PHOTOPERIODISM AND GROWTH

J M Suttie, I D Corson, J R Webster and K B Woodford

PART A - PHOTOPERIOD AND TEMPERATE DEER

Temperate deer species have well described seasonal patterns of live weight gain, antler growth and reproduction Typically adult red deer males grow in spring and summer, lose weight during autumn but do not gain appreciable weight during winter During the first year of life red deer males and females undergo a period of slow growth from approximately May to late August This slowing of growth takes place despite the provision of excess quantities of high quality food Several studies have strongly implicated photoperiod as the most likely cause of not only the winter slowing in growth but also the resurgence of rapid weight gain during the spring At Invermay we are undertaking a series of studies not only to elucidate the mechanisms underlying the photoperiodic control of growth but to evaluate systems for practical growth enhancement using photoperiod as a tool In a previous communication to this Association (Suttie and Corson 1991) we presented data which showed that if weaner red deer stags were placed indoors in mid autumn and exposed to a daily photoperiod of 16 hours of light followed by 8 hours of dark (16L·8D), the timing of the spring increase in weight was advanced relative to control animals kept on natural photoperiod This indicated to us that advancing the onset of the spring growth phase could be a practical possibility for growth enhancement in deer, particularly for producers who were already committed by management practice to in-wintering weaner stock However, several questions remained from that study, namely, (1) was 16L 8D more effective than, say, 14L 10D? (2) would the animals become unresponsive to 16L 8D and if so when? (3) what effect would varying the start time of exposure to 16L 8D have on the photoperiodic inductive effects, and (4) what effect would the long photoperiod have on reproductive maturation? The aim of this study was to determine whether a variety of other photoperiods were equally as effective as 16L 8D, whether and when growth would cease after prolonged exposure to experimental photoperiods and what effect a later start date (the winter solstice) would have on the inductive effect

MATERIALS

Animals and feeds

Fifty weaner red deer stag calves were adapted indoors, over a period of 25 days, to a diet of lucerne hay and a barley based concentrate ration containing cottonseed meal as the main protein source This concentrate ration contained 11 5 MJ ME/kg DM and 16% DCP The adaptation process took place under natural conditions of photoperiod All animals were vaccinated against Yersinia, clostridial diseases, drenched with Ivermectin and treated with copper

Pens

Four 30 m^2 pens were constructed, indoors, and each pen was sealed so that it was light-proof and no natural changes in day length could be perceived Separate ventilation and water systems were installed in each pen Illumination was provided by natural daylight fluorescent strip lights, which provided 500 lux one meter above the level of the floor The lights were controlled automatically with timers The floors were covered with sawdust which was changed regularly A feed trough 4 metres long was positioned along one wall, this permitted all deer to feed simultaneously.

Treatments

On the winter solstice the stags were allocated to one of the following treatments (n=10 per group)

1 16L 8D, indoors
2 13 25L 10 75D, indoors
3. 10 75L 13 25D, indoors
4. 8L 16D, indoors
5. Natural light, outdoors on a feeding pad with no access to grazing

Each treatment took place in one pen No changes of animals or photoperiods were made during the study The stags were fed *ad libitum* the concentrate ration with 250 g/head/day lucerne hay to stimulate digestion and alleviate coat chewing Water was freely available The stags remained on the experiment until March 4, a period of 252 days All lights were switched on at 8 00 am and the timing of lights off was adjusted to effect the different treatments

<u>Measurements</u>

At weekly intervals all stags were weighed and at two weekly intervals testis diameter, antler length and antler status was recorded. Antler status was not recorded in the outdoor group as these stags were surgically polled for another study. Uneaten food residues were collected so that group food-intake could be measured.

Data were analysed by ANOVA

RESULTS

<u>Food intake</u>

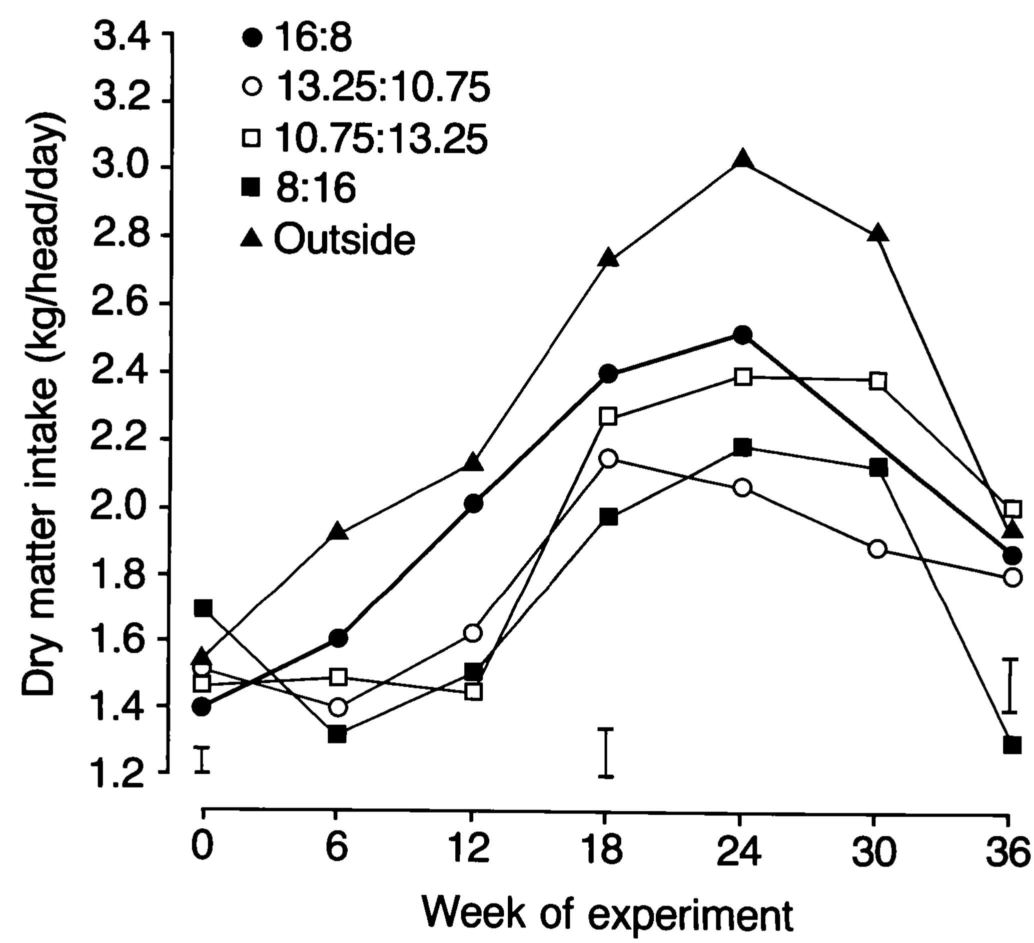

FIGURE 1 Food intake, dry matter (kg/head/day) for each group during the experiment. Note the outdoor group ate more at all times. The bar indicates the standard error of the difference among the means at 3 representative times of the experiment.

At the beginning of the study, at the winter solstice, all groups of stags were eating about 1.5 kg/head/day (Figure 1). After 6 weeks the stags exposed to 16L 8D significantly increased their food intake compared with the other 3 groups of stags indoors. Food intake remained high for the 16L 8D group until after 24 weeks of the study had elapsed. The stags exposed to 13.25L 10.75D, 10.25L 13.75D and 8L 16D all showed a similar pattern of food intake as follows. Intake rose after week 12 of the study, plateaued from 18 to 30 weeks then fell. In contrast the outdoors group had higher food intake than all other groups from 6-30 weeks of the study. Peak food intake was reached at week 24, which corresponds to approximately the summer solstice.

Overall, all groups increased food intake at some stage during the study, then food intake decreased towards the end.

Liveweight

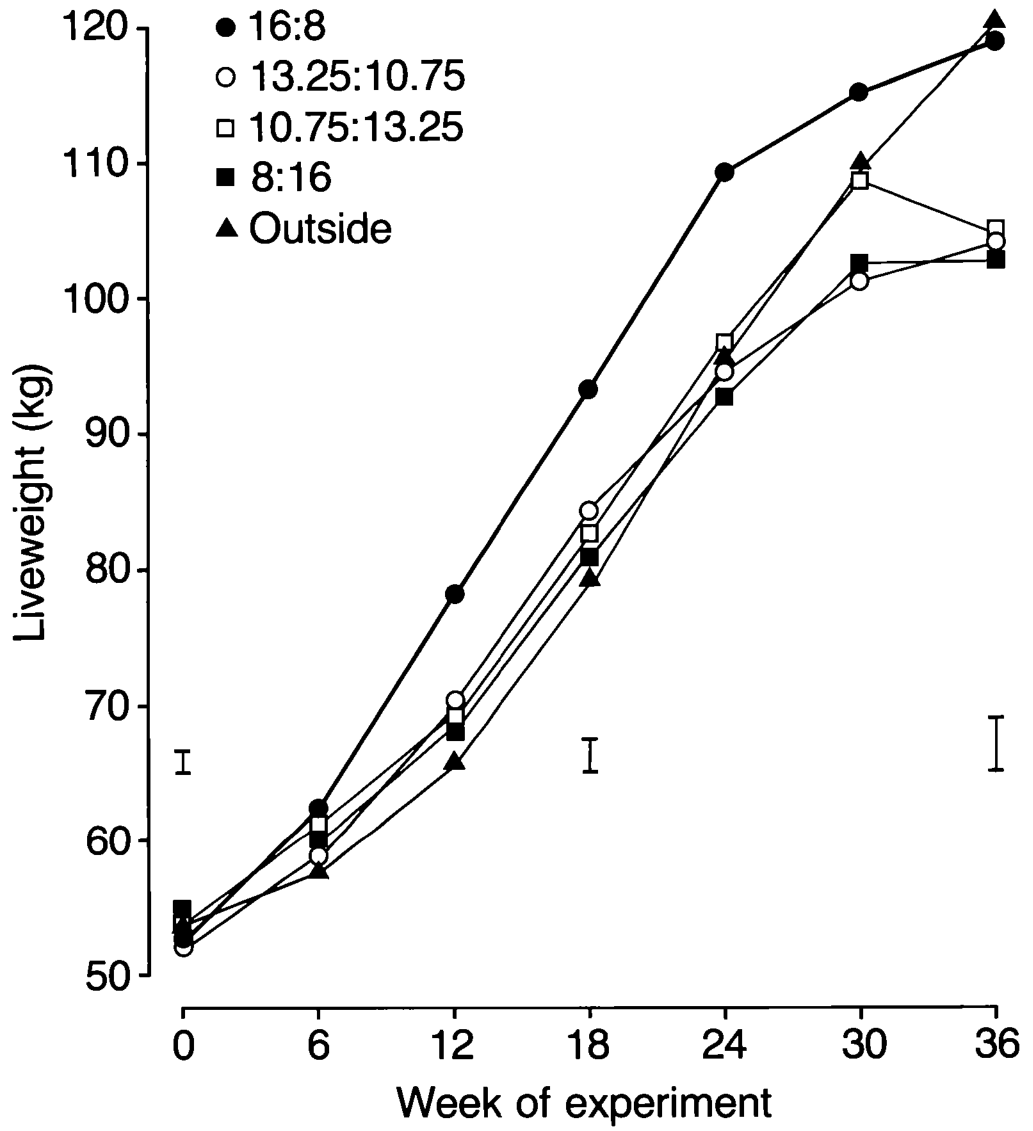

FIGURE 2 Live weight (kg) for each group during the experiment. Note that the 16L 8D group began to grow earlier, grew faster but towards the end slowed growth In contrast the outdoor group grew continuously throughout the experiment The bar indicates the standard error of the difference among the means at 3 representative times of the experiment

During the study all groups gained weight steadily until after 30 weeks of the study (Figure 2) From 6-24 weeks the group exposed to 16L 8D grew considerably faster than all other groups, growth rate then decreased All other groups showed increased growth rates from week 12-24 After week 24 the 13 25 10 75 and 10 75L 13 25D groups reduced weight gain The group kept outdoors grew steadily and at the close of the study were the largest The animals in the 16L 8D group achieved an acceptable slaughter weight of 100 kg about 20 weeks after the study began, this is about the last week of October

Testis diameter

All groups kept indoors had enlarged testes, indicative of a heightened state of reproductive activity from weeks 24 to 30 (Figure 3) This was followed by a decrease in testis diameter Testis diameter was largest in the 16L 8D group The group kept outside showed a plateau of testis diameter from weeks 18-24 (December) then grew their testes rapidly until week 36 (March)

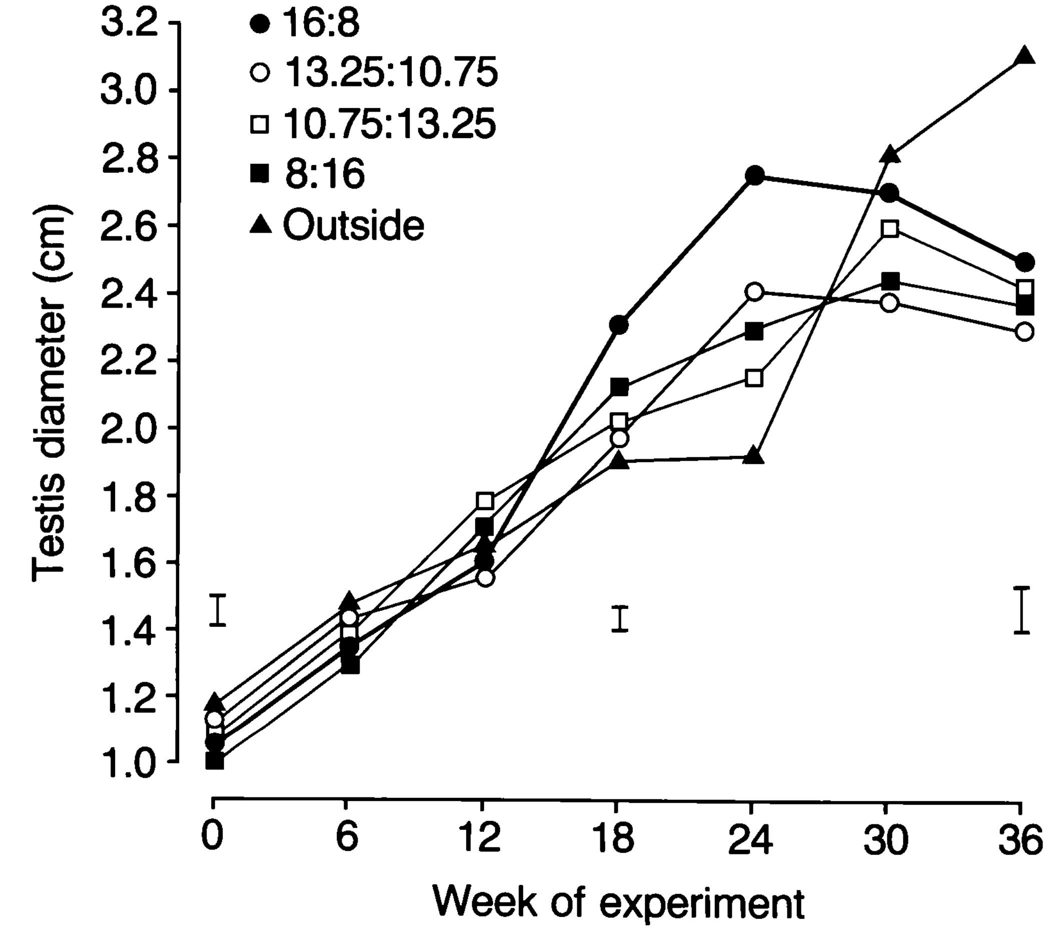

FIGURE 3 Testis diameter (cm) for each group during the experiment The bar indicates the standard error of the difference among the means at 3 representative times of the experiment

Antlers

TABLE 1 Timing of the antler cycle and hard antler length (cm) The superscript "a" indicates a significant difference (P<0.05)

Weeks from the start of the study to	Treatment				
	16L 8D	13 25L 10 75D	10 75L 13 25D	8L 16D	sed
Pedicle initiation	3	2 3	2 8	3	1 1
Antler initiation	11 7	10 5	11 5	12 1	1 8
Antler cleaning	25 6	23 8	26 0	30[a]	1 6
Antler length (cm)	44 5	42 6	32 2[a]	44 5	1 4

All groups began to grow pedicles about 2-3 weeks after the start of the study, and antlers were observed 8-9 weeks later There were no significant differences between the groups However cleaning was significantly delayed in the group kept on 8L 16D No antler data could be obtained from the outdoor control group Antler length was significantly less for the group kept on 10 75L 13 25D

DISCUSSION

Exposure of animals to 16L 8D not only advanced the onset of the spring rise in growth but significantly increased growth rate Despite the fact that only 2 h 35 min extra illumination per day was experienced by the 16L.8D group compared with the one exposed to 13 25L·10 75D this increased growth rate and the timing of the increase was significant The reasons for this advantage are obscure but, in the practical context, it seems that 16L.8D is the most appropriate photoperiod for causing growth enhancement

16L·8D was not capable of promoting growth indefinitely and after a period of about 20 weeks growth ceased in this group This may be because the deer became refractory to the positive stimulation of the photoperiod or because some "set-point" for growth was reached This cessation of growth occurred earlier in the 13 25L 10 75D and 10 75L 13 25D compared with the outdoor controls which means that either the stimulatory photoperiod had ceased or the photoperiod was now actually inhibitory for growth Either way it appears that a fixed photoperiod presents widely differing growth cues depending on the length of the light versus dark phases Such effects are not usually observed in trials where reproductive changes are measured in relation to photoperiod

As growth ceased in all groups testes increased in diameter and antlers were cleaned of velvet This confirms that stags do not require short photoperiod to permit reproductive rhythms to be expressed but, as reproduction was earlier than the outdoors controls, probably require short days to delay and accurately time puberty.

The advancement of reproductive development may have lead to the reduction in antler size in the group kept on 10 75L 13 25D by prematurely raising testosterone thus minimising the time for growth Otherwise antler length was similar to typical spikers at Invermay kept outdoors Antler cleaning was advanced in all groups except that on 8L 16D The reasons for this are not known

The present study began some 2 months after a similar trial in a previous year (Suttie and Corson 1991) In that trial 16L 8D acted to promote growth when treatment began on April 11 The present results show that growth promotion will result if stags are exposed to this photoperiod much later This also emphasises the flexibility of the system

The stags kept outdoors in terms of food intake, growth and testis development closely resembled animals observed previously at Invermay. The fact that even in summer their food intake was much higher for the same weight gain was a surprise as it was previously thought that summer food intake would be similar in animals kept outdoors and indoors

In the present study no animals were lost due to disease However one animal in 16L 8D broke metacarpal bones, which were set by Colin Mackintosh Coat chewing occurred in all groups at the end of winter when the juvenile winter coat was loose and moulting The animals were casually observed for fighting and bullying and 2 stags were removed from the 8L 16D group 4 weeks before the end of the experiment because they were observed to cause bruising in pen-mates It is clear that this kind of behaviour is intolerable in the production context and must be carefully watched for It must be pointed out that nearly all animals "rutted" but few problems were encountered. Further we do not contemplate large scale feedlotting of deer, so it is unlikely that producers would persist through spring and summer with the close confinement of young stags

From the practical viewpoint 16L 8D appeared to confer growth advantage to young stags The fact that reproductive rhythms were influenced probably contra-indicates the treatment for breeding stock

PART B - A COMPARISON BETWEEN TEMPERATE AND TROPICAL DEER

Although red deer show a seasonal pattern of growth, probably because they evolved in a predictable seasonal climate, it is not known whether tropical deer species, which evolved in a less predictably seasonal climate show these patterns We believe that red deer primarily use photoperiodic cues to time seasonal cycles In tropical latitudes the amplitude of photoperiodic variation throughout the year is much less, so tropical deer may not have evolved the ability to use photoperiod as a cue to time seasonal cycles The aim of this study was to measure growth in farmed red deer and rusa deer in Southern Queensland to determine whether any seasonal patterns emerged The study was made more compelling as it took place at a latitude (28°S) which is photoperiodically less seasonal than red deer probably evolved in

MATERIALS AND METHODS

Animals
Thirteen male and 10 female red deer calves were born during spring 1988 Fourteen male and 16 female rusa deer calves were born in autumn of 1989 The two species were run in separate paddocks but under similar conditions of management for 15 months from weaning at about 4 months of age

Measurements
At monthly intervals all animals were weighed

RESULTS

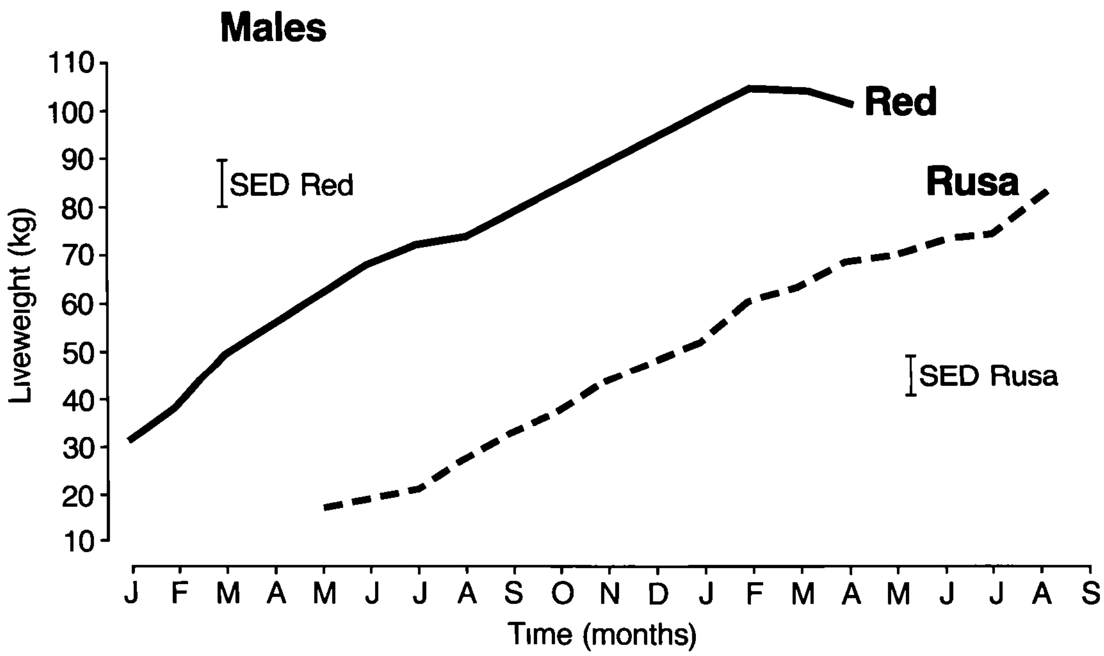

FIGURE 4 Live weight (kg) for male red and rusa deer in southern Queensland The red deer were about 3 months old in January at the start of the experiment The rusa stags were about 2 months old in May when data were initially recorded

Males
The red deer males grew from weaning in February at a rapid rate but growth rate clearly slowed from May to September (Figure 4) Growth rate increased during spring and reached a peak in late summer of 104 kg after which some weight was lost The rusa stags which were weaned in September grew continuously throughout the study

Females
The female red deer showed a conspicuous slowing of growth from May to September followed by a resumption until the close of the study in April (Figure 5) By then the females had reached a mean weight of 78 kg The female rusa deer grew continuously during the study No cessation of growth was observed during either winter of the study

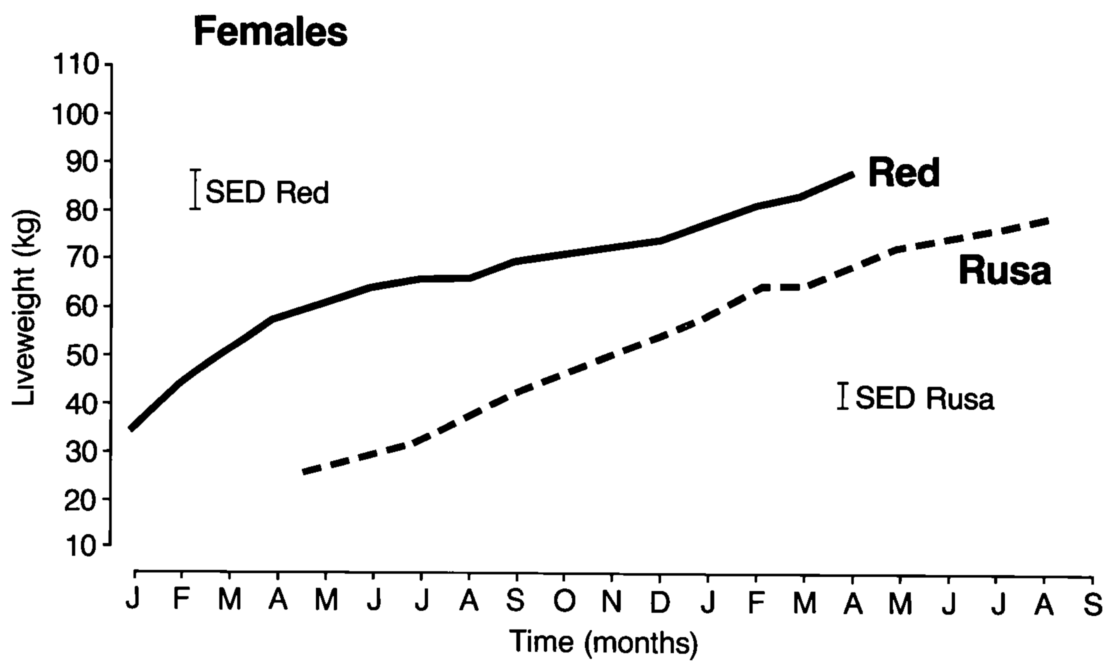

FIGURE 5. Liveweight (kg) for female red and rusa deer in south Queensland The red deer were about 3 months old in January at the start of the experiment The rusa stags were about 2 months old in May when data were initially recorded.

DISCUSSION

In sub-tropical southern Queensland the red deer remains a seasonal species in terms of growth pattern although the amplitude may be less than in red deer in a more seasonal environment In contrast, the rusa deer which evolved in the tropics differs in that it appears non-seasonal at least in the first 15 months of life Perhaps the red deer evolved in an environment where seasonal feed shortages were predictable and the animals have accommodated this In contrast feed shortages in the tropics are less predictable and the animal evolved a strategy of rapid growth at any time conditions were appropriate to permit growth

The male red deer achieved a 15 month weight similar to many NZ red deer stags. Likewise the females grew well and clearly exceeded the critical weight for yearling mating of around 70 kg The red deer thus represent well grown comparisons for the rusa deer whose growth data is much less well known

It is clear that deer species in which photoperiod does not appear to influence growth may have rather different nutrition requirements on a year round basis than red deer

REFERENCE

Suttie, J M and I D Corson (1991) Deer growth and production A review *Procs of a Deer Course for Veterinarians 8* 53-67