

Reproduction and potential rate of increase of the sika deer herd in Co Wicklow

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Abstract

All three deer species in Ireland mainly inhabit forests, where they can cause significant economic and ecological damage through browsing and bark stripping of trees. Sika deer and sika x red hybrids are currently the most numerous deer. Their expansion through Co Wicklow and beyond was associated with afforestation. Deer must be managed, and to do this effectively, knowledge of their reproductive potential is needed. We investigated the reproduction of female sika-like deer harvested in the Co Wicklow area during the hunting seasons from 1995/1996 to 1997/1998. Fifteen percent of calves, 87% of yearlings and 84% of adult females were pregnant. One female was found with twin foetuses. Seventy-two percent of adults were lactating and 71% had a calf-at-foot. Eighty-five percent of calves survived to six months of age. The deer herd has a yearly potential rate of increase of 28%. Pregnancy and survival rates are very high for sika deer in Ireland and in line with other populations elsewhere. It is likely that our estimate of 15% of calves becoming pregnant and raising offspring is low. This high fertility is despite the high densities at which sika-like deer are found in Co Wicklow. Deer are increasing in numbers because insufficient numbers are harvested compared with their rate of increase. This trend could cause a serious increase in tree damage levels. We recommend that the harvest be increased to at least 30% of the female population and reproduction be continuously monitored, with an emphasis on assessing for pregnancy in calves and checking for twins.

Keywords

Sika deer, reproduction, survival, rate of increase.

Introduction

The three species of deer found in Ireland: fallow, red and sika are all associated with forests. Red is the least numerous, with a population estimated at 3,000 in 1988 (Guerin 1989), centred around the national park areas in Kerry, Donegal and some special red deer parks. Fallow are widely distributed; their numbers were estimated in 1988 at several thousand (Guerin 1989). Sika deer and their hybrids with red deer are found in areas around former deer parks where they have escaped to form feral herds. These herds have spread extensively (Harrington 1973, Hurley 1996) and this species is now the most numerous in the country (Hayden 1997). In 1988 the total number of deer in the country was estimated at 20,000 (Guerin 1989). Since then, the population of sika deer and their hybrids in Co Wicklow alone has been estimated at 16,200 in 1994 and 19,215 in 2000 (Lowe 1994, O'Brien 2000). Sika have spread

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from Co Wicklow into other counties: they were recorded in Co Wexford in 1980 and are also currently in Cos Kildare and Carlow (Hurley 1996).

Fallow, red and sika deer are all intermediate or opportunistic feeders, and will both graze and browse (Ratcliffe 1987, Takatsuki 1988, Geist 1999). Red deer cause economically significant damage in commercial forests (Wolfe and v. Berg 1988, Welch et al. 1991, Gill 1992a, 1992b). They are considered to be more damaging than roe deer due to their large size and efficient digestive system, which allows them to subsist on forage of low nutritional quality, and their resultant bark stripping activities (Wolfe and v. Berg 1988). Browsing by roe can, however, be as costly because they reach higher densities (Wolfe and v. Berg 1988, Mayle 1996). Sika have a better capacity for digesting poor quality food than reds (Hoffman 1982), have higher reproductive rates and reach higher densities than red and often roe deer in commercial forests (Mayle 1996). In their natural range, sika feed on a variety of vegetation including bark (Asada and Ochiai 1996, Yokojama et al. 1996). In Ireland, grass can make up more than 50% of the diet (Quirke 1991) but heather, gorse, holly and other trees, including saplings and bark are also eaten (Kelly 1981). Outside their natural range, sika have become important pests in managed forests (Rose 1991). In Co Wicklow, sika damage is estimated in 45-50% of young stands, (Coillte 1995, cited in Hurley 1996). At some sites, over 60% of trees are damaged (Lowe 1994), with browsing the most common type of damage (Hannan and Whelan 1989). Fallow deer also bark strip (Gill 1992a), though fewer studies have been conducted.

The spread of sika-like hybrid deer through Wicklow was associated with the afforestation of the county over the period from the 1930s to the 1950s. Young forests are ideal habitats for sika deer (Ratcliffe 1987, Mayle 1996) and the increase in sika deer numbers in Scotland is considered a direct consequence of commercial afforestation (Ratcliffe 1987, 1989).

Deer must be actively managed in both natural/old-growth and commercial forests where they occur, to control populations and to minimize damage to commercial trees and other important plants, especially in the absence of natural predators, as is the case in Ireland and much of western Europe. In order to achieve forest certification a management plan must be created for deer, if present (Rooney and Hayden 2002). Control is usually achieved by means of harvesting a proportion of the population, with targets set for removing a certain number of individuals in an area. This number will vary depending on the local density and rate of increase of the herd. To investigate population dynamics and develop a management strategy for a deer herd, knowledge of reproductive patterns and capacities is essential. Sika, red and fallow deer are all seasonally polyestrous. In autumn, females come into oestrus, which can be cyclically repeated about every 22 days through the winter until they conceive (Chapman 1974, Moore 1995). Most females conceive during first oestrus, so that sika and red calves are generally born during May and June (Mitchell et al. 1976), with fallow fawns born a little later, in June (Moore 1995).

The age at which female deer first conceive varies widely between and within species, in relation to environmental conditions (Mitchell and Lincoln 1973, Woolf and Harder 1979, Thomas 1982, Clutton-Brock et al. 1987). A threshold level of

body condition, best indicated by body weight, must be reached in order for a female to be capable of full gestation. This occurs at different ages depending on the particular conditions under which deer are living. In general, fewer yearlings than adults in a population breed (Thomas 1982, Boyce 1989, Gaillard et al. 1992). This is related to the lower body weights of yearlings compared to adults (Putman and Clifton-Bligh 1997). Yearlings also tend to breed later in the year than adults, as they may only reach sufficient condition late in the year (Clutton-Brock et al. 1982, Feldhamer and Marcus 1994, Putman and Clifton-Bligh 1997), as is the case for adults in poor condition (Mitchell and Lincoln 1973). Pregnancy in sika and red calves is not the norm in most populations, though in some British sika populations it is becoming common (approaching 30%; Ratcliffe 1987, Mayle 1996). Females in most sika populations reach sexual maturity as yearlings (Chapman 1974, Davidson 1973, O'Donoghue 1991, Feldhamer and Marcus 1994).

In favourable conditions, females, once reaching sexual maturity, normally bear offspring every year until old age (Davidson 1973, Ratcliffe 1987, Boyce 1989, O'Donoghue 1991, Gaillard et al. 1992, Ouellet et al. 1997; Putman and Clifton-Bligh 1997), while in less favourable situations females take longer to regain condition after rearing a calf, and may not conceive the following year (Mitchell 1973, Mitchell et al. 1976, Guinness et al. 1978, Gerhart et al. 1996). Females may take longer than one year to reach their threshold weight where conditions are extremely harsh (Thomas 1982), and the threshold itself can be higher in high density populations (Albon et al. 1983).

The reproductive performance of female deer in the Co Wicklow region was examined to discover whether the reported high density (Lowe 1994; Coad pers. comm.) adversely affected age at first conception and subsequent pregnancy rate, and to determine the potential rate of increase of the population. Also, since the most important aspect of reproduction is the proportion of calves born which survive to become independent and reproduce, determining recruitment to the population, the early survival of calves was investigated.

Materials and methods

Data on female reproduction were collected during a study of deer harvests in the Wicklow region during the three open hunting seasons (September to February inclusive for males, November to February inclusive for females) of 1995/1996 to 1997/1998. Of 1,388 deer for which data were provided, stalkers¹ classified 15 as fallow, seven were classified as red, 87 hybrid and 1,231 as sika. For the purpose of this study, fallow were omitted and all other deer were pooled as sika-like deer, due to the dubious genetic integrity of both species in the Wicklow region. Stalkers were asked to check if harvested females were pregnant and/or lactating when they were gralloching the carcass, and to record whether the female had a calf-at-foot when it was shot. Pregnancy was assessed by the obvious presence of an identifiable foetus in the uterus, while lactation was assessed on the basis of milk being readily

¹ Deer hunting in Ireland is conducted by stalking; using high-calibre rifles, without the use of dogs.

squeezed from the teats. Data sheets that had no data entered under the pregnancy and lactation categories were excluded as unchecked deer. Only positive and negative assessments of reproductive status were included in analysis. Pregnancy rates were calculated only for females which were harvested from December to February, to avoid under-reporting due to difficulty in assessing early pregnancy, while lactation rates were calculated only for hinds harvested before January, to avoid problems of later cessation (un-shown data).

The percentages of females that were pregnant, lactating and with a calf-at-foot in each year were calculated to determine both the age at which females in the population first become pregnant and the age-related reproductive potential, including any evidence of reproductive senescence. The proportions of females in all years combined which were pregnant, lactating and with a calf-at-foot were calculated for each age class from 0 to 18. The proportions of females lactating and with a calf-at-foot were compared with pregnancy rates to determine the early survival rate. The proportional contribution of each age class to the following year's offspring was calculated using the age-related reproductive (pregnancy) rates and the proportion of the female population made up from each age class. The products of these two for each age class were tabulated as a percentage of the total contributions.

Results

Eighty-seven percent of yearlings and 84% of adult females were pregnant when all seasons are combined. Eighty-two percent of yearlings were pregnant in 1995/1996, 79% in 1996/1997 and 91% in 1997/1998. Eighty-eight percent of adults in 1995/1996 were pregnant, with adult pregnancy rates at 74% and 87% 1996/1997 and 1997/1998 respectively. Adult lactation rates were 72% overall: 73%, 67% and 76% in 1995/1996, 1996/1997 and 1997/1998, respectively. Seventy-one percent of females had a calf-at-foot overall: 75% during 1995/1996, 63% in 1996/1997, and 72% in 1997/1998. The survival rate of calves to 6 months of age, calculated from the proportion of females pregnant and those with a calf-at-foot was 85%.

Few calves (15%) were pregnant but the proportion rose to 87% of yearlings and was similar in age classes until age eight, after which a decrease to 50% in 11 year olds is seen (Table 1). However, 82% of females aged 12 or older were pregnant. The proportions of females with a calf-at-foot and lactating were similar in most age classes; rising from 26 and 20% respectively in yearlings, to 67 and 68% in 2 year olds and staying between 60 and 80% for the most part in all older age groups. The only age group with a decrease in the percentage of hinds with a calf-at-foot was 11 year olds, with just 20%, though the single hind checked was lactating. In females aged 12 or older, 82% had a calf, and 75% were lactating (Table 1).

There was one case reported of a hind being pregnant with twins. Two hundred and two uteri were reported to have been opened, producing a twinning rate of 0.5%

Table 2 shows the proportional contribution of each age class to the numbers of calves born the following year, based on pregnancy rates and the number of young born to each age group in a hypothetical population of 100 females. The largest contributors were 2-year-olds, producing 22% of all calves. Animals up to 4 years old

Table 1: Age specific reproductive status of hinds.

Age	Pregnant			Calf-at-foot			Lactating		
	Total	N	%	Total	N	%	Total	N	%
0	27	4	15						
1	46	40	87	54	14	26	44	9	20
2	61	53	87	76	51	67	40	27	68
3	31	27	87	44	32	73	38	28	74
4	30	24	80	38	29	76	20	14	70
5	14	12	86	22	15	68	14	9	64
6	12	11	92	15	11	73	8	7	88
7	12	11	92	12	8	67	5	3	60
8	8	7	88	14	11	79	11	8	73
9	8	6	75	12	9	75	6	4	67
10	7	4	57	11	9	82	8	6	75
11	6	3	50	5	1	20	1	1	100
12	3	3	100	4	4	100	3	2	67
13	2	2	100	3	2	67	2	2	100
14	1	1	100						
15	2	2	100	2	2	100	1	1	100
16	2	0	0	2	1	50	2	1	50
17									
18	1	1	100						
(12-18)	11	9	82	11	9	82	8	6	75

produced nearly half of all calves (47.5%). Using lactation rates, 3-year-olds and 4-year-olds reared more calves than did yearlings. Age classes from 4 to 8 years each produced around 5% of offspring, while calves themselves contributed 6% to the next generation. Individual age classes older than 8 contributed very little: 2% or less. For every 100 female deer, 66 offspring were produced, 56 of which survived to weaning. This gives a yearly potential rate of increase of 28% for the deer herd.

Discussion

Pregnancy rates of adult sika-like deer in Wicklow were very high, with 84% of adults overall being pregnant after November. Pregnancy rates of Wicklow yearlings were equally high at 87%. This shows that females in the population reach the threshold body condition for conception in their second year, and generally conceive at the same time as older females, since pregnancy was easily detected by stalkers after November.

It was unexpected to find that calves would be pregnant in the Wicklow area. That only a small number were discovered is probably because the majority of stalkers did

Table 2: The proportional contribution of each female age class to the total numbers of calves produced in the following years and the number of young born to each age class per 100 females of the herd, based on the proportion of the female population made up by each age class and the pregnancy rate of that age class.

Age	Proportion of pop. %	Pregnancy rate %	Proportional Contribution	Number of young born per 100 females
0	27.40	15	6.18	4.1
1	13.09	87	17.33	11.4
2	16.93	87	22.39	14.7
3	11.69	87	15.51	10.2
4	8.90	80	10.84	7.1
5	3.14	86	4.10	2.7
6	3.84	92	5.36	3.5
7	3.32	92	4.63	3.1
8	3.14	88	4.18	2.8
9	2.27	75	2.59	1.7
10	2.27	57	1.97	1.3
11	1.22	50	0.93	0.6
12	1.22	100	1.86	1.2
13	0.52	100	0.80	0.5
14	0.17	100	0.27	0.2
15	0.52	100	0.80	0.5
16	0.17	0	0.00	0.0
17	0.00		0.00	0.0
18	0.17	100	0.27	0.2

not check for signs of pregnancy in harvested calves, presuming it unnecessary. Only 27 calves were checked, four of which were pregnant. In some of those checked, it is possible that pregnancy was not detected because of late conception. The one pregnant calf examined by the first author, in February, had a small foetus weighing 4.67 g which was estimated to be approximately 66 days old, using the equation expressing the relationship between the cube root of fetal weight (y) and length of gestation (x) given for sika in Killarney by O'Donoghue (1991): $y = 3.945 + 0.085x$. Thus, the calf is likely to have become pregnant in late December, nearly two months after the rut. If other calves similarly became pregnant late in the year, due to the time required to attain sufficient body weight and fat reserves as seen in white-tailed deer fawns (Scanlon 1978), signs of pregnancy would still not be obvious late in the season. Therefore, calves that did not appear to be pregnant when harvested may have been.

O'Donoghue (1991) reported one pregnant sika calf out of 45 examined in Killarney. It had conceived in early January, again considered due to only attaining

sufficient weight late in the season. The author considered the foetus unlikely to have survived and the 2% pregnancy rate of calves therefore deemed negligible in terms of contributing to the overall reproductive performance of the herd. No yearlings were reported as lactating, indicating that the offspring of any calves that conceive do not survive until autumn. In Wicklow, the 15% calf pregnancy rate was superseded by the lactation rate of yearlings (20%), indicating not only that pregnancies had been successful and that offspring born to hinds giving birth as yearlings survive as well as those born to older hinds, but also that the pregnancy rate of calves is somewhat higher than 15%. Calves in Wicklow, therefore, do contribute in part to the reproductive performance of the herd (6%). Yearlings in Wicklow also seem to contribute more to the herd's reproductive performance than do yearlings in Killarney, with a pregnancy rate of 85% compared to 60%.

Overall pregnancy rates of sika and sika-like deer in Ireland are similar to other populations of sika: 85% and 80% for adults and yearlings respectively in a New Zealand population where no calves were pregnant (Davidson 1973); 90% for adults and 72% for yearlings in Dorset, Britain, (Putman and Clifton-Bligh 1997); 80% for adults and yearling pregnancy described as common in other British populations (Ratcliffe 1987); and 94% based on *corpora lutea*, 74% based on visible foetuses for adults and 100% and 56% for yearlings using the same criteria in a Maryland herd, where 8/15 calves had ovulated, and four had a blastocyst-stage embryo (Feldhamer and Marcus 1994).

O'Donoghue (1991) considered the high pregnancy rates of yearlings in Killarney indicative of good quality range and lack of density-related limiting factors which have been shown in red deer (Clutton-Brock et al. 1985). The number of adults breeding is also closely related to habitat. Female sika-like deer in Wicklow have few problems regaining body weight and reserves after rearing a calf. The same was true of sika in Killarney (O'Donoghue 1991), while sika deer in Hokkaido, Japan generally produce their first calf as two year olds and will have a calf every year until age 8 or 9, which is the life expectancy for most females there (Kaji et al. 1984). Hinds of up to 18 years were shot in Wicklow. However, the present study found no evidence for reproductive senescence, with reproductive performance of females aged 12 or older similar to that of younger (1-9 years) hinds ($\chi^2 = 0.001$, $p = 0.979$).

Twinning in red and sika females is rare. MacNally (1985) stated that five undisputed births of red deer twins were recorded in Scotland between 1970 and 1984, with one stillborn set of twins, and one report of twin foetuses. Courtier (1971) reported a captive sika hind bearing twins. A culled sika female in Maryland had two healthy foetuses (Feldhamer and Marcus 1994). Clinton et al. (1992) found a female sika pregnant with twins during routine culling in Co Wicklow, and cite twinning rates of less than 0.01% for most Old World (Pleisometacarpalian) deer, including the genus *Cervus*. During this study, one case was reported by a park ranger who verified that the uterus was opened, giving a rate of 0.05%. It is possible that there were more, but which were unidentified because rupturing of the uterus is often unnecessary to positively identify pregnancy, meaning there could have been two foetuses, but only one pregnancy was recorded.

Overall, survival of sika-like calves born in Wicklow was 85%. This is higher than recorded from lactation data from Killarney (O'Donoghue 1991) and from Japan (75%: Kaji et al. 1980 cited in Ratcliffe 1987). This very high survival rate for young sika-like deer in Wicklow is probably the result of excellent dam condition, also indicated by their longevity compared to sika in their native range (Kaji et al. 1984) and lack of reproductive senescence, giving high quality milk, and the absence of large predators in Ireland, where only red foxes (*Vulpes vulpes*) and domestic dogs (*Canis familiaris*) can attack wild deer, and then only in the first few weeks after birth, as is the case in other species of deer (Nelson and Woolf 1987). Predation of sika by dogs has never been documented, but is unlikely to be important, as it is insignificant in other species of deer where it has been examined (Scott and Causey 1973, Causey and Cude 1980). The only account of a fox attacking a deer in Ireland was a female sika calf killed in Killarney (Nowlan 1988). The high survival rate of offspring, added to the high pregnancy rate of adults and yearlings, and the pregnancy of some calves, means that for every 100 females in the population, 56 calves will be reared to weaning. If, as it seems, the foetal sex ratio is parity (unshown data), then 28 females are added to the population every year. Therefore, in order to maintain the Wicklow sika-like deer herd at current numbers, it is necessary to harvest 28% of females.

The exact number of sika-like deer in the county is unknown, but 1994 it was estimated at 16,200 deer (Lowe 1994), and in 2000 at 19,215 (O'Brien 2000). Afforestation continues today at more than twice the yearly rate of the mid 80s with much greater areas planted privately than by the state (Department of Agriculture, Food and Forestry 1996, Coillte 1999, Irish Timber Growers Association 2002) due to grant-aid schemes for afforestation (Forest Service 2003). As suitable habitat has increased during recent years, the populations of all species, especially of fallow and sika, have presumably increased in density and/or geographical range, and are likely to continue to do so. Recent work in Co Wicklow using dung counts confirms that densities, at 40 deer/100 ha in some areas (Coad, pers. comm.), are indeed at the higher end of the spectrum recorded for sika deer, compared with densities of 11.9/100 ha in Dorset (Putman and Clifton-Bligh 1997) and 36.5/100 ha recorded for an island population at Lake Toya, Japan (Kaji et al. 1984). These high densities are currently having no ill effects on the reproductive output of females. Table 3 shows the total number of red, sika and red/sika hybrid harvested in Co Wicklow each year from 1995 to 2002 (calculated from figures returned to Dúchas by hunters when applying for a new hunting licence). Most of these deer were termed sika, (yearly mean of 14.5 male and 15.5 female red deer, and 139.75 male and 138.25 female hybrid deer). The number of females harvested has more than doubled in eight years, while that of males has almost done so. While this is due in part to a request from some landowners for hunters to harvest more deer because of damage (Coad, pers. comm.) it is most probably mainly due to the result of increasing numbers of deer. Deer are increasing in numbers because too few (females) are harvested each year to counteract their high rate of increase. If there were 16,200 sika-like deer in 1994, half of which were females (an uncertain fact given the widely-reported tendency to cull

more males than females prior to then), 2,268 hinds would have needed to be culled to maintain that number of deer. As seen in Table 3, fewer than half that number were culled in 1995. By the same token, if 19,215 sika-like deer were present in the county in 2000, 2,690 hinds would need to be harvested to maintain a static population. In 2002, the number of hinds harvested still had not reached that figure. Thus, even using quite conservative estimates of deer numbers, it is clear that the potential rate of increase of the Wicklow sika-like deer population requires that more deer be harvested than at present. The numbers of fallow deer shot in Co Wicklow each year is also increasing, evidence that the population of that species is also expanding.

Trec damage is linked to deer density, though the correlation is weak (Putman and Langbein 2000). Thus as deer numbers increase, so too will tree damage. In the Wicklow area, Sitka spruce damage has been estimated at 45-60% of trees browsed, with 20-25% of trees damaged to an economically significant level (leaders eaten leading to malformed stems producing split trunks) in some forests (Lowe 1994, Coillte 1995, cited in Hurley 1996, Hayden 1997). In order to protect forests from deer damage, it will be necessary to keep population densities at or below a level where damage levels are acceptable to forest managers. This study has shown that given current damage levels, density of deer and deer reproductive potential, an increase in the deer harvest in the Co Wicklow region is required.

Management recommendations

As described above, the densities of sika-like deer in some parts of the Wicklow area are currently at the highest levels recorded for sika deer. The reproductive output of hinds is presently apparently unaffected by these high densities, but this may occur in the future. It is recommended that the reproduction of hinds be continuously monitored to assess any future changes that occur. If densities increase, the proportions of hinds that become pregnant and/or successfully rear offspring may decrease, while contrastingly, if deer numbers are reduced, reproductive output might further increase.

It was unexpected that calves in this population would be fertile. In a study of sika deer in Killarney, while the majority of yearlings became pregnant, just one calf did

Table 3: Total number of male and female red, sika and red/sika hybrids harvested in Co Wicklow from 1995 to 2002 (data provided by Dúchas).

<i>Year</i>	<i>Male</i>	<i>Female</i>
1995	1,257	1,164
1996	1,374	1,430
1997	1,106	665
1998	1,312	1,315
1999	1,565	1,694
2000	1,940	2,109
2001	2,284	2,522
2002	2,252	2,583

so. It is probable that many stalkers in the present study did not check whether calves were pregnant because of an assumption that it was unnecessary given its improbability. Lessees and stalkers using a forest should be made aware of the need to assess all females for pregnancy, regardless of age. Foetuses in calves may be very small and difficult to see, even during January and February. However, if pregnancy in this age group is not accurately assessed, it may lead to large errors in calculating the potential rate of increase and thus the appropriate target harvest level during the hunting season. Stalkers should be encouraged to check every uterus, or, if unwilling and pregnancy is not obvious, then the uterus should be collected and passed on to professionals for examination. Similarly, stalkers should be encouraged to open uteri to check for twin foetuses, so that a more accurate twinning rate may be ascertained. It is possible that twinning may be more common than presently thought, further increasing the potential rate of increase of the population.

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