HYBRIDISATION OF RED DEER AND PÈRE DAVID'S DEER

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INTRODUCTION

The greater red deer family is notable for the degree of hybridisation possible between the various species and subspecies (Fennessy and Dratch 1984) The red deer (*Cervus elaphus* ssp), in its native state, has a wide distribution through Europe, with its close relatives the wapiti (*C e* ssp) in both North America and Asia The sika deer (*C nippon* ssp) are also found in Asia (Whitehead 1972) Hybridisation between red deer and wapiti and red deer and sika has often been reported (e g Harrington 1982)

The potential value of hybridisation in the New Zealand deer farming industry has long been recognised (Fennessy 1992) In particular, practical approaches have involved the North American wapiti and the larger subspecies or strains of European red deer The possibility of hybridisation with tropical species, such as the rusa (*C. timorensis*) or sambar (*C unicolor*), in order to introduce a different breeding season, has also been considered In this respect red x rusa hybrids have been bred in Australia (D Hart and P A Dratch, pers comm) However hybridisation with the Père David's (PD) deer (*Elaphurus davidianus*) is of special interest

The PD deer, a native of China, has probably been extinct in its native land for nearly one hundred years (Beck and Wemmer 1983) The survival of the species was ensured by the Duke of Bedford of Woburn Abbey in the years around the turn of the century when he collected surviving members of the species from European zoos (Glover 1980) The species, known as *milu* in China, is notable for being a summer breeder in contrast to the red deer which is an autumn breeder and for its long gestation of around 283 days (Wemmer *et al* 1989) which is around 50 days longer than the red deer Natural hybridisation between PD and red deer has been recorded at Woburn, the red x PD hind subsequently proved fertile producing a calf to a PD male (H and R Tavistock, pers comm) Other cases have also been reported (see Gray 1972)

These reports of hybridisation and the interest in the possibilities for hybridisation within the New Zealand deer industry, coupled with the interest in the preservation of the species, lead to a number of introductions of PD deer in the mid-1980's Unfortunately, the species has not done well in New Zealand (see Asher 1990) with the susceptibility of the species to malignant catarrhal fever (MCF) (Orr and Mackintosh 1988) being the major problem such that there is now only one herd of 14 pure PD deer left in New Zealand.

HYBRIDISATION

Successful hybridisation of the PD and red deer was achieved by artificial insemination (AI) in 1986 (Asher *et al* 1988) Attempts to achieve natural mating of PD males and red females were unsuccessful with the failure of the two species to integrate socially coupled with practical difficulties in advancing oestrus in red hinds The very low pregnancy rates reported by Asher *et al* (1988) led to investigations of both active and passive immunisation of red deer females against PD leucocytes in an attempt to improve the pregnancy rate (see Kraemer 1983, Warner *et al* 1988) A summary of the Invermay data is presented in Table 1, a total of 116 laparoscopic inseminations have been carried out resulting in 15 day-38 pregnancies with 9 calves born. There was no effect of immunisation on pregnancy rate, although 6 of 7 pregnancies in controls went to term compared with only 3 of 8 pregnancies in immunised hinds going to term Table 2 compares data for the 7 stags used in the AI programme A total of 85 hinds were inseminated with semen from two stags for 14 pregnancies and 9 calves whereas the remaining 31 inseminations contributed only one pregnancy and no calves These data do raise the possibility that there are significant differences between stags, possibly in fertilising ability, or alternatively incompatibilities between the dam and the hybrid embryo

In contrast to the low success rates with generation of the F1 PDxR hybrid, the backcross hybridisation of the F1 to the red deer has been more successful Table 3 summarises the data for AI of red hinds with fresh F1 hybrid semen over 3 years at Invermay The pregnancy rates were comparable with the lower end of those for AI of red hinds with red semen (Fennessy *et al* 1990, 1991a) Natural mating with synchronised red hinds resulted in a pregnancy rate of 75% in a group of 32 hinds over 17 days Overall the data suggest that the F1 males probably have a reasonable level of fertility The F1 females are also fertile with three two-year-old hybrids producing calves to natural mating with an F1 hybrid stag at Invermay in 1991 These three females were subsequently treated to induce superovulation and mated with a red stag at Invermay in 1992

Overall 28 embryos ranging from compact morulae (5) to early (5), late (17) and hatched (1) blastocysts, were transferred using a laparoscopic technique similar to that used with AI, for a total of 13 pregnancies (Table 4) The difference in pregnancy rate between the three donor hinds highlights the potential importance of individual hind factors in embryo quality Such factors could include the immunological response of the recipient dam to the developing embryo

Table 1. Hybridisation of PD deer and red deer at Invermay (AI of synchronised red deer hinds with frozen PD semen, P F. Fennessy, C.G Mackintosh, J F T Griffin and G H. Shackell, unpubl. data)

Year	Procedure hind treatment[1]		N	Pregnant[3]	Calved
1988	Active immunisation[2]		15	2	0
	Passive immunisation		15	2	1
	Control		11	1	1
1989	Active immunisation[2]		11	3	2
	Active 1988/Boost 1989		13	0	0
	Hybrid pregnancy 1988		5	1	0
	Control		11	1	1
1990	Control		3	1	1
1991	Control		32	4	3
			116	15	9
Summary					
	Controls		57	7	6
	Immunised[4]	Total	59	8	3

[1] AI procedure 12 day CIDR with replacement at day 7-9, with an injection of 200-225 IU PMSG at CIDR withdrawal and insemination per laparoscope at 48-56 hours post CIDR withdrawal/PMSG treatment

[2] Immunisation procedure

1988 Active - 1 6x10^{7} leucocytes from adult PD males given intravenously 21 days prior to AI, Passive - plasma harvested from 5 red hinds given 2x10^{7} leucocytes intravenously *c* 120 days earlier and boosted with the same dose 80 days earlier, 20 ml of this plasma was injected subcutaneously into red hinds at the time of AI with PD semen

1989. Active - 3 0x10^{7} leucocytes from adult PD males given intravenously 38 days before AI followed by 6.5x10^{7} lymphocytes 14 days before AI Active boost - 6 5x10^{7} lymphocytes given 14 days before AI to red hinds which had been actively immunised in 1988

[3] Pregnancy diagnosis by rectal ultrasound scanning at d 37-39 following AI

[4] Hinds classed as immunised in 1989 includes those pregnant to the PD semen in 1988

Table 2 Pregnancy rates to AI with frozen semen at Invermay by year and stag for the various PD stags

	Pregnancy rate[1]						Calving	Calving
Stag semen	1988	1989	1990	1991	Total	%	rate	%
294	4/16	4/36	1/3	2/16	11/71	15	7/71	10
298	1/6	-	-	2/8	3/14	21	2/14	14
300	0/13	-	-	-	0/13	0	0/13	0
827	0/6	-	-	-	0/6	0	0/6	0
601	-	1/4	-	-	1/4	25	0/4	0
800	-	-	-	0/4	0/4	0	0/4	0
801	-	-	-	0/4	0/4	0	0/4	0
Total rate	5/41	5/40	1/3	4/32	15/116	13	9/116	8
Calving rate (calves/pregnancies)	2/5	3/5	1/3	3/4	9/15	60	-	

[1] Pregnancy rate defined as hinds pregnant at rectal ultrasound scanning at d 37-39

Table 3. Pregnancy and calving rates for artificial insemination (AI) of red hinds with fresh semen from PDxR F1 hybrid stags at Invermay (Fennessy *et al* 1991 and unpublished data)

	Stag		Number (%) of hinds				
	No	Age (yr)	Inseminated[1]	Pregnant[2]	(%)	Calving	(%)
1990	B6	3	31	20	(65)	18	(58)
1991	GW899	2	83	40	(48)	36	(43)

[1] AI procedure 12 day CIDR with replacement at day 7-9 with 200-225 IU PMSG at CIDR withdrawal and insemination per laparoscope at 48-56 hours post CIDR withdrawal/PMSG treatment
[2] Pregnancy diagnosis by rectal ultrasound at day 35-40 after AI

Table 4 Superovulation[1] and embryo recovery data for two year old PDxR F1 hybrid hinds naturally mated with a red deer stag, the embryos were transferred to synchronised red deer hinds

Hind	Ovulation rate	Embryo data: Recovery	Embryo data: Transfer	Pregnancy at day 32 after transfer
GW901	10	9	9	1
GW904	14	7	7	2
GW905	16	12	12	10

[1] Superovulation regime 12 day CIDR withdrawn pm on day 12 (CIDR replaced at day 9) and the stag introduced on day 9, follicle stimulating hormone (FSH, Ovagen, ICP, Auckland) was given at a rate of 0 64 units over 8 injections from am on day 10 to pm on day 13, with embryos transferred on day 21 to recipient hinds, treated with a 12 day CIDR with 200 IU PMSG (Folligon, Intervet, NSW) at withdrawal on day 12

GESTATION LENGTH

Gestation length data for the PD hybrids and the red deer are presented in Table 5 The PD deer has a very long gestation of 283 ± 6 1 days (Wemmer *et al* 1989), around 50 days longer than the red deer, while the F1 hybrid gestation of 262 days for males is about 7 days greater than the mid-point mean for the PD and red deer. The ¼-PD/¾-red deer had a mean gestation of 252 days, a value which is also biased towards the PD deer The considerable variability in gestation length of the PD hybrids is apparent in the relatively high standard deviations of 4 8 to 7 3 days compared with that in red deer of 3 4 days The bias towards the PD parent and the variability in gestation length suggest that some factor(s) regulating gestation length may be peculiar to the PD

Table 5 Mean gestation length (±SD) for red (R), (PDxR)xR and PDxR calves (all calves from R dams)

	Red[1] (n)	(PDxR)xR[2] (n)	PDxR[3] (n)
Male	234 6 (52)	253 3 (32)	268 3 ± 6 73 (10)
Female	234 1 (34)	251 8 (22)	262 5 ± 4 79 (10)
SD	3 41	7 30	-
SED[4]	0 76^{NS}	2 02^{NS}	2 61*

[1] Data from Fennessy *et al* (1991b)
[2] Data from P F Fennessy, A J Pearse and A J Whaanga (unpublished)
[3] Data from P F Fennessy, C G Mackintosh and A J Whaanga (unpublished, n=9), Asher *et al* 1988 (n=6) and G W Asher (unpublished, n=5)
[4] NS, not significant, *, P<0.05

In the ¼-PD, gestation lengths ranged from 242 to 274 days, a range slightly longer than that reported by Fennessy *et al* (1991b) with birthweights from 6 0 to 12 3 kg Interestingly, the 274 day gestation resulted in a very low birthweight calf (female of 6 0 kg), this very low birthweight/long gestation phenomenon has also been observed where horse embryos have been transferred into donkeys (T W Allen, pers. comm) and is believed to be the result of inappropriate immunological response of the dam to the foetal placenta

GROWTH

Comparative live weight and growth data for red and ¼-PD/¾-red deer are presented in Table 6 The hybrids were on average 12% heavier than the red deer at birth, a small difference for the average 18 day longer gestation. Thereafter the hybrids grew at considerably faster rates than their red deer contemporaries to be 15% heavier at the end of winter and 28% heavier in autumn at 15 months of age Compared with the red deer of the same sex, the hybrids had a particularly fast rate of growth prior to weaning (31% faster than the reds) and during the spring-summer period from 8 to 15 months of age (44% faster for males and 63% faster than the red females) The hybrid females had a very similar growth rate to the red males over this period The relatively fast growth rates of the hybrids, particularly over the spring-summer period (in contrast to the winter period), raise some interesting questions as to the pattern of growth in the PD hybrids, and in particular the involvement of daylength cues In this respect, the timing of the seasonal traits of food intake and coat growth, was advanced by around 8 weeks compared with red deer (Loudon *et al* 1989)

Unfortunately there are very few comparable data available for pure PD or F1 hybrids However, that available would suggest that the ¼-PD hybrids are only 5 to 10% lighter than the pure PD or F1 hybrids at the yearling stage

Table 6. Comparative birth date, live weights (± SD) and relative live weight gains for red deer and ¼-PDx¾-R deer hybrids up to 15 months of age (born 1990)

	Red deer		¼-Père David's x ¾-red deer	
	Males	Females	Males	Females
Number	12	6	5	10
Mean birth date	Dec 3 ± 2 6	Dec 2 ± 2 0	Dec 14 ± 2 6	Dec 12 ± 7 2
Mean live weights by date				
Birth	9 2 ± 0 73	8 8 ± 0 81	10 0 ± 1 50	10 2 ± 1 40
Mar 11	43 9 ± 2 95	41 8 ± 1 47	50 4 ± 4 34	49 5 ± 3 89
Aug 14	64 6 ± 5 64	57 8 ± 1 33	72 6 ± 6 95	68 1 ± 4.14
Mar 3	105 3 ± 7 61	82 5 ± 3 62	131 2 ± 10 83	108 5 ± 7 38
Relative live weight gain (compared with red females at 100)				
Birth to weaning	105	100	139[1]	132[1]
Weaning to end winter	129	100	139	117
End winter to autumn	164	100	237	163

[1] Adjusted for difference in age at weaning

ANTLERS AND SEASONALITY

The Père David's deer exhibit a unique antler formation with the tines reversed compared with red deer The F1 hybrids have displayed a range of antler forms, with a very long "brow" tine being common Adult PD deer cast their antlers in June/July and clean their hard antlers in late October/November (C G Mackintosh and R E Labes, unpublished data) The F1 hybrid data are very limited but are presented in Table 7, along with some comparative data for red deer of the same age The data indicate that the PD hybrids have a markedly advanced antler cycle compared with the red deer, with hard antler casting averaging 60 days earlier than red deer and antler cleaning 51 days earlier with the total antler growth period being similar for both the F1 hybrids and the red deer The only data available for the ¼-PD/¾-R deer are as yearlings (Table 8) when the hybrids initiated their pedicles 30 days later (P<0 10) than the red deer and at weights 22% higher than red deer The hybrids cleaned their antlers in early February, somewhat earlier than the red deer

Table 7 Comparative data for hard antler casting and antler cleaning for two PDxR F1 hybrids and red deer

	Stags	Age	Casting date	Cleaning date	Antler growth period (days)
PDxR	GW899	2	9 Sept	25 Dec	107
	GW903	2	21 Aug	15 Dec	116
	GW899	3	12 Aug	19 Dec	129
Red[1]	Group of 16	2	26 Oct ± 9 6	10 Feb ± 4 1	106 ± 7 2
	Group of 16	3	8 Oct ± 14 1	9 Feb ± 6 1	124 ± 11 2

[1] Data from Fennessy *et al* 1992

Table 8 Comparative data (mean ± SD) for pedicle initiation and antler cleaning for the red stags and ¼-PD/¾-R stags

	Red	¼-PDx¾-R
Number	12	5
Mean date of pedicle initiation	24 Aug ± 30	23 Sep ± 28
Mean weight at pedicle initiation	66 1 ± 4 6	80 6 ± 4 6
Mean date for antler cleaning	NA	3 Feb ± 13

[1] NA = not available

FUTURE PROSPECTS

The relatively rapid growth rates of the ¼-PD hybrids indicate that they may provide another alternative approach to producing larger deer (see Fennessy *et al* 1991b, Fennessy 1992) The advanced seasonality indicated by the earlier antler casting and cleaning in F1 hybrids also suggest that the hybrids may have something to offer in terms of an earlier breeding season The longer gestation of the hybrid compared with the red deer may, however, limit the usefulness of the earlier breeding

The low success rates in producing F1 hybrids will limit their practical application in the deer industry There are a total of 6 male and 5 female F1 hybrids, aged more than 1 year, in New Zealand with up to 10 yearlings, mostly females. Unfortunately F1 semen has not been frozen successfully, limiting AI to fresh semen unless a successful freezing method can be developed The success of embryo transfer means that there may be some future in producing an F2 hybrid with subsequent selection for desired traits such as an advanced breeding season However in the practical situation the future of the hybrid will likely rest on the ¼-PD/¾-R backcross as a sire or the development of an interbred ¼-PD Both of these alternatives would likely require considerable selection and a long term breeding programme for the desired traits if any real impact is to be made in the deer farming scene The usefulness of animals with the very high spring-summer growth rates is a possible exception to this generalisation. There are, however, a number of unknowns, including the pattern of inheritance of the traits associated with the seasonal cycle The susceptibility of the hybrids to MCF is also an issue The annual death rate for F1 hybrids from MCF at Invermay, while based on only 16 animal years of exposure, is nearly 20% The mortality rate for ¼-PD hybrids based on about 50 animal years of exposure to date is 1% This is similar to the death rate in red deer Antler growth and the potential for velvet production in the hybrids are also largely unknown at this stage. Currently, the greatest value of the hybrids is their contribution to basic research in molecular genetics and the possibility of using them to locate genetic markers for productive traits (Fennessy *et al* 1991b, Tate *et al* 1992)

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