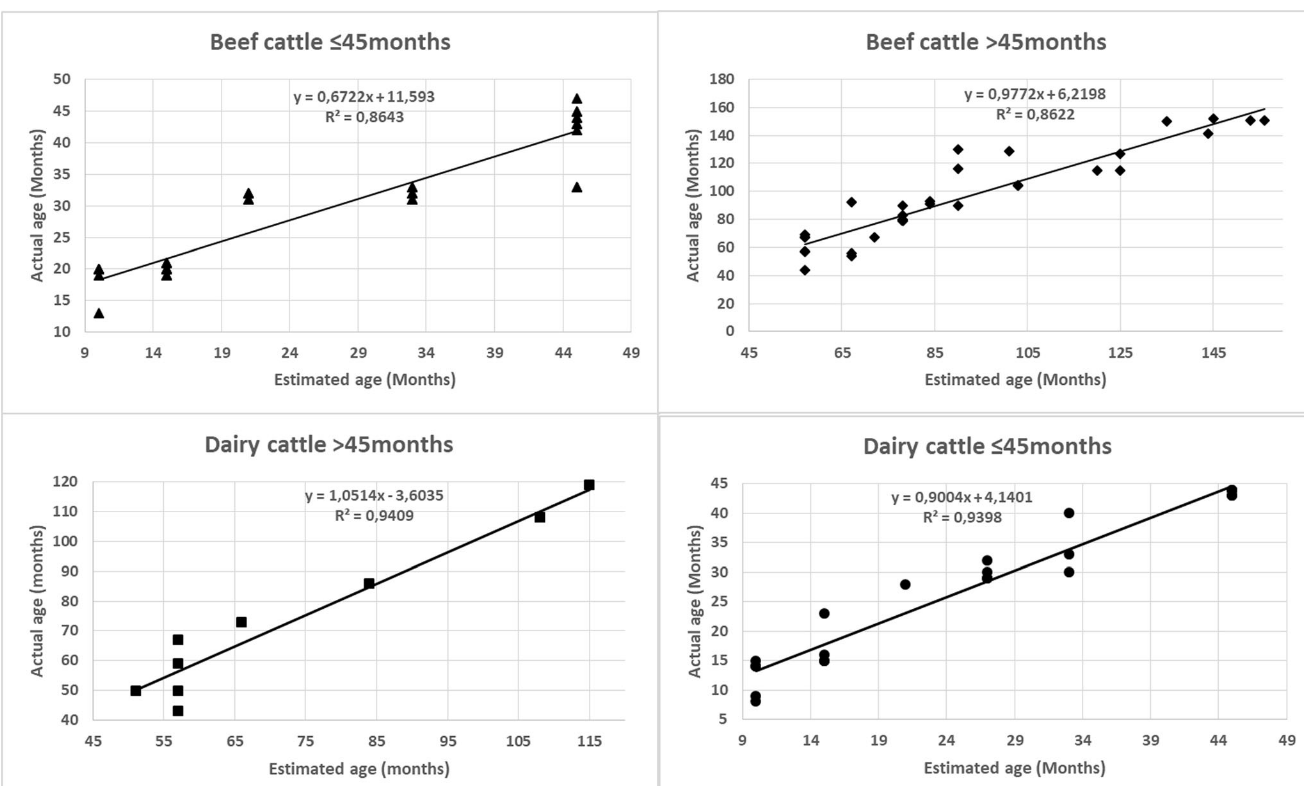

Fig. 2 Correlation of teething and actual age in beef and dairy cattle at Neudamm farm

Acknowledgement The authors would like to sincerely thank the University of Namibia for funding the publication of this manuscript as well as allowing the study to be conducted on the institution's animals.

Compliance with ethical standards

Conflict of interest The authors declare no conflict of interest.

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