Deer reproductive performance, risk factors, and management decisions

P R Wilson and L J-M Audigé

Abstract

Indices including conception rate and date by hind age, stag : hind ratios, pregnancy rates at parturition, calving rates, various ratios for weaning rates, and overall reproductive efficiency are essential measures of reproductive performance. They provide a benchmark for performance and target setting, and have diagnostic value in the event of poor reproductive performance.

Our deer herd health and production profiling study has shown that adult farmed deer have a high reproductive potential, with pregnancy rate at scanning averaging 96.8% and weaning 88%. Yearling hind pregnancy rate was 85% and weaning 70%. Foetal loss rates were 0.79% and 0.66% for adult and yearling hinds, respectively. Median calving dates were November 30 and December 13 for mixed age and yearling hinds, respectively. The major reproductive loss was peri- and post-natal with 8% and 17% of calves born to adult and yearling hinds, respectively, not surviving to weaning.

The primary risk factors for achievement of early conception and therefore calving, are body condition score, stag joining date, sire management, and a range of management and individual animal factors. Dystocia is related largely to fatness and interaction between fatness and fitness. A number of factors associated with progeny loss, including interference with calving and misadventure, are presented. Critical management tools and decisions include body condition score, feeding, weaning and joining dates, stag : hind ratios and ultrasound scanning.

3. Introduction

Reproductive performance is recognized as a major determinant of productivity and economic viability on commercial deer farms. A range of reproductive performance has been reported from New Zealand commercial deer farms (Audigé *et al*, 1998a; Asher and Adam, 1995; Moore *et al*, 1985).

Reproductive success depends on combining high pregnancy rates, low gestational loss rates, early birth date, and low perinatal and postnatal mortality rates leading to high weaning rates. Every animal and environmental characteristic affecting reproduction and every management step from mating to weaning is therefore likely to be important. However, management strategies may differ depending on the farming objectives; for example, whether farms want to give priority to high weaning rates, and thus accept late conception, or high weaning weights requiring early birth dates, or both. It is therefore essential to clearly identify the farmer's objective(s) when formulating a reproductive management programme.

To provide reference data on health and production parameters and generate hypotheses on the influence of management practices on these indices, a two-year longitudinal observational study was carried out on 15 red deer farms (Audigé *et al*, 1993, 1994b). This paper discusses a series of indices for measurement of reproductive performance, presents data on reproductive performance from the farms in our deer herd health and production profiling project, and presents a summary of risk factor analyses for various reproductive outcomes. The use of those risk factor analyses and a number of other tools which can be employed to improve reproductive efficiency on deer farms are discussed.

2. Indices of reproductive performance

A set of clearly defined indices are essential for the assessment of deer herd reproductive performance. Indices should provide a stepwise description of performance from conception to weaning or beyond, depending on the outcome(s) of importance to the individual farmer.

Indices are essential for evaluation of the individual herd against set targets or national or regional averages. They are also essential for identification of where losses are occurring so decisions can be made in choosing areas for improvement or further investigation. Indices also provide a comparative measure of performance between farms. Thus, accurate identification of indices enables the farmer to focus on management areas needing modification, and for the industry as a whole to identify where advisory activity extending current knowledge is needed. This in turn can identify where there is a lack of current knowledge, therefore focussing on what research needs to be initiated, to provide the information needed by farmers to achieve objectives.

2.1 Conception

- ***Rate***

  There is no practical, economic way of determining conception rate *per se* in a commercial farming environment, therefore a surrogate measure, ie: early pregnancy, is used. Ultrasound scanning is clearly the most practical, cost-effective technique (Wilson, 1997). There is little evidence of loss of conceptus between mating and scanning, but such losses should be considered if pregnancy rates at scanning are low.

  The indice is:
  $$\frac{no.\ scanned\ pregnant}{no.\ put\ to\ stag} x\ 100$$

  On an individual farm it is useful that this indice is measured for each hind mating group and age group on a given property and is analysed as such. This can help narrow the focus for investigation where percentages are sub-optimum.

- ***Date***

  It is proposed (Audigé *et al*, 1998a) that a successful breeding herd will have a high percentage of hinds conceiving, and therefore calving, early. The date of conception is best determined by ultrasound foetal age determination (Revol and Wilson, 1991a,b). The date can be categorised according to either a standard definition, eg: early = conceived before May 1, or by customised categories for a given farm, eg: before April 1, April 1-18, after April 18 (the latter has been used in the Deermaster project - see Beatson *et al*

elsewhere this Proceedings). Categorising conception dates has the advantage of being fast because measurements only need be taken around the critical points between categories. An alternative is to assess the foetal age individually for each hind. This, of course will give a more accurate prediction of the absolute day by day calving pattern.

Obviously the calving span can be modified by advancing or delaying the date the stag is removed from hinds. The choice of date will depend on numerous factors specific to the individual farm.

- ***Hind age***

  Conception rate and date *must* be evaluated for both yearling and adult hinds separately. A single percentage based on data from pooled age groups is of limited value because it will be intrinsically affected by the ratio of hinds in different age categories. In some circumstances it may be appropriate to categorise adults into 2-year-olds and older groups, because sometimes the latter group has a lower conception rate if management factors during first lactation are sub-optimum. These categories are based on observations that early pregnancy rates differ between those age groups. Different factors will contribute to conception rates in different age groups of hinds (see Section 4.1.2).

- ***Stag : hind ratio***

  While evaluating conception rates and dates by different age groups the stag : hind ratio should be recorded and the reason for that choice of ratio understood. For example, on a given farm "efficiency" may mean the greatest possible number of offspring to a given sire. In this instance, the number of conceptions per sire may be the appropriate index. The highest possible percentage may not be the target in all situations. Observations are being made in the Deermaster project to evaluate extended stag hind ratios (see Beatson *et al*, these Proceedings). Thus, the most appropriate indices to choose vary between farms depending on objectives.

2.2 Pregnancy

There is only anecdotal evidence of significant foetal loss in hinds. There have been no reported abortion storms, and therefore there is presently no proven cause of abortion in farmed deer herds in New Zealand.

However, there is often a reported disparity between the number of hinds scanned pregnant, and the number of calves at weaning less observed perinatal and postnatal losses. The suggestion is, therefore, that foetal loss may be significant in some herds. To prove this there needs to be either physical evidence of foetal loss, or assessment of the pregnancy status of the hind immediately prior to calving, against pregnancy status at scanning.

Whether or not a hind has carried a foetus to term can be determined by:

- palpation for udder development
- visual assessment of the abdominal area
- palpation/ballotment
- hormonal measurements

- scanning (usually by the percutaneous method)
- observation of calving.

An indirect measure may be the change in bodyweight of the hind during the last two months of pregnancy, although data of Audigé (1995) andWagner (this Proceedings) suggests this may be unreliable.

The indices that can be calculated are:

$$\frac{No.\ hinds\ calving}{No.\ hinds\ mated}\ x\ 100\%$$

$$\frac{No.\ hinds\ calving}{No.\ hinds\ pregnant}\ x\ 100\%$$

2.3 Calving

There is a range of potential causes of perinatal mortality including mismothering, dystocia, disease, rejection, and misadventure. The perinatal mortality rate is almost impossible to gauge accurately without extremely intensive observation for dead newborn calves. Our study suggests that a large number of calves suffering perinatal mortality simply disappear, possibly through scavenging and possibly through being hidden, even from close inspection. Thus, for most practical purposes the perinatal mortality rate can only be indirectly assessed by:

$$\frac{No.\ live\ calves\ (at\ a\ chosen\ time)}{No.\ of\ hinds\ actually\ calving}\ x\ 100\%$$

The dystocia rate is also difficult to identify accurately, because some dystocias resulting in death of offspring may not be observed; ie: they calve naturally but the calf is dead. Conversely, it is simple to gauge the dystocia rates which require human intervention or which result in death of the hind.

Postnatal mortality rates are difficult to achieve accurately, because it is difficult to accurately measure perinatal mortality. Thus, the most practical index combines both peri- and postnatal mortality, being:

$$\frac{Calves\ weaned}{Hinds\ calving}\ x\ 100\%$$

2.4 Weaning

"Weaning rates" are variously reported as:

- calves weaned per hinds to stag
- calves weaned per hinds scanned pregnant
- calves weaned per hinds calving
- calves weaned per calves born alive

Each indice gives a different measure with a different purpose. The first gives a composite measure only, but is the most commonly used ratio in practice. The important message is that the ratio quoted must be defined to avoid confusion, or to avoid spurious comparisons, when different ratios are used.

Weight of weaners may also be used as an indice of reproductive success, eg: the ratios:

- average weaner weight per hind mated
- average weaner weight per hind calved, or
- average weaner weight *per se*. These can be by sex.

These ratios encompass the results of both reproductive management and outcomes, as well as feeding outcomes, and are therefore better estimates of overall farming efficiency.

2.5 Reproductive efficiency

There are numerous measures of reproductive efficiency which combine all or some of the above ratios but with the inclusion of disposal of surplus hinds and hind mortalities. For example: reproductive efficiency = no. of weaners per hinds mated.

This ratio takes into account loss factors, wastage factors and selling decisions. In a deer herd which has a higher hind retention rate as a result of an expansion policy, the reproductive efficiency probably will be high; ie: few hinds will be sold. However, other herds may decide to mate a higher number of hinds than intended for winter, and sell surplus deer after pregnancy scanning. In those instances the reproductive efficiency figure would drop.

2.6 Definition of reproductive indices

It is important when comparisons are being made, either between farms or within a farm between years, that the indices used are clearly defined and that the ratios used for comparison are identical.

3. Reproductive performance data

The following data is from the Deer Herd Health and Production Profiling project undertaken at Massey University (Audigé . 1995; Audigé *et al*, 1998a). Data was collected over a 2-year period from 15 red deer farms.

3.1 Conception

The average conception rate in yearling hinds was 84.7%, whereas the early conception rate (before May 1)was 64.8%.

In adult hinds, 96.8% conceived whereas 94.1% conceived early before 1 May. Data for individual farms has been published in previous Deer Branch NZVA Conference Proceedings (Wilson *et al*, 1995).

Summary statistics of farm level reproductive performance are presented in Table 1, and a summary of reproductive performance in both yearling and adult hinds from pregnancy testing, calving and weaning is presented in Tables 2 and 3. These data show that there are large differences between farms in all parameters. For example, for yearling hinds one farm had a conception rate before May 1 as low as 8.3%, while others exceeded 90%. For adult hinds the range is significantly less, with 77.6% being the lowest achievement of conceptions before May 1. Many herds achieved early conception rates of approaching 100%.

The percentile data in Table 1 provides useful targets. For example, if a farmer was achieving at a 25 percentile performance, a short-term target of increasing to a 50 percentile could be appropriate (see Wilson *et al*, 1996 for discussion on target setting).

3.2 Pregnancy

Using the methods for confirmation of current carriage of pregnancy to term described in Section 2.2, results from our studies indicate that foetal loss rates were 0.79% for mixed age hinds and 0.66% for yearling hinds. There is considerable debate about the importance of foetal losses, but more evidence is required to identify both loss rates and potential causes. Initial data from the Deermaster Project (Beatson *et al*, this Proceedings), suggests a foetal loss rate averaging 1.4%, with the highest being 2.5%. It is essential that detailed investigations are undertaken in herds in which foetal loss rates exceed these "benchmark" figures.

3.3 Calving

Figure 1 shows normal calving patterns from pooled data from a number of herds in our study which recorded calving dates for individual animals. There is a considerable difference in calving pattern between adult and yearling hinds.

Data in Table 4 shows the start/finish median and mean calving dates for yearling and adult hinds, again showing a significant range between herds in all parameters.

Figure 1. Calving date distributions of yearling (mated at 15 months) and adult hinds in 1992 and 1993. Data from 4 survey farms combined

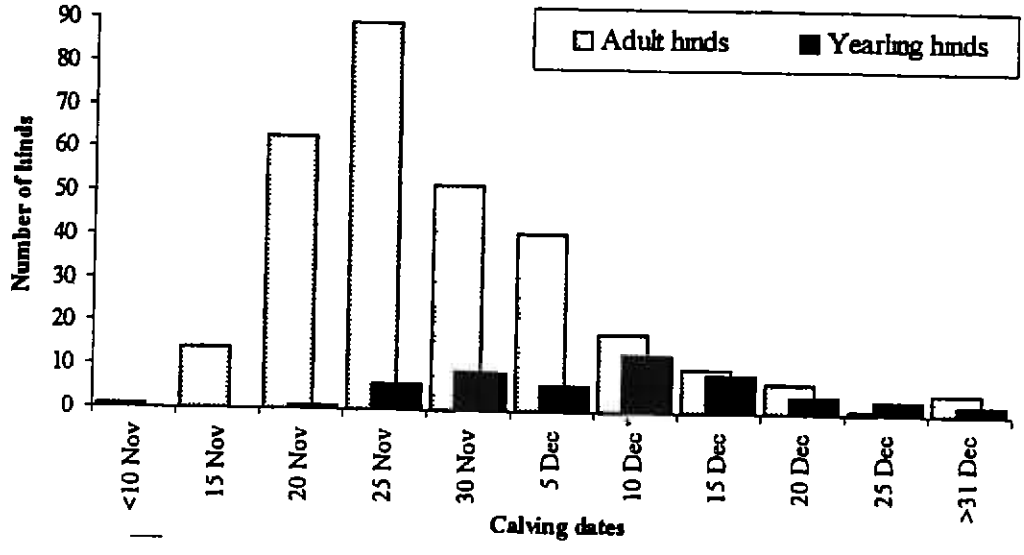


Table 1. Summary statistics of farm-level reproductive performance of yearling and ult hinds in 1992, 1993 and both years combined

			Yearling hinds							Adult hinds						
Year		Unit	Number of farm-year*	Min	25th percentile	Mean	75th percentile	Max	SD	Number of farm-year	Min	25th percentile	Mean	75th percentile	Max	SD
1992	Number of hind mated		12	12	19	33	47	48	14	15	40	87	137	166	226	54
	Early conception rate (before May 1)	%	12	17 4	51 9	61 5	80 7	92 9	24 2	15	77 6	83 8	89 2	93 8	98 3	6 3
	Conception rate	%	12	60 0	75 7	85 0	94 5	100 0	12 3	15	92 7	95 4	96 7	98 4	98 8	1 8
	Number of hind calving		12	11	18	26	35	42	11	15	33	76	122	156	205	48
	Weaning rate	%	12	64 3	76 9	83 2	87 1	100 0	9 9	15	84 1	87 7	91 8	95 4	98 3	4 3
	Reproductive efficiency	%	12	43 5	58 1	66 4	73 2	87 5	13 0	15	68 8	77 5	81 3	85 6	93 5	6 4
1993	Number of hind mated		13	7	12	31	38	76	19	14	53	66	121	146	194	44
	Early conception rate (before May 1)	%	13	8 3	58 8	69 1	84 7	95 0	24 0	14	84 6	85 6	92 9	96 6	98 4	4 9
	Conception rate	%	13	50 0	74 4	85 0	95 6	100 0	17 7	14	84 6	94 9	96 6	98 8	100 0	3 9
	Number of hind calving		13	4	12	28	32	92	22	14	51	60	119	136	188	44
	Weaning rate	%	13	73 3	77 1	84 7	89 2	92 3	6 3	14	81 4	86 3	91 7	96 3	99 3	5 4
	Reproductive efficiency	%	13	25 0	57 4	70 6	83 7	91 7	19 8	14	72 7	81 6	86 0	90 0	93 3	5 8
Both years	Number of hind mated		25	7	16	32	43	76	16	29	40	82	129	155	226	49
	Early conception rate (before May 1)	%	25	8 3	53 8	65 5	83 1	95 0	23 9	29	77 6	84 9	91 0	95 5	98 4	5 9
	Conception rate	%	25	50 0	74 5	85 0	94 7	100 0	15 0	29	84 6	95 4	96 7	98 4	100 0	2 9
	Number of hind calving		25	4	13	27	32	92	17	29	33	76	121	145	205	45
	Weaning rate	%	25	64 3	76 9	84 0	87 8	100 0	8 1	29	81 4	87 7	91 8	95 7	99 3	4 8
	Reproductive efficiency	%	25	25 0	57 4	68 6	81 2	91 7	16 6	29	68 8	78 0	83 6	87 3	93 5	6 5

Min = minimum, Max = maximum, SD = standard deviation

* Farm-year with less than 5 yearling hinds at mating were not included (see Appendix 3 38)

Note : descriptive statistics of yearling and adult hind reproductive performance on each farm are presented in Appendix 3 38 and Appendix 3 39, respectively

Table 2. Reproductive performance of adult hinds on each survey farm in 1992 and 1993

Farm code	Number of hinds			Pregnancy testing in June				Hinds in calving mobs			Hinds at weaning				
	Naturally mated		AI*	Number of hinds scanned	Percentage not diagnosed	Percentage of diagnosed hinds (%) conceiving before May 1	conceiving after May 1	not pregnant***	Total number of hinds	Pregnancy status: Unknown	Pregnancy status: Not pregnant	Number of hinds weaned	Number of hinds diagnosed wet	Number of calves weaned	Weaning rate† (%)	Reproductive efficiency‡ (%)
	Culled**	Bred														
Year 1992																
1		154		138	0 7	92 0	0 7	7 3	127	0	1	127	108	106	84 1	68 8
2		226		214	0 0	93 0	5 6	1 4	205	18	0	205	186	185	90 2	81 9
3		146		146	0 0	93 8	3 4	2 8	139	2	4	137	121	119	85 6	81 5
4		62		59	0 0	98 3	0 0	1 7	62	0	3	62	57	58	98 3	93 5
5		82		82	1 2	88 9	9 9	1 2	73	2	0	73	67	64	87 7	78 0
6		137		131	0 0	78 6	16 8	4 6	118	7	4	118	103	104	91 2	75 9
7	13	40		53	0 0	88 7	5 7	5 7	35	3	2	35	31	31	93 9	77 5
8		219		132	9 1	93 5	4 2	2 5	185	18	2	183	164	177	96 7	80 8
9		87		86	0 0	83 7	12 8	3 5	77	1	1	77	71	72	94 7	82 8
10	28	165		154	1 3	77 6	19 7	2 6	148	3	1	148	137	138	93 9	83 6
11		129		128	0 0	86 9	1 6	1 6	110	3	1	110	105	104	95 4	80 6
13		181		84	13 1	84 9	11 0	4 1	177	14	0	172	149	155	87 6	85 6
14		166		140	0 7	90 6	7 9	1 4	156	4	0	155	148	150	96 2	90 4
15		150		131	4 6	94 4	0 0	5 6	121	28	3	99	82	108	91 5	72 0
16		105	17	105	0 0	83 8	13 3	2 9	119	4	2	118	105	105	89 7	86 1
All farm		2049	17	1783	1 9	89 3	7 5	3 1	1852	107	20	1819	1654	1676	91 5	81 1
Year 1993																
1	9	136		136	0 0	84 6	0 0	15 4	113	0	0	113	105	105	92 9	77 2
2	18	184		184	1 1	96 2	3 3	0 5	184	25	0	184	158	156	84 8	84 8
3	4	135		134	0 0	93 3	3 7	3 0	133	1	5	132	124	126	98 4	93 3
4	1	63		63	0 0	98 4	0 0	1 6	61	0	1	61	58	58	96 7	92 1
5		66		65	0 0	89 2	6 2	4 6	60	5	1	60	53	48	81 4	72 7
6	28	119		118	0 0	94 9	4 2	0 8	118	7	1	118	105	101	86 3	84 9
7		53		53	0 0	84 9	11 3	3 8	51	1	0	51	46	46	90 2	86 8
8		194		186	0 0	97 3	2 7	0 0	188	0	0	188	178	175	93 1	90 2
9	2	80	24	79	0 0	92 4	2 5	5 1	98	1	2	98	93	93	96 9	87 7
10		155		155	0 0	96 8	1 3	1 9	146	0	3	146	141	142	99 3	91 6
11		107		106	0 0	93 4	3 8	2 8	102	4	2	102	96	96	96 0	89 7
13	27	155		178	2 8	97 7	0 0	2 3	175	7	1	175	122	153	87 9	85 2
15	34	136		115	0 9	96 5	2 6	0 9	126	14	1	126	110	111	88 8	81 6
16		111	24	111	0 0	85 6	9 0	5 4	132	0	4	132	117	117	91 4	86 7
All farm		1694	48	1683	0 5	93 7	3 1	3 2	1687	65	21	1686	1506	1527	91 7	88 9
Total		3743	65	3466	1 2	91 4	5 4	3 2	3539	172	41	3505	3160	3203	91 6	85 6

Wet = still lactating at weaning

*AI Artificial Insemination Farm 16 in 1992 had 9 hinds from AI, the rest conceived from back-up stag

Farms 9 and 16 in 1993 had both 12 hinds conceiving from AI and 1 hind not conceiving. Farm 9 had one foetal loss following conception from AI

** For reasons not related to pregnancy results

*** Hinds not pregnant at calving either from pregnancy scanning in June or from observation of physical characteristics and weight change before calving.

† Percentage of hinds behaved to be pregnant at calving that reared a calf up to weaning. The number of wet hinds was checked were possible from the number of calves actually weaned from these hinds, assuming there was no twinning.

‡ Percentage of hinds mated in the breeding herd that reared a calf up to weaning. These figures includes hinds sold or slaughtered after mating, excepted those for which the decision of culling was made prior to mating.

Notes Hinds at calving include bought in hinds and hinds artificially inseminated, some hinds were known (by scanning result) or suspected (by bodyweight change) not pregnant

Farms 5, 8 and 15 Hind lactings were inaccurate so best estimates of numbers of hinds mated and at calving were obtained from grazing records

Year 1992 Farm 7 13 hinds were taken off the farm for calving

Farm 10 20 hinds were culled on June 1 without being scanned

Farm 13 Not all hinds could be separated at weaning and some weaners stayed behind, thus the number of non lactating hinds is underestimated

Year 1993 Farm 1 9 hinds went in mating mob from March 30 to April 14 before being culled

Farm 2 18 hinds mated left the farm on June 2 before pregnancy testing

Farm 3 4 hinds culled on May 16

Farm 6 28 hinds mated and culled on May 19 without being scanned or suspected at slaughter; 5 hinds were missing at weaning

Farm 13 27 hinds left the farm on June 17 after pregnancy testing (all conceived before May 1), and 20 others were bought in July 10 the conception rate of hinds staying on the farm was 97 4%. The reproductive efficiency was that of hinds staying on the farm assuming the 20 bought hinds reared a calf up to weaning, the overall reproductive efficiency was corrected accordingly

Table 3. Reproductive performance of yearling hinds on each survey farm in 1992 and 1993

Farm code	Number of hinds mated		Pregnancy testing in June					Hinds at calving			Hinds at weaning			
			Number	Percentage	Percentage of diagnosed hinds (%)			Total	Pregnancy status		Number of hinds		Weaning	Reproductive
	culled or left the farm*	breeding herd	of hinds scanned	not diagnosed	conceiving before May 1	conceiving after May 1	not pregnant**	number of hinds	Unknown	Not pregnant	weaned	diagnosed wet	rate† (%)	efficiency‡ (%)
Year 1992														
1	4	36	36	2 8	60 0	0 0	40 0	23	0	1	22	19	86 4	52 8
2	26	46	22	0 0	81 8	9 1	9 1	20	0	0	20	20	100 0	43 5
3		4	4	0 0	25 0	25 0	50 0	2	0	0	2	2	100 0	50 0
4		14	14	0 0	92 9	7 1	0 0	14	0	1	14	10	76 9	71 4
5		12	10	0 0	90 0	0 0	10 0	11	2	0	11	9	81 8	75 0
6		47	46	0 0	17 4	76 1	6 5	45	10	3	37	27	64 3	57 4
7	8	16	24	0 0	70 8	4 2	25 0	16	0	0	16	14	87 5	87 5
8		34	32	0 0	50 0	28 1	21 9	25	1	0	25	24	96 0	70 6
9		34	34	0 0	20 6	55 9	23 5	31	0	3	31	20	76 9	58 8
10		22	21	0 0	57 2	42 8	0 0	22	0	0	22	19	86 4	86 4
11		1	1	0 0	100 0	0 0	0 0	0	0	0	0	0		
13		48	46	2 2	64 4	31 1	4 4	40	2	1	38	33	84 6	68 8
15		48	47	6 4	79 5	6 8	13 6	48	12	6	46	30	71 4	62 5
16		42	41	4 9	53 8	20 5	25 6	39	2	9	39	26	86 7	61 9
All farm		404	378	1 9	56 1	27 5	16 4	336	29	26	323	253	81 6	62 6
Year 1993														
1		43	43	0 0	60 5	14 0	25 6	35	0	2	34	27	81 8	62 8
2	5	20	20	0 0	95 0	5 0	0 0	20	3	0	20	17	85 0	85 0
3	13	17	17	0 0	58 8	29 4	11 8	17	0	2	17	11	73 3	64 7
4		12	12	0 0	75 0	25 0	0 0	12	0	0	12	11	91 7	91 7
5		7	7	0 0	71 4	28 6	0 0	7	1	0	7	6	85 7	85 7
6		26	26	0 0	42 3	7 7	50 0	26	2	13	26	11	84 6	42 3
7		12	12	0 0	8 3	41 7	50 0	4	0	0	3	3	75 0	25 0
8		32	32	0 0	84 4	9 4	6 3	28	0	0	28	24	85 7	75 0
9		47	46	0 0	61 7	12 8	25 5	35	1	0	35	27	77 1	57 4
10		35	35	0 0	91 4	0 0	8 6	32	0	1	32	28	90 3	80 0
11		1	1	0 0	100 0	0 0	0 0	1	0	0	1	1	100 0	100 0
13	12	34	46	0 0	93 5	0 0	6 5	31	3	0	31	28	90 3	82 4
15		76	76	0 0	71 1	21 1	7 9	98	11	6	98	81	82 0	76 3
16		40	40	0 0	85 0	12 5	2 5	40	0	1	38	36	92 3	90 0
All farms		402	413	0 0	72 7	13 0	14 2	386	21	25	382	311	86 1	77 4
Total		806	791	0 9	64 8	19 9	15 3	722	50	51	705	564	84 1	70 0

Wet = still lactating at weaning

* For reasons not related to pregnancy results

** Hinds not pregnant at calving either from pregnancy scanning in June or from observation of physical characteristics and weight change before calving

† Percentage of hinds not suspected not pregnant at calving that reared a calf up to weaning The number of wet hinds was checked were possible from the number of calves actually weaned from these hinds, assuming there was no twinning

‡ Percentage of hinds mated in the breeding herd that reared a calf up to weaning This figure includes hinds sold or slaughtered after mating, excepted those for which the decision of culling was made prior to mating

Notes

Year 1992

Farm 1 4 hinds left the farm on May 28 without being scanned

Farm 2 5 hinds left on May 3 and 21 hinds were culled on May 23, without being scanned

Farm 6 10 light-weight hinds were separated from mating mobs on 23 3 92 and 9 were joined again with back-up stag on 4 5 92 All 9 but one hind conceived in May

Farm 7 6 other hinds weighing 71 8-75 8 kg were culled but mated and were scanned all not pregnant, 2 hinds left the farm for calving

Year 1993

Farm 2 5 hinds were taken off the farm on June 2 without being scanned Pregnancy status unknown

Farm 3 8 and 5 hinds were culled on May 16 and June 10, respectively, without being scanned or suspected at slaughter

Farm 13 12 hinds all conceiving before May 1 were sold on June 17

Farm 15 Calving hinds includes 23 wapiti cross in-calf hinds bought on Oct 29, the reproductive efficiency does not include their 23 offspring in the calculation

It is of particular concern that the median calving dates for yearling hinds is 13 days later than that for adult hinds. This factor alone contributes considerably to the lower weaning weight of offspring from yearling hinds, and is therefore an issue that needs to be addressed on farms where high weaning weight is a target. The two-week difference in birth date would contribute to more than 4 kg difference in weaning bodyweight.

Table 4: Mean, standard deviation (SD), median, range of calving dates of yearling and adult hinds on farm recording birth dates in 1992 and 1993

Year	Farm code	Numbers of hinds	Start	End	Median	Mean	SD
Yearling hinds							
1992	1	3	21-Nov	28-Nov	26-Nov	25-Nov	2 9
	4	11	27-Nov	3-Jan	14-Dec	14-Dec	9 6
	9	10	13-Dec	24-Dec	15-Dec	16-Dec	3 5
	16	10	28-Nov	25-Jan	8-Dec	13-Dec	13 2
1993	4	10	30-Nov	28-Dec	10-Dec	10-Dec	8 9
	All farms	53	21-Nov	25-Jan	13-Dec	12-Dec	11 1
Adult hinds							
1992	1	74	4-Nov	22-Jan	29-Nov	30-Nov	10 2
	4	57	19-Nov	23-Dec	2-Dec	1-Dec	6 6
	9	10	22-Nov	13-Dec	6-Dec	5-Dec	5 9
	16	102	18-Nov	31-Dec	30-Nov	3-Dec	10 0
1993	4	58	16-Nov	21-Dec	26-Nov	27-Nov	7 0
	All farms	301	4-Nov	22-Jan	30-Nov	1-Dec	9 2

3.4 Dystocia

During two calving seasons 22 dystocias were reported from 9 farms in this study (Audigé *et al*, 1998e). Veterinary attention was involved in 3 cases, 12 were handled by farmers, and 7 received no intervention. Six hinds died, 2 were euthanased, and only 2 offspring survived. The risk of dystocia in yearling and adult hinds was 0.0108 and 0.0045, respectively.

3.5 Progeny loss

The individual farm progeny loss rates are presented in Table 5, and the distribution of loss rates between farms is presented in Figure 2. It can be seen from those data that overall progeny loss rates up to weaning are significant. Indeed, the mean progeny loss factor from yearling hinds at around 17% is the greatest loss factor observed on our trial farms. The progeny loss rate from adults of around 8% is also of significant concern. There was a wide variety of causes of these losses, and a description of these and the risk factors associated with these losses has been presented elsewhere (Audigé *et al*, 1998b).

Table 5. Calculation of progeny loss rates (%) of yearling (< 26 months) and adult hinds on each survey farm in 1992, 1993 and both years combined

		FARM CODES														All
		1	2	3	4	5	6	7	8	9	10	11	13	15	16	farms
YEARLING HINDS																
1992	Number of hinds at risk*	22	20	2	14	11	44	16	25	26	22		39	42	30	313
	Suspected foetal losses				1											1
	Observed calf losses†	3			3						3				2	11
	Hind lactating at weaning	19	20	2	10	9	27	14	24	20	19		33	30	26	253
	Unobserved foetal or calf losses					2	17	2	1	6			6	12	2	48
	Progeny loss rates	13 6	0 0	0 0	28 6	18 2	38 6	12 5	4 0	23 1	13 6		15 4	28 6	13 3	19 2
1993	Number of hinds at risk*	33	20	15	12	7	13	4	28	35	32	1	31	70	39	340
	Suspected foetal losses										1					1
	Observed calf losses†				1			1			1				2	5
	Hind lactating at weaning	27	17	11	11	6	11	3	24	27	28	1	28	59	36	289
	Unobserved foetal or calf losses	6	3	4		1	2		4	8	2		3	11	1	45
	Progeny loss rates	18 2	15 0	26 7	8 3	14 3	15 4	25 0	14 3	22 9	12 5	0 0	9 7	15 7	7 7	15 0
Both years	Number of hinds at risk*	55	40	17	26	18	57	20	53	61	54	1	70	112	69	653
	Suspected foetal losses				1						1					2
	Observed calf losses†	3			4			1			4				4	16
	Hind lactating at weaning	46	37	13	21	15	38	17	48	47	47	1	61	89	62	542
	Unobserved foetal or calf losses	6	3	4	0	3	19	2	5	14	2	0	9	23	3	93
	Progeny loss rates	16 4	7 5	23 5	19 2	16 7	33 3	15 0	9 4	23 0	13 0	0 0	12 9	20 5	10 1	17 0
ADULT HINDS																
1992	Number of hinds at risk*	126	205	139	61	73	115	35	185	76	148	110	175	121	119	1688
	Suspected foetal losses	1			1		1	2	2		1	1				9
	Observed calf losses†	18		5	3	1		2	6		7	1	1		7	51
	Number of calves weaned‡	106	185	119	58	64	104	31	177	72	138	104	155	108	105	1526
	Unobserved foetal or calf losses	1	20	15		8	10				2	4	19	13	7	99
	Progeny loss rates	15 9	9 8	14 4	4 9	12 3	9 6	11 4	4 3	5 3	6 8	5 5	11 4	10 7	11 8	9 6
1993	Number of hinds at risk*	113	186	129	61	59	117	51	188	97	144	102	175	126	128	1676
	Suspected foetal losses			1	1					1	1	2			1	7
	Observed calf losses**	4	2	1	3		2	2	2		2	1			3	22
	Number of calves weaned‡	105	156	126	58	48	101	46	175	93	142	96	153	111	117	1527
	Unobserved foetal or calf losses	4	28	1		11	14	3	11	3		3	22	15	7	122
	Progeny loss rates	7 1	16 1	2 3	0 0	18 6	13 7	9 8	6 9	4 1	0 0	5 9	12 6	11 9	8 6	8 9
Both years	Number of hinds at risk*	239	391	268	122	132	232	86	373	173	292	212	350	247	247	3364
	Suspected foetal losses	1	0	1	2	0	1	2	2	1	2	3	0	0	1	16
	Observed calf losses†	22	2	6	6	1	2	4	8	0	9	2	1	0	10	73
	Number of calves weaned‡	211	341	245	116	112	205	77	352	165	280	200	308	219	222	3053
	Unobserved foetal or calf losses	5	48	16		19	24	3	11	7	1	7	41	28	14	224
	Progeny loss rates	11 7	12 8	8 6	4 9	15 2	11 6	10 5	5 6	4 6	4 1	5 7	12 0	11 3	10 1	9 2

Note Farms 5 and 13 in 1992, and farm 13 in 1993 observed 2, 1 and 3 calf losses, respectively, that could not be attributable to yearling or adult hinds, so they were not included with "observed calf losses"

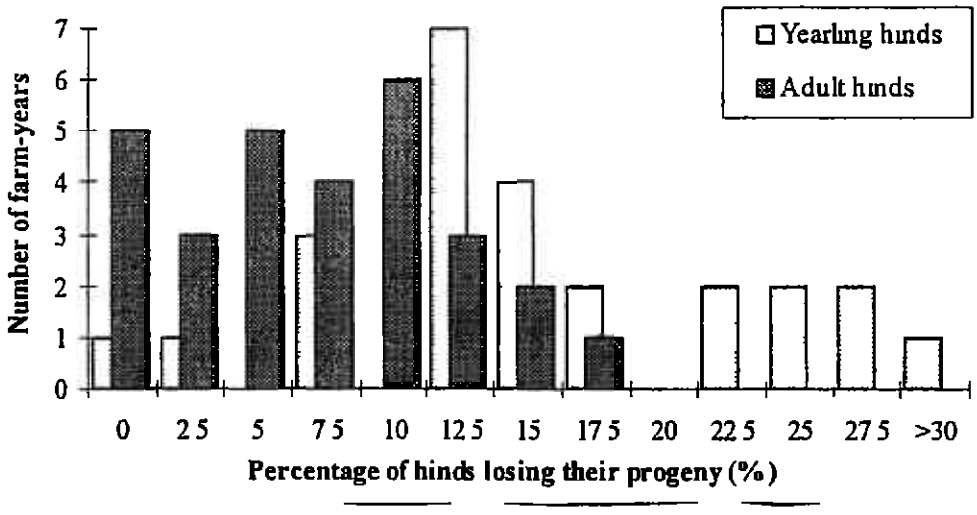
Farm 15 in 1992 23 in-calf yearling wapiti-cross hinds bought prior to calving were not included in this calculation

* Number of hinds at risk = Estimated number of hinds pregnant in June (number of hinds mated X conception rate /100) that were on farms for calving including hinds artificially inseminated

† Includes calves found dead and death of pregnant hinds during calving, 8 adult and 1 yearling hinds that were diagnosed pregnant in June died during calving for reasons not identified as related to calving difficulties, so were not reported as "observed calf loss"

‡ All dry (not lactating) hinds at weaning were not identified according to the number of calves weaned. For convenience, the number of calves from yearling hinds have been counted as the actual number of hinds recorded wet (lactating) at weaning, but misclassification could have occurred.

Figure 2. **Distribution histogram of progeny loss (%) in yearling 2 years old at calving) and adult hinds within farms each year. Data from 1992 and 1993 combined.**



3.6 Reproductive efficiency

Table 6 shows a summary of the overall reproductive efficiency from our survey farms. Seventy percent of yearling hinds and 83.6% of adult hinds mated reared an offspring to weaning. Note that this figure takes into account hinds which were sold during winter, hind deaths between mating and weaning, and progeny loss factors.

Table 6 **Overall weaning rate (calves weaned/hinds mated x 100%) and reproductive efficiency of yearling and adult hinds in 1992, 1993 and both years combined**

	1992	1993	Both years combined
	Weaning rate (%)		
Yearling hinds	81.6	86 1	84 1
Adult hinds	91 5	91 7	91 6
	Reproductive efficiency (%)		
Yearling hinds	62 6	77 4	70 0
Adult hinds	81 1	88 9	83 6

4. Risk factors for reproductive outcomes

The following discussion summarises an extensive range of multivariable analyses and development of path diagrams for each outcome as part of our Deer Herd Health and Production Profiling project. Further detail can be found in individual references cited in each section.

4.1 Early conception

4.1.1 Adult hinds

The management model proposed for optimising the conception in adult hinds is as follows using models of association between events or observations, and the outcome (Audigé *et al*, 1998c):

- Early weaning - preferably in February but no later than the first week in March;
- Sell hinds not rearing a calf to weaning;
- Ensure all hinds to be mated reach a body condition score ≥2.5 - at weaning if hinds are below that level, preferential feeding must be given in order to increase bodyweight in the period pre-mating;
- Join hinds with stags early - a stag effect has been shown elsewhere (Wilson, 1992) and has been proposed (Moore *et al*, 1985). While there is no definitive date at which a stag effect will or will not arise, our proposal is that stags should be joined before March 10. There appears to be no disadvantage in joining stags late February;
- Experienced sire - experienced sires have been shown to have a higher conception rate in their mating groups. In order to become experienced it is proposed that back-up stags be those without previous sexual experience in order for the farm to establish a pool of experienced stags;
- Limit stag : hind ratio - our study did not identify a critical ratio beyond which conception rate decreased. A ratio of up to 1 : 80 was recorded. It is possible that beyond 50 the conception rate may decrease. It should be noted that this decrease was only small, and the relative merit of decreasing conception rate *vs* enhancement of genetic potential by using much wider stag : hind ratios, eg: 1 : 120, must be weighed up for the individual farmer's situation (see Beatson *et al*, these Proceedings);
- Back-up sire - those herds which used a back-up sire had a higher early conception rate;
- Avoid disturbance - herds which were moved or that had frequent disturbance of any type had lower conception rates;
- Environmental factors - while our study showed that some environmental factors, for example topography, shade and shelter, were associated with conception rate, there appears currently to be no logical biological reason for these relationships. They may indeed be causal, but that they may be spurious cannot be discounted. More research needs to be done to examine these interrelationships before management advice can be given.

4.1.2 Yearling

A full description of risk factors for yearlings is found in Audigé *et al*, (1998d). The following factors are associated with high early conception rates:

- High live weight and height - our study showed that hinds with the greatest shoulder height had the highest probability of conceiving early. Above the accepted threshold weight of 65 kg, higher bodyweight animals conceive early as a direct effect of bodyweight. (This should not be confused with the "categorical" bodyweight of approximately 65 kg under which hinds are unlikely to conceive;

ie: bodyweight affects the ability to conceive, but above the minimum, bodyweight also affects conception date).

- Body condition score 2.5 - 4: hinds under a BCS of 2.5 and above 4 had a lower probability of early conception. Note that the observation of an apparent effect of fatness in this study is consistent with the observation of lower conception rates in fat heifers;
- Contact with peer group stags - our study showed that yearling hinds which had been managed with their cohort males until late the previous year, followed by separation so that spiker stags can be velveted without disturbing their sisters, followed by re-joining January/February and then joining with the intended sire stag (or mated with those spikers), resulted in a significantly higher conception rate early in the breeding season. This management proposal has subsequently been tested and in a commercial farming environment appears to be successful. (Data of Laurence and Beatson *et al*, elsewhere in these Proceedings, also supports this observation).
- Use of single experienced sire
- Use of back-up sire
- Do not change mating mobs - it appears that the social interaction resulting from changing mating mobs may have a negative effect on conception rates;
- Minimise mixing with adults
- Minimise disturbance during mating
- Environmental factors as for adult hinds above, may be important for yearlings.

4.2 Conception *per se*

The main method of improving conception *per se* is simply to leave the stags in with the hinds for longer. This, however, has the negative impact of spreading the calving pattern, delaying the conclusion of calving and therefore decreasing weaning weights. This is considered to be undesirable in most commercial farming situations. This factor should be included with all of the factors above for early conception.

4.3 Dystocia

Full detail is found in Audigé *et al* (1998e). To minimise the risk of dystocia

- pregnant hinds should be of a body condition score 3 - 3.5 after winter but should be below 4;
- should hinds be over-fat (BCS 4 or above) in September, feed allowance should be restricted and/or they should graze on steeper hill slopes;
- large terminal sires should not be used with yearling hinds and small adults;
- hinds should not put on body condition in the last third of pregnancy.
- grazing steep paddocks may significantly reduce the risk of dystocia only for hinds with a BCS over 3.5, suggesting that fitness may be important. Grazing flat paddocks *per se* did not significantly increase the risk of dystocia for hinds with body conditions scores below 4.

4.4 Rearing calf to weaning

Our studies showed that only one management practice was associated with the ability of yearling hinds to rear a calf to weaning, that of close monitoring (ie: disturbance) of calving paddocks by farmers. While it must be acknowledged that a number of other factors may contribute to the yearling hind's ability to rear a calf, they are factors other than those investigated in our studies. A full description of factors associated with calf rearing to weaning is found in Audigé *et al*, (1998b).

For adult hinds the probability of rearing a calf to weaning can be enhanced by:

- selling hinds which did not rear a calf in previous seasons;
- ensuring hinds are in good body condition (score ≥ 2.5) at mating and do not lose body condition during winter;
- maximising the proportion of hinds conceiving before May 1 (see factors in 4.1.1);
- avoiding paddocks with wire and batten fences;
- grazing hinds on pasture not less than 5 cm surface height
- not mixing adult hinds with mature stags at calving;
- not tagging calves at birth.

Anecdotal evidence and experience of deer farmers would confirm the validity of many of these recommendations. This study is the first to propose that management practices in the winter before weaning affecting the body condition and weight of hinds, may be related to their ability to rear a calf to weaning; ie: that outcomes can be influenced by events which take place about a year earlier. This is evidence that the causal web of factors associated with a number of outcomes on deer farms is probably very complex indeed, and has a prolonged chronological sequence.

4.5 Individual hind markers

Full discussion of the relationship between certain biological markers and hind characteristics, and reproductive outcomes, is presented in Audigé *et al*, (1998f). During the course of our study it was observed that those hinds of a quiet disposition, allowing ease of handling, had a high probability of conception. There was a positive relationship between blood phosphorus and conception rate in adult hinds.

Lower conception rates were observed in yearling hinds when blood glutathione peroxidise, serum vitamin B_{12} and serum albumin concentrations were low, and when faecal lungworm larval counts were high.

NOTES ON INTERPRETATION

The factors described in Section 4 above are those found to be statistically significantly associated with the respective outcome. Many have been proven to be caused by other forms of research. However, some of the above associations have not yet been proven as causal. More research is needed before causation can be assumed

5. Critical management tools/decisions

There are a number of management tools which can be useful in helping to make management decisions. The following is a short list:

5.1 Body condition score

We believe this to be the single most useful tool in assisting management decisions aimed at maximising reproductive performance. A full description of the method for and use of body condition scores is presented elsewhere (Audigé *et al*, 1998g). We have shown above that outside certain body condition score categories conception rates will be reduced. At high body condition scores, the risk of dystocia increases. If body score increases toward the end of gestation the risk of dystocia increases, and if body condition scores reduce in the early stages of pregnancy, there is a reduced probability of rearing a calf to weaning. We propose that on a year-round basis all individuals should fall within the range 2.5 - 3.5, to achieve optimum reproductive outcomes.

5.2 Pasture/supplementary feeding

Knowing the relationship between pasture height and feed intake, and animal performance, should enable the appropriate decisions to be made in order to achieve the necessary body condition scores on animals. Feeding decisions may be routine or remedial, depending on circumstances. It is likely that the greatest need for remedial action will arise between weaning and onset of the breeding season, since the most likely time of year for reduction of body condition of hinds is during mid- to late lactation, and because BCS is such an important determinant of reproductive success. Maintenance of body condition through winter also is important. A comprehensive review of feeding of deer is to be found in the Deer Branch NZVA Conference Proceedings No 13 (1996).

5.3 Weaning date

Delaying weaning date can often result in prolonged lactation and loss of body condition in hinds. This becomes critical as the time between weaning and onset of the breeding season reduces. Indeed, late weaning may have the effect of delaying the onset of the breeding season, although this is subject to debate (see Pollard and Pearce, these Proceedings). We recommend that the efficient breeding herd wean as early as possible. Some efficient herds are now weaning as early as mid-February. This provides maximum flexibility for management of hinds, for management of feeding, and will have the maximum beneficial effect in advancing the onset of the breeding season by removing the stress of lactation and weaning, as early as possible before the breeding season.

5.4 Joining date

The "stag effect" is a tool which can be used to benefit the induction of early cycling in hinds, thereby advancing the median calving date with the flow-on effect to weaning weights. We propose that the stag effect is probably most effective if the joining is before March 10, although this needs to be tested (see Audigé *et al*, 1998c).

5.5 Hormonal manipulations

Melatonin treatment to stags has been shown to advance median calving dates by 8-10 days (Wilson, 1992). The use and management implications of melatonin in deer herds has been discussed earlier (Wilson, 1989; Wilson, 1990; Fennessy, 1990).

The use of CIDRs in hinds can also advance the breeding season, but more work needs to be done to look at the cost-effectiveness of this technique *vs* melatonin *vs* natural management techniques, as discussed above. (Data of Beatson *et al* in these Proceedings provides some data).

5.6 Stag : hind ratios

While our survey has shown an average stag : hind ratio of approximately 1 : 45, recent work with the Deermaster project (Beatson *et al*, these Proceedings) indicates high pregnancy rates with ratios in excess of 1:100. While there may be a slight reduction in early conception rate, this may be offset in many circumstances by the genetic gain associated with extended use of superior sires.

5.7 Ultrasound scanning

The use of ultrasound for pregnancy diagnosis and foetal ageing has been discussed elsewhere (Revol and Wilson, 1991a,b) and the range of applications for ultrasound techniques in deer herds has been discussed by Wilson (1997). The technique is used for the diagnosis of pregnancy, confirmation of non-pregnancy, foetal ageing, evaluating stag fertility, diagnosis of reproductive failures, ovarian abnormalities, twinning and mummification.

6. Conclusions

This paper has discussed a range of indices of reproductive performance that can be used for comparative and diagnostic purposes. Data presented from surveys of commercial deer farms indicate that biological reproductive potential of farmed deer is high, yet that potential is often not achieved. Research has shown that a number of management practices can be implemented to maximise reproductive potential. Thus, while the knowledge of how to achieve high levels of reproductive performance exists, there is considerable potential for application of that knowledge across the deer industry. Most of the factors associated with improvement of reproductive performance are low cost: they relate to knowledge and skill.

Acknowledgments

We wish to thank participating farmers for their active cooperation during this health and production profiling research project. We thank personnel of the Veterinary Faculty at Massey University for help and assistance. Financial assistance was provided by the NZGIB, the French Government (Scholarship), CIRAD-EMVT, Deer Branch NZVA, Massey University, Pitman Moore (now Schering Plough NZ), Rhône Mérieux, Cyanamid, Agresearch, Allflex NZ Ltd, and Te Pari Products.

References

Audigé LJM, Wilson PR, Morris RS (1993). Deer herd health and production profiling: The method. Proc Deer Course for Veterinarians, Deer Branch NZVA No 10, 78-100. Ed. P R Wilson.

Audigé LJM, Wilson PR, Morris RS (1994). Deer herd health and production profiling: Study design. Vet Rec 25, 130-33.

Audigé LJM (1995). Deer herd health and production profiling. PhD thesis, Massey University.

Audigé LJM, Wilson PR, Morris RS (1995) Deer herd health and productivity data Proc Deer Course for Veterinarians, Deer Branch NZVA No 12, ed. PR Wilson, 31-56

Audigé LJM, Wilson PR, Morris RS (1998a). Deer herd health and production profiling. III. Concepts and components. NZ vet J. Accepted.

.. 1998 (b) Reproductive performance in farmed red deer (*Cervus elaphus*) in New Zealand. I Risk factors associated with calf rearing to weaning. In preparation

. 1998 (c) Reproductive performance in farmed red deer (*Cervus elaphus*) in New Zealand III. Risk factors for adult hind conception Prev vet med. Accepted

.1998 (d) Reproductive performance in farmed red deer (*Cervus elaphus*) in New Zealand II Risk factors for yearling hind conception. Prev vet med. Submitted.

....1998 (e). Reproductive performance in farmed red deer (*Cervus elaphus*) in New Zealand. V. Risk factors for dystocia. Prev vet med. Submitted.

....1998 (f). IV. Sentinel hind characteristics and biological markers as risk factors for yearling and adult hind conception. Anim Reprod Sci. Accepted.

...1998 (g). A body condition score system as used for farmed red deer hinds NZ J Agric res Accepted.

Asher GW, Adam JL (1995). Reproduction of farmed red and fallow deer in Northern New Zealand In. Biology of deer production. Ed. Fennessy PF, Drew KR. Royal Soc NZ Bulletin 22, 217.

Fennessy PF, Suttie JM, Fisher MW, Jopson NB, Webster JR. Melatonin in male deer - effects on seasonal cycles. Proc Deer Course for Veterinarians, Deer Branch NZVA No 7. Ed P R Wilson, pp159-166

Moore GW, Cowie GM, Bray AR (1985). Herd management of farmed red deer In Biolology of Deer Production. Ed. Fennessy PF, Drew KR Royal Soc NZ Bulletin 22, 343

Revol B, Wilson PR (1991) Foetal ageing in farmed red deer using ultrasonography. Anim Reprod Sci 25, 241-253.

Revol B, Wilson PR (1991). Ultrasonography of the reproductive tract in early pregnancy in red deer Vet Rec 128, 229-33.

Wilson PR (1989). Advanced calving in deer. practical aspects Proc Deer Course for Veterinarians, Deer Branch NZVA No 6. Ed. P R Wilson, 54-68

Wilson PR (1990). Melatonin and advanced breeding. Further research: two dosage regimes and the influence of the stag Proc Deer Course for Veterinarians, Deer Branch NZVA No 7 Ed P R Wilson, 152-7.

Wilson PR (1992). Further studies on advancing the breeding season using melatonin implants in farmed red deer: two dosage regimes and the stag effect In: Biology of Deer Ed R D Brown, Springer Verlag, NY Pp318-319

Wilson PR, Audigé LJM (1996). Target setting. body condition scores and weights. Proc Deer course for veterinarians, Deer Branch NZVA No 13 Ed PR Wilson, 27-60

Wilson PR (1997). Viewing pregnancy by ultrasound The Deer Farmer, April 1997