Management of weanlings on commercial Thoroughbred stud farms in the North Island of New Zealand

N.L. STOWERS, C.W. ROGERS and S.O. HOSKIN

Institute of Veterinary Animal and Biomedical Sciences, Massey University, Private Bag 11-222, Palmerston North 4442, New Zealand

ABSTRACT

The feeding of concentrates to growing thoroughbred horses in New Zealand is common practice, despite the availability of pasture all year round. Whilst the sale of young stock is the primary focus of the majority of the breeders in the Thoroughbred industry, there is still limited data on the production process and the optimal strategy to grow horses to their maximum athletic potential. To obtain data on the management of Thoroughbred weanlings a face-to-face survey was conducted on 46 stud farms in the northern and central regions of the North Island during the 2007/08 breeding season. Analysis was based on location and size of the breeding operation. Prior to weaning, 87% of foals were exposed to concentrate feed and all weanlings received concentrates. Weanlings received 47 ± 2 MJ of digestible energy (DE) and 563 ± 40 g of crude protein (CP) per day from concentrate initially. This increased to 64 ± 6 MJ DE and 683 ± 54 g CP immediately before yearling preparation. The data collected indicated that management of weanlings is generally consistent between regions and across farm sizes with weanlings receiving large quantities of concentrate feed whilst at pasture.

Keywords: horse; thoroughbred; growth; nutrition; management.

INTRODUCTION

Thoroughbred breeding in New Zealand is a major economic enterprise. The sale of young Thoroughbred racehorses from New Zealand generates over NZ$ 110 million in export earnings annually (New Zealand Racing Board, 2004). The sale of yearling horses is the primary focus of the majority of breeders in the Thoroughbred industry with the 2008 premier sale grossing NZ$ 77.1 million from the sale of 387 yearlings. Select and Festival sales together grossed NZ$ 33.9 million from the sale of 784 yearlings (New Zealand Bloodstock, 2008). Buyers from New Zealand, as well as buyers from Hong Kong, South Africa, Singapore, England and Ireland have a strong presence at the yearling sales held at Karaka in South Auckland. However, despite the lucrative financial returns available from the sale of young stock, there is still limited data on the production process and the optimal strategy to grow horses to their maximum athletic potential.

The New Zealand Thoroughbred breeder has the unique opportunity to grow horses at pasture all year round, using grass as their staple diet, as opposed to overseas breeders who are forced to grow horses more intensively, with pasture playing a less significant role in the growth and development of the young horse (Rogers *et al.*, 2007). Foals are usually kept with their dams until weaning at 4 to 6 months of age (E.K.Gee, Personal communication). At this time, weanlings often undergo extensive handling prior to yearling preparation for the major sales at Karaka in January and February. At weaning, and often before, foals are introduced to concentrate feeding and general handling in the form of hoof trimming, drenching and handling for educational purposes. Feed rations for weanlings are mostly assigned by visual assessment. It is however, becoming increasingly popular, especially amongst the large studs,, to weigh the foals and/or use one of the many computerised growth programmes available to monitor weight gains in the growing horse (E.K. Gee, Personal communication).

A study carried out by Rogers *et al.* (2007) gathered baseline data for the management of Thoroughbreds in the North Island and found that often young horses were provided with large amounts of concentrate feed, even when foals were grown at pasture. There is still limited knowledge of detailed weanling management and nutrition practices on Thoroughbred Studs in New Zealand. This paper reports on the feeding and management practices associated with weanling Thoroughbred foals on commercial Thoroughbred stud farms in the North Island of New Zealand.

MATERIALS AND METHODS

A face to face survey was conducted on Thoroughbred Stud Farms throughout the North Island of New Zealand between May and June 2008. Sixty-two commercial, Thoroughbred stud farms were contacted to participate in the study. The sampling frame was defined as ‘Commercial farms’ being those that sent five or more yearlings to the

TABLE 1: Description of stud farms and weanling management by geographical region described as median and interquartile range in brackets.

Management criteria	Auckland 7 farms	Waikato 31 farms	Central Districts 7 farms
Farm size (ha)	107 (39-162)	65 (20-178)	81 (40-101)
Area available to weanlings (ha)	40 (6-81)	23 (5-80)	12 (11-36)
Area of farm used by weanlings (%)	25 (15-62)	42 (27-79)	28 (19-45)
Weanling paddock size (ha)	1.5 (0.6 - 2.6)	1.6 (0.8 - 2.8)	1.5 (0.7 - 2.0)
Usual sward height for weanlings (cm)	7 (4 - 10)	9 (8 - 12)	10 (5 - 10)
Weanling stocking density (no/ha)	3.3 (2.9- 4.5)	2.6 (1.9 - 4.9)	2.8 (2.5 - 3.8)
Proportion weanlings exercised (%)	0	10	29
Proportion weanlings receiving supplements (%)	29	58	86
Proportion weanlings receiving extra forage (%)	86	81	100
Faecal egg counting carried out (%)	29	50	50
Proportion weanlings covered at pasture (%)	43	24	50

TABLE 2: Description of stud farms and weanling management by farm size described as median and interquartile range in brackets.

Management criteria	Boutique ≤15 mares 11 farms	Moderate 16 - 70 mares 24 farms	Medium 71 - 199 mares 6 farms	Large ≥200 mares 4 farms
Farm size (ha)	15[a] (5 - 20)	84[b] (37 - 159)	118[b] (86 - 224)	418[c](189 - 567)
Area available to weanlings (ha)	5[a](4 - 10)	30[b] (12 - 65)	53[b] (19 - 216)	86[b] (50 - 159)
Area of farm used by weanlings (%)	50 (15 - 80)	37 (23 - 60)	41 (26 - 75)	27 (18 - 32)
Weanling paddock size (ha)	0.6[a] (0.4 - 1.3)	1.6[b] (1.3 - 3.0)	1.8[b] (1.2 - 2.1)	2.7[c] (2.5 - 3.0)
Usual sward height for weanlings (cm)	6 (3 - 9)	10 (8 - 11)	10 (9 - 13)	10 (8 - 18)
Weanling stocking density (no/ha)	3.7 (3.2-5.0)	2.7 (1.6 - 4.0)	2.9 (2.4 -3.9)	2.1 (1.7 - 2.8)
Proportion weanlings exercised (%)	9	13	14	0
Proportion weanlings receiving supplements (%)	64	61	57	25
Proportion weanlings receiving extra forage (%)	91	74	100	100
Faecal egg counting carried out (%)	11	55	60	75
Proportion weanlings covered at pasture (%)	57	0	50	24

Karaka yearling sales in 2008. Some stud farms were excluded due to location and this included all South Island farms (n = 5) and five North Island farms. Studs were contacted initially through email, then via phone and were provided with a brief synopsis of the study. If there was no response from studs after five contact attempts, they were excluded from the sample set. If willing to participate, the studmasters were then interviewed on the stud farm. The face-to-face survey consisted of a combination of 50 closed and open ended questions. The survey was structured to provide data on general farm practices and management practices for weanlings. The survey was emailed to the studs prior to the farm visits to help familiarise the studmasters with the questions.

The data were tabulated and edited using MS Excel 2007 (Microsoft Corporation, USA). Parametric data were examined using the general linear model procedure and non parametric data were examined using either the Chi squared or the Kruskal-Wallis test in SPSS v16 (SPSS, 2004) with a significance level of $P < 0.05$. Parametric data is presented as mean ± standard error and non parametric data as median and interquartile range.

RESULTS

The sample set consisted of 52 stud farms, seven of which were located in Auckland, 31 were located in Waikato and 14 were located in the Central Districts regions. Using the categories previously defined by Rogers *et al.* (2007), farms were divided into large (≥200 mares), medium (70 to 199 mares), and moderate sized farms (<70 mares). A further category was defined to account for the smaller breeding operations of boutique (≤15 mares), altering the moderate category to (16 to 70 mares). Of the 62 Stud farms, 46 took part in the survey, of which 4 were large, 17 were medium and 23 were moderate sized stud farms. The response rate was therefore 74%.

Effective farm size ranged from 5 to 562 ha and was 107 (50 to 176) ha, 64 (5 to 181) ha and 80 (36 to 115) ha in the Auckland, Waikato and Central Districts regions farms, respectively (Table 1). The mean number of resident broodmares was 67 with a range of 0 to 500. The mean number of stallions in Auckland and the Central Districts regions was 2, with ranges of 0 to 4 in Auckland, 0 to 3 Central Districts and whilst the mean number of stallions in the Waikato was 0, a range of 0 to 7. Auckland and

TABLE 3: Mean ± standard error (SE) feeding value of concentrate diets fed to weanlings on North Island farms at 5 and 12 months-old compared with National Research Council (NRC) (2007) recommendations for horses. MJ = megajoules, DE = Digestible energy.

Variable	5 months-old		12 months-old	
	Mean	NRC recommendation	Mean	NRC recommendation
Energy (MJ DE)	47 ± 2	60	64 ± 6	79
Crude protein (g)	563 ± 40	673	683 ± 54	846
Ca (g)	37 ± 3	39	45 ± 4	38
P (g)	22 ± 2	22	28 ± 2	21
Cu (mg)	275 ± 26	48	359 ± 44	80
Zn (mg)	459 ± 30	192	598 ± 44	321
Se (mg)	2.1 ± 0.2	0.5	0.8 ± 0.1	0.8
Ca:P	1.8 ± 0.1:1	1.8:1	1.8 ± 0.1:1	1.8:1
Zn:Cu	2.1 ± 0.1:1	4:1	2.0 ±0.1:1	4:1

Central Districts farms had a higher mean number of stallions than Waikato farms, as many of the Waikato farms did not stand stallions. The mean number of weanlings and yearlings on farms was 36 ± 4 and 17 ±2, respectively, and did not differ between regions. However, when asked to rank the production focus, more Waikato stud farms (64%) placed primary emphasis on producing yearlings for sale than Auckland (9%) and Central Districts farms (9%) (P = 0.016). The mean number of sheep and cattle used to cross graze with horses on farms was 157 ± 58 and 158 ± 90 respectively.

Abrupt box weaning was carried out on 38/46 farms, whilst gradual paddock weaning methods were carried out on only 8/46 farms. The average proportion of effective farm size allocated to weanlings was 46%. The mean paddock sizes weanlings were kept in was 2.1 ha ± 0.36 and the average stocking density was 3 ± 0.28 weanlings/ha. Boutique sized farms generally kept weanlings in smaller sized paddocks than moderate, medium and large sized farms (Table 2). Medium sized farms also kept weanlings in significantly smaller sized paddocks than large farms. Weanlings were typically kept in groups of four horses with a range of 2 to 8. The average sward height in weanling paddocks was 9.3cm with a range of 1.2 to 20 cm and the quality of pasture available in these paddocks was described as "Good", where good was defined as less than 25% weed density.

The majority (64%) of farms administered anthelmintic drenches to foals and weanlings via oral paste, whilst only 9% used tube drenching, 3% used injectable, intramuscular drenches and 24 % used a combination of both oral paste and tube drenching. Anthelmintic drenches were administered on average at 6, with a range of 3 to 14, weekly intervals before and after weaning. The number of farms conducting faecal egg counts increased with farm size (Large = 9/10; Medium = 10/21; Moderate = 1/4; Boutique = 1/4).

Most farms (37/46) also implemented some kind of pasture renewal programme. This often included over- and under-sowing as well as fertilising pastures. Many studs (30/46) also sowed low-endophyte ryegrasses. Only 11% of weanlings received controlled exercise, other than for the sole purpose of education. Fifty eight percent of stud farms fed mineral supplements to their weanlings, additional to their concentrate feed. Most studs (84%) also provided extra forage to the weanlings when at pasture.

Foals on most stud farms (39/46) were first introduced to concentrate feed before weaning, and all weanlings received concentrate feed. At an average age of 5 months old, weanlings received, on average, 47 MJ digestible energy (DE) from concentrate alone (Table 3). They also received on average 563g crude protein (CP) and the average Calcium (Ca):Phosphorous (P) and Zinc (Zn):Copper (Cu) ratios were 1.8:1 and 2.1:1 respectively. At 12 months-old, they received an average of 64 MJ DE and 683 g CP from concentrate alone. The average Ca:P and Zn:Cu ratios at this time were 1.8:1 and 2:1 respectively. Weanlings also spent 24 hours per day at pasture, apart from when were brought in for education, at an average sward height of 9.3 cm. The average area each weanling had available to graze was 1.2 ha with a range of 0.2 to 4.5 ha.

DISCUSSION

The overall management of weanlings was relatively consistent between regions and across farm sizes. This is in agreement with previous studies carried out on stud farm management in New Zealand (Rogers *et al.,* 2007). Large differences in farm size may be a causative factor for the subtle differences in management and production focus.

Waikato region stud farms placed more emphasis on producing yearlings for sale than Auckland and Central Districts regions farms and allocated a greater percentage of the effective grazing area for weanlings than Auckland or Central

Districts regions farms. A possible explanation for this may be found in the clustering of the higher priced sires within the Waikato region. The returns from selling yearlings were greatest from the progeny sired by the more expensive sires. Progeny of the medium to lower priced stallions tend achieve break-even, or even provide a net loss to the vendor (stud farm). However, it is still important for the farms that stand medium to lower priced stallions to market yearlings at the sales to ensure progeny are placed in the hands of trainers and given adequate opportunity to be tested on the racetrack, hopefully providing a positive result for the sire and encouraging increased demand for subsequent foal crops.

The intensive production of foals for sale as yearlings was reflected in the weaning methods used, with the majority of farms using abrupt, box weaning. Previous studies had indicated there are no significant differences in average daily gain between abrupt or progressive weaning methods (Rogers *et al.,* 2004; McCall *et al.,* 1987). When abrupt weaning was used, foals also began their education process, which reflected the actual start of the yearling preparation. At the time of weaning, foals were introduced to concentrate feed, if they had not been already been consuming it as foals, and were often taught to lead and have covers on. Irrespective of the weaning method used, after weaning, foals were later brought in to be stabled and educated on an ongoing basis until the start of the yearling preparation in November.

Recently there has been a large interest in the effect of early exercise on the musculoskeletal development and athletic potential of growing horses (Rogers *et al.,* 2008b, Rogers *et al.,* 2008a). Even though there were no differences between stocking densities when studied by region or farm size, paddock sizes were significantly smaller on boutique-sized farms than moderate-, medium- and large-sized farms. These animals may have less opportunity to participate in high strain rate exercise, such as galloping. This may not optimise development of the musculoskeletal system ands and racing potential.

Frequent worming may help to minimise the worm burden at times of stress, such as at weaning. In the long term this heavy use of anthelmintic drenches may predispose the farms to parasite resistance. The number of farms conducting faecal egg counts increased with farm size, indicating a greater awareness of parasites and perhaps the risks of parasite resistance. Faecal egg counts are useful in any parasite control programme and help reduce resistance to parasites that can arise from the over-use of anthelmintic drenches. It has been reported that equine cyathostomes are now commonly resistant to benzimadozles (Lloyd *et al.,* 2000). Surveys carried out in the USA and UK indicate resistance in cyathostome populations is as high as 80% (Proudman & Matthews, 2000). Studs could minimise the risk of drench resistance by implementing faecal egg counts on a regular basis, only drenching when necessary. Most studs also cross-grazed horses with either sheep or cattle. This may also reduce the need for high levels of anthelmintic drenches. Cross-grazing may also help to improve pasture quality. Most studs, also implemented some form of pasture renewal program which often included over- and under-sowing as well as fertilising pastures. Low-endophyte ryegrasses were also commonly sown in areas available to weanlings, which may reduce the likelihood of growing horses developing ryegrass staggers. However data reported by Hunt (1997) suggest no negative effect of ryegrass staggers on the growth of foals.

On average, weanlings were fed high amounts of concentrate feed whilst at pasture from 5 to 12 months-old. Energy and protein intake are the primary factors influencing the growth rate of young horses (Ott, 2005). Weanlings received an average of 79% and 81% of the National Research Council recommendation for energy from concentrate feed alone at 5 and 12 months-old respectively (National Research Council, 2007). Under the assumptions of Grace *et al.* (2002; 2003), weanlings and yearlings allocated 0.2 to 0.25 ha per horse of ryegrass-based pasture with a pre-grazing mass 1,800 to 2,000 kg dry matter (DM)/ha would not limit feed intakes. These intakes were estimated at 5.5 kg DM or 63 MJ DE/d and 6.9 kg DM or 78 MJ DE/d for weanlings and yearlings respectively (Grace *et al.,* 2002; 2003). Weanlings in this study spent all their time at ryegrass-based pasture, apart from being stabled for education. The total pre-grazing mass per weanling was estimated using the industry predictions of Lincoln University for ryegrass/white clover based pastures. Based on New Zealand pasture guidelines (Fleming, 2003) an average sward height of 9.3 cm and a total land allocation per weanling of 1.2 ha, provides each weanling with an estimated 2,300 kg DM/ha. Therefore, based on the assumptions of Grace *et al.* (2002; 2003), on average, weanlings in this study should have adequate growth rates from pasture alone without the need for supplementary concentrate feed.

The uncertainty surrounding the composition and quality of pasture could be a factor in the decisions made by stud farms to feed such high amounts of concentrate feed and subsequent informal questioning of stud masters at a later date suggests that this is the case. The current industry practise of feeding a high level of relatively expensive concentrate feeding in the presence of sufficient pasture creates economic inefficiencies.

The weanlings in this study are therefore effectively standing in the pasture, rather than consuming it to attain their requirements for growth. We propose that optimal growth rates and production of high quality yearlings for sale could be achieved at a lower per unit cost if the pasture was more efficiently utilised as a primary feed source and concentrate feed was used strategically to maintain, or maximise growth, during times of lower pasture DM cover.

Instead of consuming a diet based on forage with concentrate supplementation for growth, these weanlings are consuming the majority of their nutrient requirement from grain-based concentrates predominantly made up of non-structural carbohydrates. High intakes of non-structural carbohydrate and accelerated growth have been associated with skeletal abnormalities (Glade *et al.,* 1984). It has been hypothesised that horses fed high carbohydrate diets may become temporarily hypothyroxemic post-prandially, which could have adverse effects on cartilage (Jeffcott & Savage, 1996). It has also been reported however, that high DE intakes, composed of both carbohydrate or oil may be instrumental in the induction of osteochondrosis (Savage *et al.,* 1993). It is not clear whether high DE or high carbohydrate diets instigate developmental orthopedic disease (DOD), but it is conceivable that feeding excessive DE in some ways causes endocrinological alterations, especially through mediation of local cartilaginous factors (Jeffcott & Savage, 1996). Limited data is available on the prevalence of DOD in New Zealand horses. Overseas data suggests this disease is common in growing horses and some reports indicate rates as high as 10 to 50% across a number of breeds (Jeffcott, 2004) and around 10% for North American Thoroughbreds (Pagan, 2000).

Weanlings also received on average 84% of their CP requirement when they were 5 months-old and 81% of their daily requirement at 12 months-old (National Research Council, 2007). The growing horse requires 50 g/Mcal of DE/day according to National Research Council (2007) requirements. This amount equates to 0.5% of CP per 0.1 Mcal/kg of diet (Lewis, 1995). It has been proposed that diets with excess protein may be associated with DOD (Pool, 1987) due to the hypercalciuric effect which occurs when there is an excessive intake of sulphur-containing amino acids (Jeffcott & Savage, 1996). This may result in a subsequent overload of the renal buffering capacity of sulphuric acid and the subsequent acidotic state may inhibit renal mineral reabsorption and calcium (Ca) may then be lost in the urine (Glade *et al.,* 1985). Excessive dietary protein has however, not been confirmed as a causative factor for the DOD osteochordritis dessicans, nor has it to be reported to have negative effects on the growth of young horses (Jeffcott, 1996).

Sufficient mineral intake and the correct balance of minerals in the diets of young horses may be required for optimal growth. Absolute amounts of Ca, P, Cu and Zn as well as relative amounts in the diet can influence growth and imbalances of mineral homeostasis may have a role in the pathogenesis of osteochondrosis (Jeffcott & Savage, 1996). An optimal Ca:P ratio has been stated as 1.5 to 2:1 (Pagan, 2005) and a Ca:P ratio of above 2 may be associated with a lower incidence of DOD (Pagan and Geor, 2001). The mean Ca:P ratio for weanlings in this study was 1.8:1 with a range of 1.29:1 to 5:1). Although most (61%) farms fed weanling diets that were balanced in terms of Ca and P, some (39%) provided diets below 1:5 Ca: 1 P. Although Cu and Zn levels fed to weanlings were in excess of requirements, there have been no reports of Cu toxicity. Zn toxicity in horses is very rare and has only been documented where Zn levels of the pasture available to these horses was 20 times that of "normal" New Zealand pastures (Eamens *et al.*, 1984).

CONCLUSION

Many weanling management variables on Thoroughbred horse studs were similar between regions and farms sizes. Larger farms in the Waikato and Auckland regions had a greater focus on producing yearlings for sale than central districts farms. Large quantities of concentrate feed were provided, even though the weanlings appeared to have access to adequate quantities of high quality pasture.

REFERENCES

Eamens, G.J.; Macadam, J.F.; Laing, E.A. 1984: Skeletal abnormalities in young horses associated with zinc toxicity and hypocuprosis. *Australian veterinary journal* **61**: 205-207.

Fleming, P.H. 2003: Farm technical manual. Lincoln University, Canterbury, New Zealand. 1010 pp.

Gee, E.K. 2003: Aspects of growth and development of the pature-fed Thoroughbred foal in New Zealand. Ph.D. thesis, Massey University.

Glade, M. J.; Beller, D.; Bergen, J.; Berry, D.; Blonder, E.; Bradley, J.; Cupelo, M.; Dallas, J. 1985: Dietary protein in excess of requirements inhibits renal calcium and phosphorous reabsorption in young horses. *Nutrition reports international* **31**: 649-659.

Glade, M.J.; Gupta, S.; Reimers, T.J. 1984: Hormonal responses to high and low planes of nutrition in weanling Thoroughbreds. *Journal of animal science* **59**: 658-665.

Grace, N.D.; Gee, E.K.; Firth, E.C.; Shaw, H.L. 2002: Digestible energy intake, dry matter digestibility and mineral status of grazing New Zealand Thoroughbred yearlings. *New Zealand veterinary journal* **50**: 63-69.

Grace, N.D.; Rogers, C.W.; Firth, E.C.; Faram, T.L.; Shaw, H.L. 2003: Digestible energy intake, dry matter digestibility and effect of increased calcium intake on bone parameters of grazing Thoroughbred weanlings in New Zealand. *New Zealand veterinary journal* **51**: 165-173.

Jeffcott, L. 2004: Developmental diseases affecting growing horses. In: Juliand, V.; Martinrosset, W. eds. 2nd European Workshop on Equine Nutrition. Dijon, France. Wageningen Academic Publishers, Wageningen, The Netherlands. p. 231-245.

Jeffcott, L.B. 1996: Osteochondrosis – An international problem for the horse industry. *Journal of equine veterinary science* **16**: 32-37.

Jeffcott, L.B.; Savage, C.J. 1996: Nutrition and the development of Osteochondrosis (Dyschondroplasia). *Pferdeheilkunde* **12**: 338-342.

Lewis, L.D. 1995: Equine clinical nutrition: feeding and care. Williams and Wilkins. Baltimore, Maryland, USA. 587 pp.

Lloyd, S.; Smith, J.E.; Connan, R.M.; Hatcher, M.A.; Hedges, T.R.; Humphrey, D.J.; Jones, A.C. 2000: Parasite control methods used by horse owners: factors predisposing to the development of anthelmintic resistance in nematodes. *Veterinary record* **146**: 487-492.

McCall, C.A.; Potter, G.D.; Kreider, J.L.; Jenkins, W.L. 1987: Physiological responses in foals weaned by abrupt or gradual methods. *Journal of equine veterinary science* **7**: 368-374.

National Research Council, 2007: Nutrient requirements of horses. National Academies Press, Washington, D.C., USA. 360 pp.

New Zealand Bloodstock, 2008: 2008 National Yearling Sales Series Summary. *http://www.thoroughbrednews.co.nz/nz/default.aspx/id=33405*

New Zealand Racing Board, 2004: Size and scope of the New Zealand racing industry. New Zealand Racing Board, Petone, New Zealand. 71 pp.

Ott, E.A. 2005: Energy and protein metabolism of normal growth. In: Julliand, V.; Martinrosset, W. eds. The growing horse: nutrition and prevention of growth disorders. Wageningen Academic Publishers, Wageningen, The Netherlands. p. 91-102.

Pagan, J. D. 2000: The incidence of developmental orthopedic disease (DOD) on a Kentucky Thoroughbred Farm. In: Pagan, J.D. ed. Advances in Equine nutrition. Nottingham University Press, Nottingham, UK. p. 469-475.

Pagan, J. D. 2005: Nutrition of the growing horse: feeding management to reduce DOD. Applied equine nutrition. 1st Equine Nutrition Conference, Hanover, Germany. Wageningen Academic Publishers, Wageningen, The Netherlands. p. 127-138.

Pagan, J.D.; Geor, R.J. 2001: Advances in Equine Nutrition II. Nottingham University Press, Nottingham,UK. 547 pp.

Pool, R.R. 1987: Developmental orthopedic disease in the horse. Normal and abnormal bone formation. *Proceedings of the American Association of Equine Practitioners* **33**: 135-138.

Proudman, C.J.; Matthews, J. 2000: Control of intestinal parasites in horses. *In practice* **7**: 90-97.

Rogers, C.W.; Firth, E.C.; Mcilwraith, C.W.; Barneveld, A.; Goodship, A.E.; Kawcak, C.E.; Smith, R.K.W.; Van Weeren, P.R. 2008a: Evaluation of a new strategy to modulate skeletal development in racehorses by imposing track-based exercise during growth: The effects on 2-and 3-year-old racing careers. *Equine veterinary journal* **40**: 119-127.

Rogers, C.W.; Firth, E.C.; Mcilwraitht, C.W.; Barneveld, A.; Goodship, A.E.; Kawcak, C.E.; Smith, R.K.W.; Van Weerew, P.R. 2008b: Evaluation of a new strategy to modulate skeletal development in Thoroughbred performance horses by imposing track-based exercise during growth. *Equine veterinary journal* **40**: 111-118.

Rogers, C.W.; Gee, E.K.; Faram, T.L. 2004: The effect of two different weaning procedures on the growth of pasture-reared thoroughbred foals in New Zealand. *New Zealand veterinary journal* **52**: 401-403.

Rogers, C.W.; Gee, E.K.; Firth, E.C. 2007: A cross-sectional survey of Thoroughbred stud farm management in the North Island of New Zealand. *New Zealand veterinary journal* **55**: 302-307.

Savage, C.J.; Mccarthy, R.N.; Jeffcott, L.B. 1993: Effects of dietary energy and protein on induction of dyschondroplasia in foals. *Equine veterinary journal Supplement* **16**: 74-79.

SPSS, 2004: SPSS 12.1. SPSS Inc., Chicago, Illinois, USA.