Sub-clinical parasitism, weaning date, growth of deer calves and reproductive performance of hinds

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Abstract
A recent survey indicated March was the most common month for pre-rut weaning of farmed deer (31%), with 5% weaned in February (n=119 farms). Both weaning date (March vs. June) and date of first anthelmintic treatment potentially influence liveweight gain of young deer. This study investigated the impact of pre-rut weaning date on parasitism and liveweight gain (LWG) of deer calves and hinds, and conception date and rate of hinds by untrasound scanning. Seventy-six deer calves were randomly allocated in a 2x2 factorial design, involving weaning date (February 17 or March 17) and two treatments with moxidectin anthelmintic at a six-week interval (Jan 14 and Feb 25) or no anthelmintic treatment. LWG of calves was monitored at 2-4 week intervals from Jan 12 to Mar 31. Sixty-four mixed-age hinds were used to investigate the effect of pre-rut weaning date on internal parasitism and conception date. Deer grazed permanent perennial ryegrass-based pasture together until weaning. Calves weaned in March had a higher LWG to March 31 than those weaned in February ($P<0.0001$). A significant weaning/anthelmintic treatment interaction was found ($P<0.02$), with LWG being higher in treated calves weaned in March ($P<0.017$) but not February ($P>0.10$). Faecal larval counts in treated calves were zero, but faecal egg counts in treated calves averaged 136 epg (range 0-600). In Hinds, FLC averaged 5 lpg (range 0 – 122) and FEC averaged 26 (range 0- 200) with no significant relationship between weaning date and either FLC or FEC. No effect of weaning date was shown on conception rate or date. This study has shown that pre-rut weaning date and sub-clinical parasitism during summer and early autumn can influence LWG in young farmed deer.

Key words: Deer, parasites, lungworm, gastrointestinal worms, anthelmintic, weaning, weight, pregnancy, conception date

Introduction

Lungworm (*Dictyocaulus* spp.) has been the parasite of most concern in New Zealand farmed deer (Mason, 1985, Johnson et al 2003). Deer less than 6-months of age in their first autumn are most susceptible to infection because they have not yet developed immunity, and the environment in autumn favours development and survival of endoparasite larvae. Adult farmed deer usually carry a low worm numbers, but appear to be largely resistant to heavy infestation under optimum management conditions (Mason, 1985; Audige et al 1998; Mackintosh and Wilson, 2002). Nevertheless, calves over two months of age shed more larvae than their dams (Audige et al 1998) and are likely to be the major source of re-infection in autumn (Mason, 1985).

Little is known about the epidemiology and pathogenicity of lungworm infections, and even less is known about GI nematode infections of farmed deer. However, investigations have shown that even small numbers of lung and GI nematodes cause sub-clinical infections of during autumn can reduce voluntary feed intake and liveweight gain post-weaning (Hoskin et al 2000). Investigations have shown that although gastrointestinal parasites seldom cause clinical disease or deaths, they can have a significant effect on growth of young deer (Charleston, 2001). Therefore, lungworm and GI nematode parasitism can potentially have a marked effect on the ability of young deer to reach slaughter weight by one year of age (Hoskin et al 1999). More knowledge is needed about the effect of parasitism on growth of young farmed deer in summer and early autumn prior to weaning.

Bodyweight of hinds influences both their ability to conceive and the date of conception (Guiness et al 1978; Hamilton and Blaxter, 1980; Audige et al 1998). Weaning before mating resulted in a more compact calving because suckling can delay calving through later mating over and above any effects of liveweight by itself (Loudon et al 1983). Pollard et al (2002) reported an earlier median conception date in hinds weaned prior to the rut. Therefore to achieve a high pregnancy rate early in the mating season, one recommendation has been that farmers should wean calves before the mating season.

The aim of this study was to examine the impact of early or late pre-rut weaning with and without anthelmintic treatment on growth of calves, and weaning date effects on hind reproductive parameters.

Materials and methods

The study was undertaken at the Massey University Deer Research Unit (Palmerston North, New Zealand). Observations began January 14 and concluded for weaners on March 31 and for hinds on June 3. Seventy-six deer calves comprising 47 red (15 female + 32 male) and 29 ¼ elk-hybrid (17 female + 12 male) were randomly allocated in a 2x2 factorial design (based on sex, genotype and live weight) on January 12, 2005. One group was weaned on February 17 and the other on March 17. Moxidectin pour-on (500µg/kg, Cydectin®, Fort Dodge Animal Health NZ Ltd) was given January 14 and February 25, based on the live weight of the heaviest animal, to half of the animals within each weaning date groups.

In addition, 64 dams (mixed-age) weaned either February 17 or March 17were joined with a single red stag from March 1 to May 4. Conception rate was assessed by a rectal ultrasound (Bingham et al 1988) performed by a single operator on May 30 and June 3 to assess pregnancy status and estimated conception date using foetal age equations of Revol and Wilson, (1990).

Calves and hinds were rotationally grazed together on permanent perennial ryegrass-based pasture until weaning, when calves were removed to a separate pasture. Feed allowances (excluding dead matter) were set at 10kg DM/hind/day prior to weaning and for calves post weaning at 5kg DM/day. The March 17 weaned group was put with the February 17 weaned group. The hinds remained together before and during mating.

Live weight of the calves and hinds was measured January 12, February 17, and March 17 and 31, and May 4 for adult hinds only. At the same times, rectal faecal samples of 6-10g were taken from each animal for faecal egg count (FEC) using the modified McMaster technique (Stafford et al 1994) and faecal larval count (FLC) using the Baermann technique (Hendriksen, 1965). Counts are expressed per gram of fresh faeces.

Data analysis was undertaken using SAS (Statistical Analysis System, version 9.1; SAS Institute Inc., Cary, NC, USA). Faecal larval count, FEC and LWG were analysed using the proc MIXED procedure with a linear model that considered the fixed effects of sex, genotype, anthelmintic treatment, weaning date and their interactions and the random effect of animal. While FEC and FLC required log-transformation [LOG_{10} (count + 1)], least squares means are presented as back-transformed means. Significance was declared at $p<0.05$. Accumulated pregnancy curves of hinds weaned either in February or March were estimated using survival analysis (proc PHREG). Correlations between traits were obtained using the GLM procedure.

Results

Calf weight

Live weight data are presented in Figure 1.

Anthelmintic treatment and weaning date: Anthelmintic treatment and weaning date had no significant effect on LW *per se*. The interaction between both was significant ($p<0.05$), with calves treated and weaned in March having a significantly higher mean LW (48.3 kg) on March 31 compared to the calves treated and weaned in February (44.3 kg). Both sex and genotype had a significant influence on LW ($p<0.0001$ and $p<0.001$ respectively). Male calves averaged 49.8 kg and females 42.1 kg, while the hybrid calves averaged 48.1 kg and red deer calves averaged 43.7 kg on March 31.

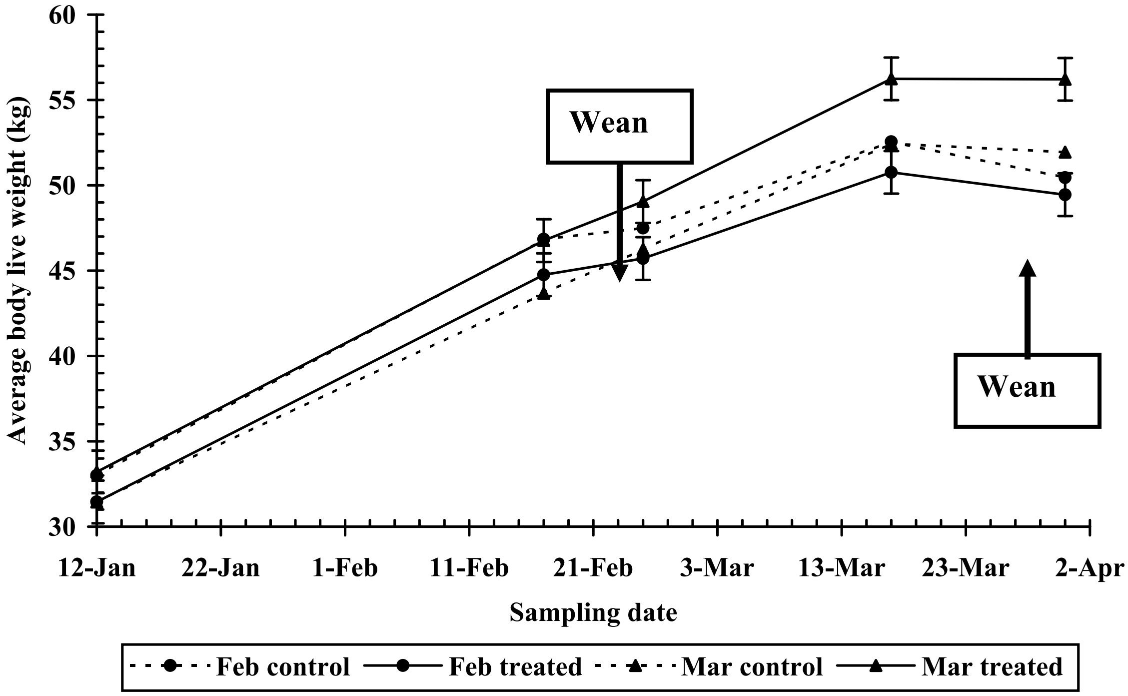

Fig 1: Mean (± SEM) body live weight of calves weaned in mid-February (Feb) or mid-March (Mar) and treated with anthelmintic (treated) or remaining as untreated controls (control).

Calves weaned in March had a significantly higher mean LWG than those weaned in February (253 vs.153g/day, $p<0.0001$)). The weaning by anthelmintic treatment interaction was significant ($p<0.05$), with higher LWG of anthelmintic treated calves weaned in March (<0.001) but not in February ($p>0.05$).

There was no significant effect of sex or genotype on LWG. However, the interaction between sex and weaning date was significant with the March weaned male calves having higher LWG than February weaned male and female calves ($P<0.05$) (Table 1). There was no significant difference in LWG between female calves weaned in February and March.

Table 1: Mean (± SEM) LWG (g/day) of male and female calves weaned in February and March and the significance of the interaction between sex and weaning date on LWG.

Effect			
Sex	**Weaning date**	**LWG**	**Sex*Weaning date**
Male	Feb	144.2 ± 23.4	P<0.001
	Mar	259.3 ± 24.1	
Female	Feb	161.3 ± 26.7	Not Significant
	Mar	226.1 ± 26.9	

Despite the difference in LW *per se* not being different, anthelmintic treated male and female combined, had significantly higher LWG ($P<0.05$) than control calves. Treated male, but not female, calves had a significantly higher LWG compared with the controls (Table 2) indicating an interaction between sex and anthelmintic treatment.

Table 2: Mean (± SEM) LWG (g/day) of male and female calves weaned in February and March and the significance of the interaction between sex and anthelmintic treatment.

Effect			
Sex	**Treated**	**LWG**	**Sex*Treated**
Female	Control	159.63 ± 12.4	Not Significant
	Treated	157.13 ± 12.4	
Male	Control	147.64 ± 10.7	P<0.05
	Treated	190.85 ± 10.7	

Calf Parasitology

Tables 3 and 4 show the average, range and proportion positive for FLC and FEC, respectively. In early March the untreated control group weaned in February had low a mean FLC with 26% positive compared with higher mean counts in March and 95% positive. In contrast, for the untreated control calves weaned in March (Table 3), FLC was higher in late March with 89% positive than in those weaned in February, with 32% positive.

The elk-hybrid deer had higher mean FLC than red deer ($p<0.001$). Sex and weaning date had no effect on FLC. FLC averaged 83 in mid-February (range 0- 320) in untreated control calves with 100% positive in March weaned calves. Moxidectin reduced FLC to zero ($p<0.0001$), but FEC remained similar to the untreated control calves regardless of when they had been treated (average 136, range 0- 600 epg in mid-February and average 92, range 0-350 epg at the end of March).

Table 3: Average and range of larval counts (lpg) and the proportion positive from calves treated with Moxidectin on January 14 and February 25, and untreated controls.

Sampling dates

Weaning date	**Jan-12**			**Feb-17**			**Mar-17**			**Mar-31**		
	Ave	***Range***	**%+ve**	**Ave**	***Range***	**%+ve**	**Ave**	***Range***	**%+ve**	**Ave**	***Range***	**%+ve**
February-17												
Control	20	*0-124*	0.63	48	*0-300*	0.95	<1	*0-2*	0.26	4	*0-19*	0.32
Treated	32	*0-212*	0.58	<1	*0-1*	0.21	0	*0*	0.0	0	*0*	0.0
March-17												
Control	6	*0-71*	0.44	83	*0-320*	1.0	3	*0-16*	0.44	94	*0-108*	0.89
Treated	12	*0-78*	0.68	<1	*0-1*	0.11	0	*0*	0.0	0	*0*	0.0

The proportion of positive FECs in the treated calves was high 36 (February 17) and 34 days (March 31) after treatment (Table 4). The FEC in the control calves averaged 108 epg (ranged 0- 850) with the highest counts in February (Table 4). There was no effect of sex, genotype, anthelmintic treatment or weaning date on FEC.

There was a significant negative correlation between FEC and LWG ($R^2 = -0.203$, $p<0.001$), and between FLC and LWG ($R^2 = -0.162$, $p<0.01$).

Hind Parasitology

Mean FEC and FLC from hinds were low with the proportion being positive declining to 9% for both by the beginning of May (Table 5). There was no significant relationship between weaning date of hinds and either FLC or FEC.

Table 5: FLC (lpg) and FEC (epg) data from mature mixed-age hinds.

	Sampling date	**Jan-12**	**Feb-17**	**Mar-17**	**May-04**
FLC	Average	5	1	<1	<1
	Range	0-122	0-9	0-8	0-12
	% +ve	62	28	6	9
FEC	Average	26	17	16	6
	Range	0-200	0-100	0-150	0-100
	% +ve	28	25	22	9

Table 4: Average and range of faecal egg counts (epg) and proportion positive from calves treated with Moxidectin on January 14 and February 25, and untreated controls.

	Sampling dates											
Weaning date	**Jan-12**			**Feb-17**			**Mar-17**			**Mar-31**		
	Ave	***Range***	**+ve**	**Ave**	***Range***	**+ve**	**Ave**	***Range***	**+ve**	**Ave**	***Range***	**+ve**
February-17												
Control	47	*0-350*	0.26	108	*0-850*	0.37	32	*0-150*	0.32	142	*0-800*	0.68
Treated	58	*0-700*	0.21	159	*0-450*	0.58	42	*0-200*	0.32	74	*0-300*	0.53
March-17												
Control	31	*0-300*	0.22	131	*0-550*	0.50	47	*0-200*	0.50	114	*0-350*	0.72
Treated	26	*0-150*	0.37	136	*0-600*	0.47	37	*0-200*	0.37	92	*0-350*	0.58

Hind reproduction

The cumulative daily percentages of hinds weaned either February or March, conceiving from day 0, corresponding to 24 March, are shown in Figure 2. There was no difference in overall conception rate (84.4%) or conception date related to weaning date. However, three hinds in the March weaned group conceived after the last of the February weaned hinds, with the latest being 10 days later.

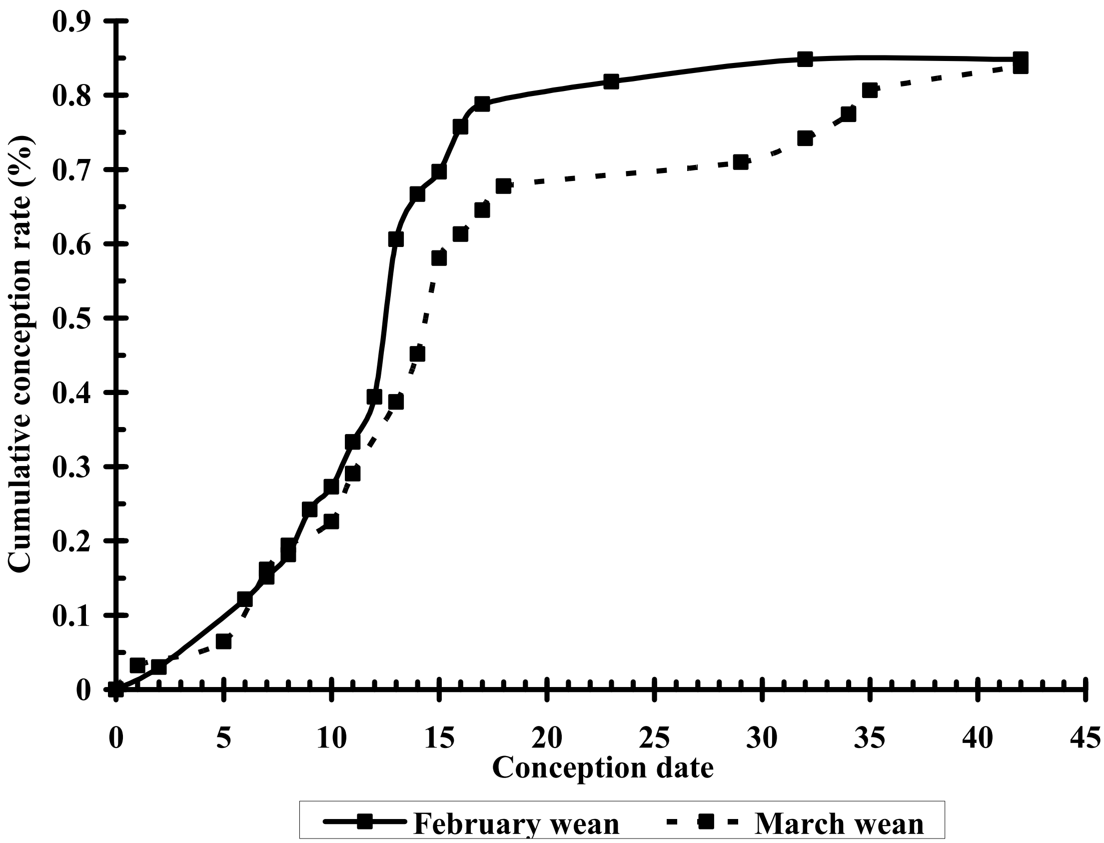

Fig 2: The daily cumulative conception rate (%) of hinds weaned February or March with day 1 being March 24.

A summary of conception dates (Figure 3) shows that the median conception date was day12 and 13 for February and March-weaned hinds, respectively. Thus the February weaned hinds achieved a more compact mating.

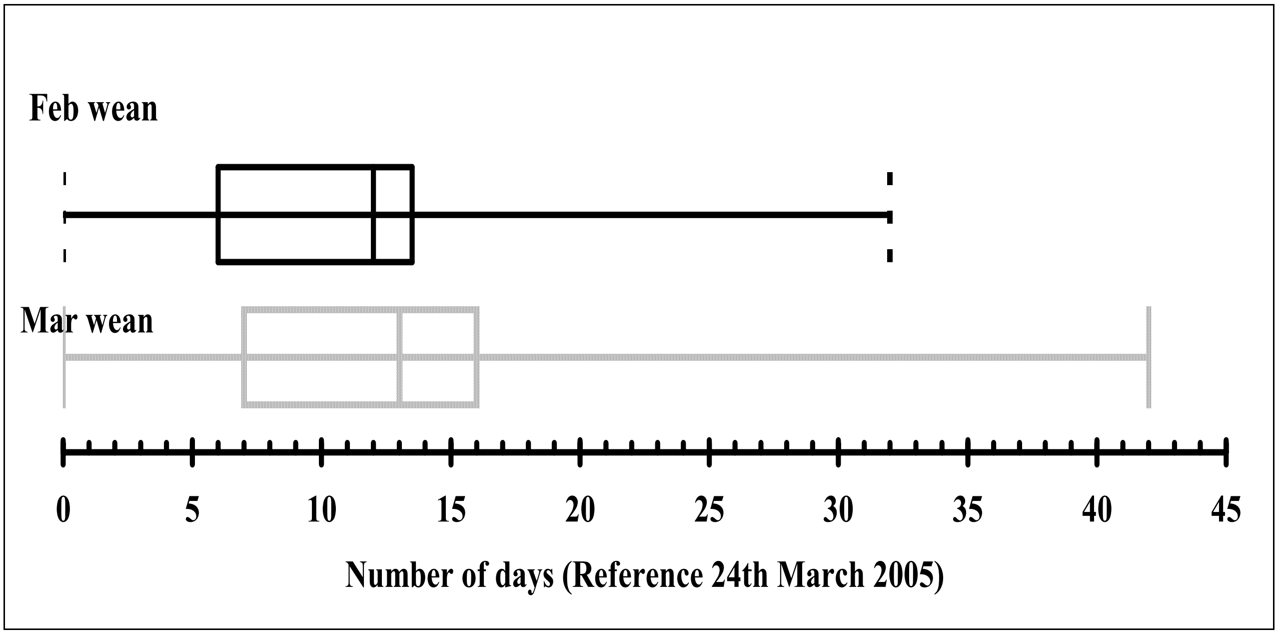

Fig 3: Box plot representation of conception date of February an March weaned hinds with day 0 being March 24th, showing the range of conception dates (line), with the box showing the range over which 75% conceived. The vertical line within each box shows the median conception day.

Discussion

This study has shown that date of weaning and anthelmintic treatment influenced growth rate of weaners, but weaning date had no effect on reproductive measures in hinds. It has previously been shown that calves weaned pre-rut had a lower weight gain from March to June than those weaned after the rut (Pollard, 2002), although that research may have been confounded by factors not common to weaned and un-weaned deer. There is limited information on the weight gain of red deer calves weaned prior to 90 days (Bao et al 2004). This is the first research into the impact of pre-rut weaning date on parasitism and LWG of deer calves, with calves weaned on February 17 vs. March 17. The advantage in

LWG of calves in the later weaning date group could be associated with milk intake (Arman, 1974), and/or with age-related stress associated with weaning (Bao et al 2004).

Calves weaned early onto pasture are likely to suffer an initial growth check for one or two weeks due to the stress of weaning (Bao et al 2004). The growth check may be reduced by weaning onto high quality feed to which calves have been accustomed prior to weaning. However, although accustomed to the pasture and the paddock, calves in this study were weaned onto permanent perennial ryegrass-based pasture of low to moderate feeding value. This may have contributed to a nutrition-induced growth check.

It appears that the experimental design of this study may have influenced the weaner growth result. Calves weaned in February were removed to a separate paddock, previously grazed with their dams earlier in the rotation, with two 'uncles' (castrated fistulated stags), whereas calves weaned in March were placed with the earlier-weaned calves possibly decreasing the level of stress for the group weaned in March. Therefore it is suggested that in further work of this type, groups weaned at different times are weaned into separate paddocks under the same conditions.

Faecal egg and larval counts recorded in this study remained at sub-clinical levels. Faecal larval counts were higher in hybrid than pure red deer indirectly supporting the observation of increased susceptibility to lungworm associated with wapiti/elk genes (Mason, 1977). In contrast, Parsons et al (1994) found that red deer had higher FLCs, but red ¼ -wapiti hybrids had higher FECs. Therefore the relative susceptibility of red and hybrid deer to internal parasitism warrants further investigation using challenge studies and worm count data rather than egg and larval counts.

A recent survey has shown that Moxidectin pour-on was the most commonly used anthelmintic for weaner deer (Castillo-Alcala et al 2005). Moxidectin 0.5% pour-on has persistent activity for 35 to 42 days against reinfection with lungworms (mature and immature) and GI nematodes (Mackintosh et al1997; Waldrup et al 1998), respectively. As the persistent activity of moxidectin against GI nematodes is the same as the treatment intervals, FEC after the first treatment should have remained at zero. The failure of

Moxidectin to reduce FEC to zero could be interpreted as sub-optimal efficacy and/or anthelmintic resistance (Charleston and McKenna, 2002; Hoskin et al 2005). Emergence of deer GI nematode resistance is a concern and may result in major loss of production in young farmed deer (Charleston, 2001), if this issue is not addressed by the deer industry.

Low FLC and FEC of mature hinds in the absence of clinical signs indicated sub-clinical parasitism throughout the trial. These findings support previous research showing that adult deer had lower FEC and FLC than calves (Mason and Gladden, 1983; Parsons et al 1994) probably due to immunity. However, it has been suggested that climatic and nutritional stress may reduce immunity to parasites in adult deer (Audige et al 1998).

In this study the hinds weaned in February had a relatively compact mating. Previous trials found mean conception dates to be earlier in pre-rut weaned hinds compared with post-rut weaned hinds by 12 and 7 days in 1999 and 2000, respectively (Pollard et al 2002). This study showed no difference in reproductive parameters resulting from two pre-rut weaning dates.

This study has shown that pre-rut weaning date and sub-clinical parasitism during summer and early autumn can influence LWG in young farmed deer.

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