SECTION VI

RELEASE OF CAPTIVE-BRED SPECIES: DEER

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INTRODUCTION

There are 7 species of deer in Britain (Table 1) but only red (*Cervus elaphus*) and roe (*Capreolus capreolus*) deer are indigenous. Fallow (*Dama dama*) deer were deliberately introduced both into parks and into the wild probably during Roman times. Populations of Muntjac (*Muntiacus* spp.) and Chinese Water (*Hydropotes inermis*) deer are derived from escapes, largely from Woburn Park. Sika (*Cervus nippon*) deer populations also arise from escapes from deer parks with some deliberate introductions. Reindeer (*Rangifer tarandus*) became extinct in Britain by the 12th century (Ritchie 1920). Several attempts have been made in the past to reintroduce them but, until the most recent in 1952, all failed (Whitehead 1964). This last introduction is of interest in the context of this report, since it suggests that survival was related to different genotypes. Scandanavian reindeer are thought to be of two types related to the habitats they occupy - forest and mountain (open plain). In 1952, 8 animals of the 'mountain type' were introduced into an area of the Cairngorm mountains with subsequent releases of the 'forest type'. Only the forest type were successful. This is interesting in that the original Reindeer in Britain were forest-dwelling animals. Despite the re-introduction being on to open hill ground, the forest type still fared better.

There has been a long tradition of deliberately releasing captive-bred deer into the wild. In addition to this, there are numerous instances of accidental escapes from deer parks and, in recent years, from deer farms.

Deer are usually released into wild populations for sporting purposes (stalking and hunting). This is done for:

(1) topping-up existing stocks

(2) increasing variability, or

(3) introducing specific characters such as antler size and shape, body conformation and size.

The commonest reason is (3), and involves males more than females.

Deer have been bred in deer parks for centuries. Towards the end of the last Century there were estimated to be 390 parks holding fallow deer in England alone (Whitaker 1892). Numbers were estimated to be 140 in 1950 (Whitehead 1950) and currently between 200 - 300 (Cantor 1989). Many parks hold more than one species.

Since 1970 there has been a proliferation of deer farms, which now number over 100; these hold mainly red or fallow deer.

IMPLICATIONS

The ecological effects of releasing captive-bred individuals can be:

(1) to weaken the fitness of the native stock

(2) to improve it through greater genetic diversity

(3) competition or hybridization with related species

(4) spread of disease into the wild stocks

(5) detrimental effects on habitats and other wildlife.

Aspects of (1) - (3) above are discussed under the species in question. Case studies are given where relevant. Concern for (4) is current with bovine tuberculosis being found in deer in parks or farms. In one instance, this was due to importing a red deer stag from eastern Europe. However, there is little background information on the natural occurrence of diseases in free-ranging deer. Nevertheless, it is generaly felt that wild deer are more at risk from disease from captive stock than vice-versa.

Although in-breeding depression has been seen in some deer parks (Pemberton & Smith 1989), in other species, in-breeding has not been a problem. The classic example is of Pere David's Deer or mi-lou (*Elaphurus davidianus*). Only discovered in 1866, and extinct in the wild, the current population is derived from 18 of specimens collected from the one park population; the present population shows very little genetic variability (Fig. 1).

It is only relatively recently that genetic sub-divisions between and within populations has been recognised (eg Smith *et al.* 1984, Marlowe *et al.* 1976, Smith & Aitken in press). Nevertheless, although associations between allele frequency and some performance parameters are found, no studies have yet shown how shifts in gene frequency has substantially altered the deers' ecology.

SPECIES

Roe deer (*Capreolus capreolus*)

Roe deer were extinct throughout most of Britain by the beginning of the 18th Century, except in remnant woodlands in the central and north western

Highlands of Scotland (Staines & Ratcliffe 1987). Deliberate introductions were made into various areas apart from the natural colonization within and out of Scotland. The introductions were often of unknown origin (Lowe 1979), although roe from Germany were introduced into East Anglia in 1884 (Chapman *et al.* 1985); those in the Lake District are thought to be of Austrian origin (Lowe 1979). Whether Scottish animals were also introduced is not known.

With the increase in commercial forestry since 1920, roe have proliferated and extended their range. The Lake District and Scottish populations are now contiguous and the Southern England and East Anglian ones are close to joining (if they haven't already done so) (Arnold 1984; Staines & Ratcliffe 1987).

In addition, Siberian roe deer (*C. capreolus pygargus*) were introduced into many areas or have escaped from parks such as Woburn, Bedfordshire (Whitehead 1964); they are known to hybridise with *c.c. capreolus* (Flerov 1952). Siberian roe were introduced into Czechoslovakia and hybridised with the native stock. "When a Siberian female is mated with a native male, the offspring are abnormally tall, with thick antlers, a trait which is still seen in the Czechoslovakian population" (Ebenhard 1988).

To my knowledge the genetics base of roe deer in Britain has not been systematically studied. However, clearly animals from the different sources have proved successful in colonizing Britain. It would be worthwhile to study the current genetic status of the various stocks in order to determine whether the ancestral genotypes still exist or whether they have

been swamped by the native population. This may in part be covered by a new research project initiated by the Forestry Commission relating population genetics to performance. In addition, dispersal in roe deer is by both sexes whereas in other species, such as red deer, the dispersing sex is the male. Clearly mating systems (polygamy in red deer, territorial system and one male mating one to three females only in roe) together with differences in sex-dispersal will greatly affect the spread of new genes into the population.

Fallow deer (*Dama dama*)

Feral. Widespread and abundant throughout England and Wales; localised in Scotland. The main source of introductions into the feral populations are from escapes from deer parks.

Parks have different traditions in stock manipulation but there are three common features relevant to genetics (Pemberton & Smith 1989):

(1) it is a single, enclosed unit,

(2) it is culled each autumn/winter to a desired size, removing a disproportionate number of young males,

(3) mating is uncontrolled.

Fallow have less variation than red deer (Fig. 1) (Pemberton & Smith 1985). The different herds may be managed for different traits. The commonest is for colour, which ranges from white to almost black, but with recognisable types. Colour is genetically controlled and is predictable from a knowledge of

parental colour types (Smith 1980, Pemberton & Smith 1989). In the wild, populations of mixed colours are common, whereas in some localities one colour predominates. Epping Forest deer were originally all of the black variety; a common-coloured fallow was seen in 1953 and by 1964 only 80% of the herd were of the original black type. Earlier this Century New Forest fallow were all of the same (dun) variety; now this herd is of mixed colours (Chapman & Chapman 1975). No other trait (eg body size) has been related to the different colour types. A new long-haired variety has been discovered at Mortimer Forest, near Ludlow (Springthorpe 1980).

Red deer (*Cervus elaphus*)

Probably the most widely studied species with considerable genetic variation (Fig. 1). The question of species status for Eurasian and North American *Cervus* has been the subject of much debate in recent years. On the basis of reproductive compatability when brought together, resulting in fertile offspring, *C. elaphus* can be regarded as a super species or a "holarctic cline" (Caughley 1971). Guthrie (1966) noted that *C. elaphus* exhibited little speciation during the late Pleistocene and this lack of speciation "has resulted in a circumpolar group that exhibits marked interpopulational variations but no major morphological discontinuities" (Bryant & Maser 1982).

Dratch (1983) made an isoenzyme study of European red deer and N. American elk and concluded that both should be regarded as a single species though not necessarily a panmictic population (see also Bryant & Maser 1982; Dratch & Gyllenston 1985).

Some traits are known to be inherited, in particular the antlers (Harmel 1983, Templeton 1983). Although antler size is generally limited by food supply, ultimate size, and shape, are genetically determined. Ahlèn (1965) quotes an example of a German stag with wide antlers being introduced into a Danish deer park (the deer there had narrow antlers). The German stag dominated the matings for a few years, and the predominant antler shape now is the wide (introduced type). It has been suggested at least for White-tailed (*Odocoileus virginianus*) deer that releasing into wild populations can "improve herd quality" (Hillestrad, 1970).

Variation in British red deer

It has been common practice to introduce red deer from deer parks into wild populations in Scotland to "improve the blood stock" (Mitchell *et al.* 1977). In addition, wapiti have also been released directly into the wild (Whitehead 1964, own data). A complicating factor is that the herds in the parks are of mixed origin (Lowe & Gardiner 1974) with many wapiti features in some (such as at the famous Woburn and Warnham Court Deer Parks, Pemberton & Smith 1989).

Lowe and Gardiner (1974) used multivariate methods on craniological measurements to examine the relationships between different red deer populations. They concluded that there were marked discontinuities between the wild deer of Scotland, Ireland and north-west England with feral red deer that had escaped or had been released from parks elsewhere in England. Despite introductions into Scottish forests they also concluded that natural selection favoured the native genes. However, this view is not universally held, anecdotal evidence suggesting wapiti-like features in some populations (eg

antler shape, Darling *pers commun*). Dratch (1983) used electrophoresis to study different populations of red deer. Two populations from Galloway and one from the Island of Rhum were very closely related. He suggested that this was due to all populations being derived from 19th Century introductions, including park deer (Fig. 2); therefore some of the traits would be from the introduced stock. Similarly, he showed marked similarities between the Norwegian and Caithness stocks. Langvaten (*pers commun.*) believes that the indigenous Norwegian deer were swamped by the importation of Scottish deer by the Vikings (ie the Orkneyinga saga, where red deer in Caithness were hunted by the Norsemen). However, Lowe & Gardiner (1974) could not detect such similarities using craniological information. Clearly there are major differences in interpretation using biochemical and morphological data that need to be resolved. Possibly phenotypic effects due to the environment mask differences in some growth features (Batchelor & McLennan 1977). In addition, Gyllensten *et al.* (1983) found an allele unique to Scottish red deer in an enclosed Swedish population where imports of Scottish deer were known to have taken place.

In White-tailed deer the introduction of individuals into an existing herd resulted in a change in gene frequencies (Smith *pers commun.*) but with no known effects on the ecology of the deer.

It is not clear if the introduction of captive bred red deer influences the genetic make up of the native stock. Mostly males are introduced, and are usually much larger than the native males. Although data are not available,

such males would likely only survive a short while because the impoverished nature of Scottish hill land could not support them (unless artifically fed). Native stags are smaller because they are adapted to the local conditions. However, in a polygamous species like red deer one male could theoretically mate with several hinds each year, and if he could survive, pass on his genes to many offspring. However, ∮Clutton Brock *et al.* (1982) have shown that, on Rhum, individual stags may only sire up to 25 progeny that reach breeding age.

Red deer x wapiti crosses Hybrids between red deer and wapiti in captivity is well documented (Flerov, 1952; Bryant & Maser 1982). Mention has already been made of the likelihood of red x wapiti crosses in deer parks later being released into the wild. The best known cases of hybridization occur in New Zealand (Caughley 1971; Batcheler & McLennen 1977). Wapiti were introduced into Fiordland in 1905 and red deer dispersed there by 1940. Within a decade hybrids were reported. Batcheler and McLennan's sample indicated 8% red deer, 52% hybrids and 40% wapiti. The hybrid group is essentially bimodal with "red-like" and "wapiti-like" types. They argue that differences in the ecology of the two species result in "one-way hybridization" ie a few mature males dominate in mating. Wapiti bulls are socially dominant to red deer stags (who are much smaller also) and possibly rut earlier. They therefore mate with red, hybrid and wapiti females, then absorbing most of the red deer into a hybrid gene pool.

However, in Fiordland, wapiti were smaller than their North American counterparts, whereas red deer were noticeably larger than in other parts of their NZ range. Hence the size differential between wapiti males and red

females is less than would occur, for example, if a mature wapiti bull were mated with a wild Scottish red deer hind. It is possible this latter mating could result in the death of the small hind as happens when red deer stags mate with the smaller sika hinds (Harrington 1973).

Red deer x sika crosses First documented in the late 19th Century (Powerscourt 1884) soon after their introduction. The status and separation of the 7 - 13 sub-species is still uncertain (Ratcliffe 1987) (Table 2). Current evidence suggests a two-way split into Japanese island deer (*C.n. nippon*) and mainland Asiatic (Manchurian) and Formosan forms (*C.n. hortulorum*). Most British populations are thought to be of Japanese stock (Lowe & Gardiner 1975) but many populations are of unknown origin. Only two wild populations came direct from Japan, others being derived from parks (Fig. 3). In parks hybridization could already have occurred with other forms of sika or with red deer, so their 'true' origins are unknown (Ratcliffe 1987). In fact, Lowe and Gardiner (1975) think that only Sika from the Japanese islands were *C. nippon* and that Manchurian and other mainland forms are "hybrids of great antiquity" possibly between Chinese wapiti (*C.e. xanthogyqus*) and Japanese sika (*C.n. nippon*).

Introgression is thought to be complete in the south Lake District (Lowe & Gardiner 1975), Wicklow (Harrington 1973, 1982) and Czechoslovakia (Bartos & Zirovnicky 1981 a, b; *pers commun.*).

Experiments by Harrington (op cit) investigated the controlled crosses of red deer and Japanese sika, although his sika stock came from Killarney which had

been stocked from Powerscourt Park ie so it cannot be definately stated that the deer were not of hybrid origin (Ratcliffe 1987). Various suggestions have been made as to how hybridization occurs:

(a) Lowe & Gardiner (1975) suggest that pure Japanese do not hybridize with red deer in the wild, but only the mainland sika forms, (themselves possibly hybrids, see above). The mainland forms are larger than the Japanese and so closer to the red deer in size. However Japanese x red crosses are now known in the wild (Ratcliffe 1987).

(b) Harrington's (op cit) experiments suggested that juvenile red deer stags mate with Japanese hinds.

(c) Powerscourt (1884) reported that the female was always a red deer, whereas Whitehead (1950) quotes only male red x Manchurian female crosses at Woburn Park.

(d) Lowe and Gardiner (1975) thought also that red deer involved in hybridization were of park origin, their mixed genetic background making hybridization more likely. But hybrids occur in Scotland with apparent native stock.

(e) All putative hybrids in Scotland occur where red deer are invading predominantly sika areas or sika invading red-only areas (Ratcliffe 1987). Since the colonizing animals are invariably males it seems likely young (red) or older (sika) males are the main source of initial hybridization - mature red deer stags will kill a sika hind if mated, due to its large size (Harrington 1973). Once hybrids are present in the population, hybridization proceeds rapidly.

A case should be made for preserving native red deer stocks, perhaps on islands, where sika cannot colonise.

SUMMARY

1. Release of captive-bred deer into the wild has been widely practiced for
    centuries, usually for sporting purposes.

2. Little follow-up information is available on the success or otherwise
    of such introductions.

3. Local populations of roe deer could well be from different origins and is
    worthy of study.

4. More is known on the variability in red deer, but little of the
    ecological consequences.

5. Hybridization between red and sika deer and with wapiti are common.

6. Introgression between red and sika is complete in many areas. There is
    no evidence of hybrids reverting to a 'wild type'. With wapiti in New
    Zealand, F_1, F_2 and F_3 generations were "red-like" or "wapiti-like".

7. Ecological factors can affect the way hybridization comes about:

    (a) Colonizing young males of red deer being able to mate with
         sika hinds

    (b) Colonising sika stags mating with young red hinds

    (c) Social dominance and possibly earlier breeding season
         enables wapiti bulls to prevent red deer stags mating
         leading to a pure wapiti or hybrid-dominated population.

8. There is a need for intensive research into the extent of hybridization
    between red and sika deer in Britain. Sanctuary areas for red deer
    should be considered as advocated by Ratcliffe (1987).

9. Evidence is equivocal on whether native genes dominate after introductions due to natural selection or whether vigour is increased (as in hybrids).

10. Research into gene flow due to different mating systems and dispersal patterns are suggested.

Table 1. Deer in Britain

Red	(*Cervus elaphus*),	native
Roe	(*Capreolus capreolus*),	native
Fallow	(*Dama dama*),	introduced, probably Roman
Reindeer	(*Rangifer tarandus*),	introduced Scotland 1952
Chinese Water deer	(*Hydropotes inermis*),	escaped, 19th Century
Muntjac	(*Muntiacus* spp.),	escaped, Reeve's and Indian sub-species, 19th Century
Sika	(*Cervus nippon*),	escaped and introduced, probably Japanese and Manchurian sub-species, 19th Century

Table 2. Taxonomy of Sika deer. From Ratcliffe 1987.

| Origin	Ellerman & Morrison-Scott (1951)	Whitehead (1972)	Suggested split
Manchuria	*Cervus nippon hortulorum* Swinhoe (1864)	*C.n. hortulorum*	
Manchuria & Korea		*Cn.n. mantchuricus* Swinhoe (1864)	
N China	*C.n. mandarinus* Milne–Edwards (1871)	*C.n. mandarinus*	*C.n. hortulorum*
Shansi, China	*C.n. grassianus* Heude (1884)	*C.n. grassianus*	
SE China	*C.n. kopschi* Swinhoe (1873)	*C.n. kopschi*	
Formosa (Taiwan)	*C.n. taiouanus* Blyth (1860)	*C.n. taiouanus*	
Vietnam		*C.n. pseudaxis* Eydoux & Souleyet (1841)	
Hokkaido, Japan		*C.n. yesoensis* Hevoe (1884)	
Hondo, Japan		*C.n. centralis* Kishida (1936)	
Kyushu, Japan	*C.n. nippon* Temminck (1838)	*C.n. nippon*	*C.n. nippon*
Mageshima, Japan		*C.n. mageschimae* Kuroda & Okada (1951)	
Yakushima, Japan		*C.n. yakushimae* Kuroda & Okada (1951)	
Kyukyu, Japan	*C.n. keramae* Kuroda (1924)	*C.n. keramae*	
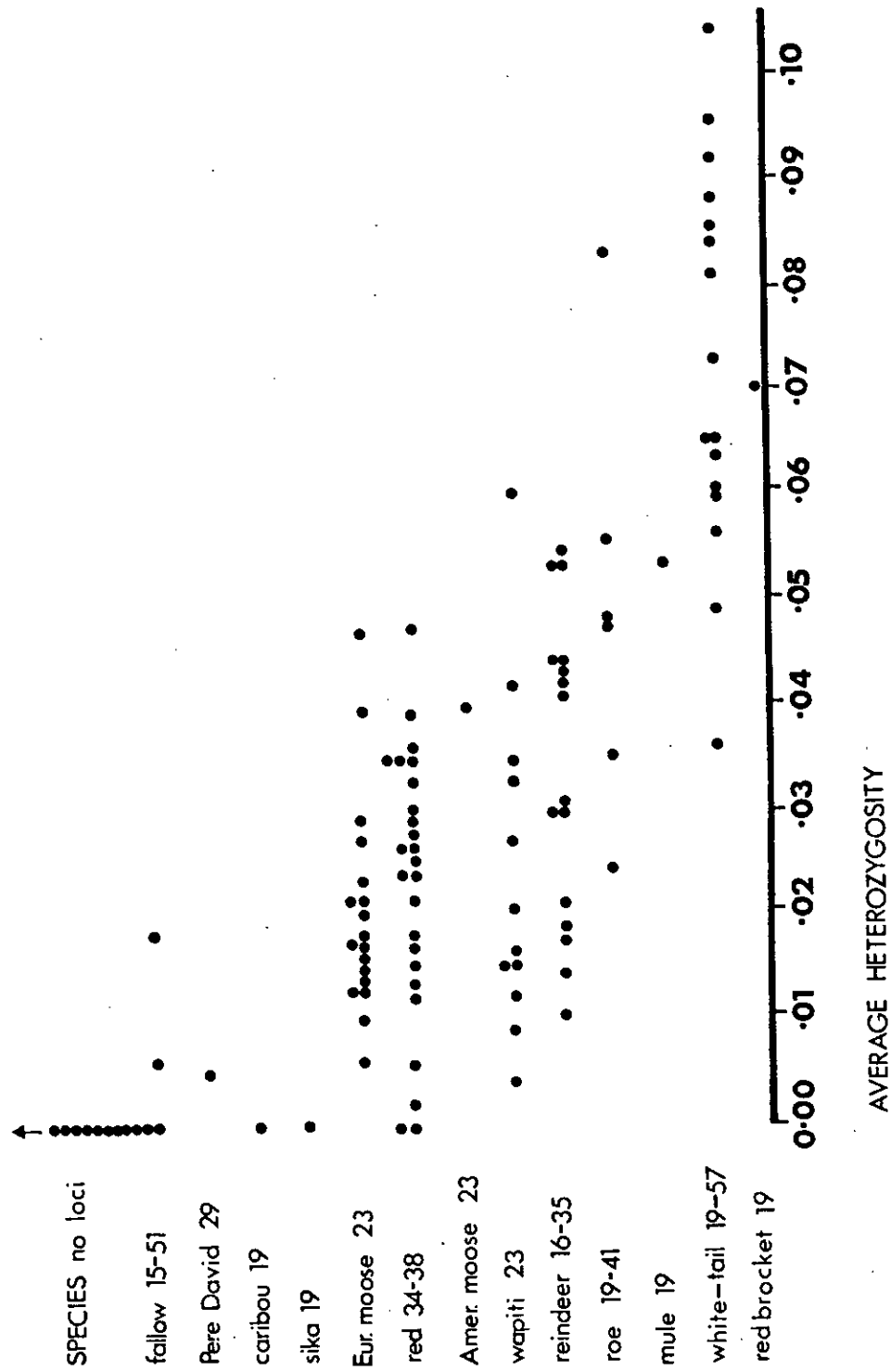
Fig. 1. Levels of genetic variation in deer as revealed by electrophoresis. From Pemberton & Smith, 1989.
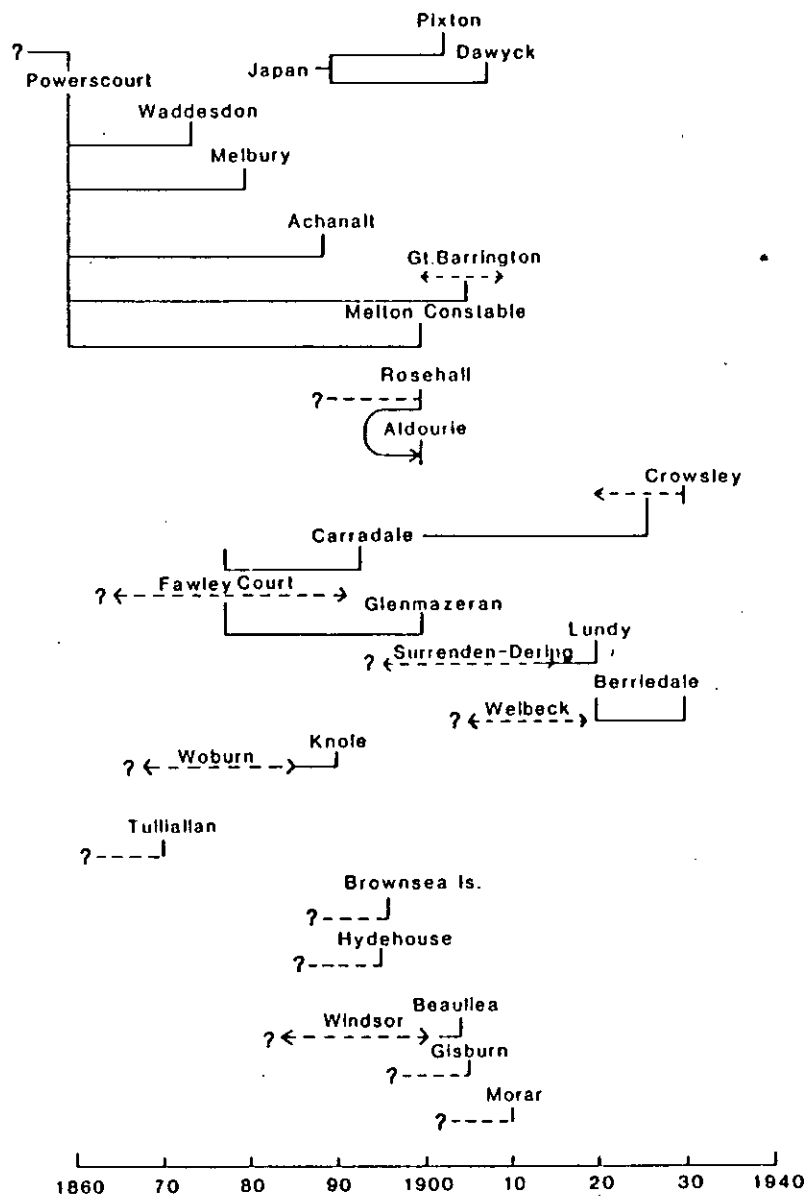
Fig. 3. Origins of major feral populations and known translocations of Sika Deer in Britain. From Ratcliffe 1987.
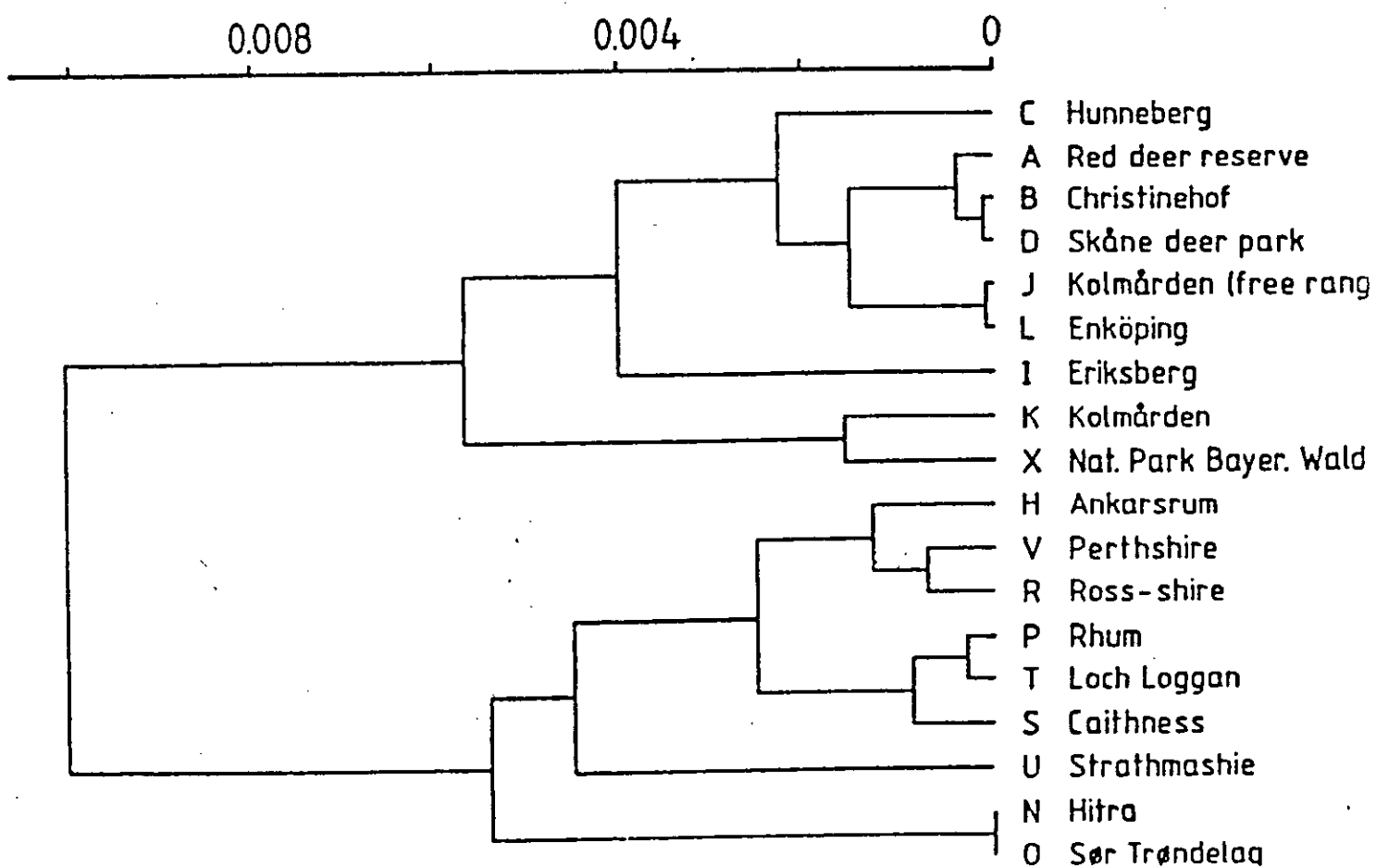
Fig. 2. Dendrogram of genetic distance of northern European red deer. Letters
denote collection sites. From Dratch, 1983