Exotic diseases of deer

Deer farming is an important and developing industry in New Zealand. In 1988 there were 606,042 farmed deer in 4,625 herds.

The New Zealand deer population is free of many of the important diseases which affect farmed deer in other countries. However, the expansion of the New Zealand deer herd requires the importation of new bloodlines, and attendant on such importation is the risk of exotic disease.

Dr Colin Mackintosh, a well-known New Zealand researcher into problems of deer, has prepared an extensive review on the exotic diseases of deer. The review appeared initially in the Proceedings of a Deer Course for Veterinarians (No. 5, July 1988), *and has been edited, with the author's permission, for republication in* Surveillance.

Opinions expressed on importation requirements are Dr Mackintosh's own and may not necessarily reflect current MAF policy.

Exotic diseases of deer have been of considerable interest in the last 8 years when deer have been imported into New Zealand from the northern hemisphere, either to infuse new genetic material for existing species (wapiti, European red deer) or to introduce species (eg, Pere David's, Mesopotamian fallow). The following is a review of the exotic diseases known to affect deer, and diseases which may be present in New Zealand but for which exotic strains may occur overseas.

Viral diseases

Aujeszky's disease is caused by a herpes virus which produces nervous signs and mortality in young pigs and abortion in sows. Persistently infected pigs are the major disseminators of virus. The clinical syndrome in cattle, sheep and other species is called pseudorabies or "mad itch" because pruritis is the most prominent feature. Pseudorabies is apparently not transmitted between ruminants[12] and therefore deer are not likely to be important carriers of this virus.

Bluetongue (BT) and **Epizootic haemorrhagic disease** (EHD) are closely related arthropod-borne diseases. BT primarily affects sheep causing fever, hyperaemia, frothing at the mouth and nasal discharge. There is a marked loss of condition and animals may die. Cattle and deer are usually subclinically infected and may act as important reservoirs of BT virus.[19] EHD affects white-tailed and pronghorn antelope severely, while infection in mule deer, elk and moose is usually subclinical. The geographical distribution of BT is worldwide, whereas EHD is confined to parts of USA, western Canada and Nigeria.[13]

Epizootics generally occur in late summer and early autumn. Both diseases are transmitted by *Culicoides* midges which are not present in New Zealand. Nevertheless, imported deer should be seronegative for BT and EHD.

Bovine herpes virus-1 (BHV-1)/IBR and **Cervine herpes virus-1** (HVC-1). Serological titres to BHV-1 (IBR) have been found in reindeer in North America[6] and Scandinavia[7] and red deer in the United Kingdom.[26] Subsequently, a herpes virus which differed serologically from BHV-1 has been isolated in the United Kingdom from deer with ocular and upper respiratory disease.[32] Ronsholt and colleagues[34] isolated from British red deer a herpes virus which had characteristics in common with BHV-1 but which was distinguished by its host specificity, serological reaction and genomic restriction fragment pattern. It was tentatively designated HVC-1.

Colin Mackintosh, author of this article on exotic diseases of deer.

HVC-1 infections in young deer are relatively mild and resolve spontaneously with little consequence. If the disease is not present in New Zealand already then it would be preferable to avoid its introduction. Imported animals should be seronegative for BHV-1 and HVC-1 even though there is a small risk of importing latently infected seronegative deer. A period of quarantine will help to reduce this risk because the stresses of importation may cause the expression of a latent infection.

Foot and mouth disease (FMD) has a worldwide distribution and, although all species of deer appear to be susceptible to infection, few develop serious clinical disease.[11] Experimental infection studies[10] suggested that pharyngeal virus was rarely recovered from red and roe deer beyond 14 days after exposure, whereas all fallow deer carried virus in the pharynx for a minimum of 5 weeks. These results suggested that FMD could be transmitted by close contact between deer and domestic animals. Wild deer are considered unlikely to be important in the maintenance and transmission in an epidemic of FMD in domestic livestock.

To safeguard our livestock stringent controls must be used to prevent FMD infected deer entering New Zealand. Currently, all live deer from European countries where FMD exists must first go through 6 months' residency and testing in the United Kingdom prior to 1 month's quarantine before shipment to New Zealand. This should be adequate safeguard. FMD is not currently present in USA or Canada.

Rabies has a worldwide distribution and is endemic in wildlife in parts of Europe, Asia, Africa and North and South America. Sporadic cases occur in deer but they are regarded as dead-end hosts.[28] Nevertheless, New Zealand should avoid importing rabies infected deer. Deer should only come from areas certified free of rabies or they should be quarantined for 6 months.

Rinderpest is a highly infectious disease characterised in cattle by fever, necrotic stomatitis, gastroenteritis, lymphoid necrosis and high mortality. It also causes severe disease in most species of deer. Transmission is by direct contact. Rinderpest is present in parts of Africa and Asia but Europe, except for Turkey, has been free since 1930. North and South America are also free. Deer should be imported only from countries free of rinderpest or should be quarantined and tested appropriately prior to importation.

Skin papillomas and **fibromas** have been reported in most species of deer in North America, United Kingdom and Europe. Deer fibromas are usually firm, round nodular skin tumours up to 1 cm in diameter although some are up to 25 cm diameter. They are usually brown or black with a smooth or wrinkled surface. Most fibromas are found around the eyes, mouth, neck and medial aspect of the forelegs. They have a viral aetiology but the mode of transmission is unknown.[38] Clinically these fibromas appear to be unimportant but they may lead to a reduction in hide value. Only deer free of fibromas should be imported.

Vesicular stomatitis virus (New Jersey strain, VSVNJ) is endemic in parts of North America and the antibody prevalence is high amongst wildlife including deer, feral swine and racoon. Sudden outbreaks, seasonal occurrence, and movements of VSNJ outbreaks in North American livestock suggest an anthropod spread of the virus. The disease in cattle, swine, horses and deer is characterised by fever, large vesicles in the mouth and on the nose, lips, muzzle, coronary band and teats, salivation, anorexia and depression. The vesicles break, leaving raw erosions which heal in a few days. The disease is a zoonosis and causes influenza-like symptoms.[35] It is not known if a suitable anthropod vector is present in New Zealand.

To prevent its introduction into New Zealand deer should not be imported from areas where vesicular stomatitis

occurs. Serological testing and quarantining of deer from affected areas could be contemplated.

Louping ill is an arbovirus causing an often fatal encephalitis in sheep and causing occasional natural disease in horses, humans, pigs and cattle. It is transmitted by the tick *Ixodes ricinus*. It is found only in the United Kingdom and has been isolated from a roe deer. There is serological evidence of infection in red, roe and sika deer.[35] Experimental infections in red and roe deer suggest that these species are unlikely to have a significant role in the ecology of louping-ill virus because the titres of virus in the blood were too low to infect the tick vector.[31] It is unlikely that a suitable anthropod vector is present in New Zealand. However, imported deer should be seronegative and have no clinical evidence of disease.

Spongiform encephalopathy (chronic wasting disease) is listed under "virus diseases" although the aetiologic agent has not been characterised. It has occurred in parts of North America in mule, black-tailed, mule X white-tailed hybrid deer and wapiti. The lesions in the CNS are qualitatively comparable to other spongiform encephalopathies of animals (scrapie, transmissible mink encephalopathy) and humans (Kuru, Creutzfeld-Jakob disease)[41] and are very similar to those of bovine spongiform encephalopathy which occurs in the United Kingdom and is thought to be caused by the scrapie agent. [See *Surveillance 16 (1)*:11-13 and *16 (3)*:25-26.] The clinical course of the disease lasts 1 to 6 months and is characterised by nervousness, hyperexcitability, changes in behaviour toward handlers, and progressive weight loss leading to emaciation.

Deer should not be imported from areas or herds where chronic wasting disease or bovine spongiform encephalopathy have occurred. There is no test available which is capable of diagnosing these infections in the preclinical phase.

Rickettsial diseases

Rocky Mountain spotted fever is a tick-borne infection of wildlife in North America which causes acute severe disease in humans characterised by fever and a macular rash on wrists and ankles and influenza-like symptoms. Serological evidence of infection has been found in white-tailed deer. *Dermacentor, Amblyomma, Rhipicephalus, Haemaphysalis, Otobius* and *Ixodes* spp are either known or presumed to be vectors.

It is possible that the New Zealand tick *Haemaphysalis longicornis* could act as a vector if infection were introduced.

Deer should not be imported from areas where this disease occurs.

Q fever is caused by *Coxiella burnetii* and infections are present in a wide range of wildlife and domesticated animals in most parts of the world. It is transmitted by close direct contact and a wide range of insect vectors. Infections in deer have been demonstrated in Europe and North America[1] but infections in animals are usually mild and often inapparent. The disease in humans is characterised by fever, influenza-like symptoms and pneumonia. Cases are usually mild and fatalities rare although intractable endocarditis can result. Tetracycline antibiotics and chloramphenicol are used to treat human cases.

Currently deer are tested by complement fixation test for Q fever on entry to quarantine in Canada and the United Kingdom. However, the test is not particularly sensitive and therefore treatment with a tetracycline should be considered.

Tick-borne fever (TBF) (Ehrlichiosis, pasture fever) is caused by *Ehrlichia* spp (and related organisms) which commonly affect dogs, horses, cattle, sheep, deer and other wildlife in United Kingdom, Europe, Africa and Asia. Infection is transmitted by ticks (*Ixodes, Hyalomma,* and *Rhipicephalus* spp). Infections in animals are usually subclinical or mild, with tetracyclines speeding recovery.[1]

Imported deer should have blood smears examined using Giemsa stain and/or fluorescent antibody. Treatment with one of the tetracyclines should be considered at the end of quarantine.

Bacterial diseases

Anthrax *(Bacillus anthracis)* is an infectious, febrile disease characterised by sudden onset and rapidly fatal course, exudation of tarry blood from body orifices, enlargement of the spleen and gelatinous infiltrations of the subcutaneous and subserous tissues. It has a universal geographical distribution. In Europe it still causes deaths in wild animals including red, fallow and roe deer, moose, wild boar, badgers and hares.[4]

The incubation period is from hours to several days. Therefore a 4 week period of quarantine for imported stock should prevent the shipment of infected animals.

Brucellosis *(Brucella suis)* type 4 infections have been described in caribou, reindeer and moose in Alaska, Canada, northern Europe and USSR. They cause reproductive failure and affected animals often develop swollen lower limb joints. Experimental infections in cattle and sheep suggest that this agent may not represent a threat to domestic livestock.[39] If the importation of these deer species was contemplated then stringent testing would be required.

Brucella abortus infections are endemic in some North American elk and bison herds.[39,40] Infections in European and United Kingdom deer have been described but are probably rare.[42] All imported deer should be from herds free of clinical brucellosis and be negative to individual tests.

Lyme Disease is caused by a spirochaete, *Borrelia burgdorferi* and is transmitted by ticks (*Ixodes* spp). Infection is carried by a variety of wildlife including deer. In America, Europe and the United Kingdom small mammals and passerine birds are the principal reservoirs of infection, and deer may serve as amplification hosts, allowing tick numbers to increase and become more widespread.[29] Human cases are associated with a history of tick bite and recreational activities in wooded or forested areas, or contact with dogs carrying ticks. The human disease is characterised by initial rash, fever, chills, headache and backache. The disease progresses to a second phase of worse headaches, inability to concentrate and sometimes facial nerve paralysis and/or severe meningitis. A third stage may develop with the onset of arthritis anything up to 2 years after the bite.[27] There has been a recent dramatic rise in cases in the USA. Lyme disease is now the most frequently diagnosed tick transmitted illness in the USA. The disease is found in the United Kingdom, throughout Europe and it has been recorded in USSR, Australia, Japan, China and Africa. Because its symptoms are severe the disease has elicited much interest over the 12 years since it was first described.[27]

Ixodes spp do not infest livestock in New Zealand, but species infesting birds are common. Measures should be taken to avoid importing deer infected with *Borrelia burgdorferi*. All deer for importation should have blood smears examined by direct immunoflourescence.[25] It appears that broad spectrum antibiotics, including the tetracyclines, control the infection and therefore consideration should be given to treating all imported deer.

Tularaemia is caused by *Francisella tularensis*. It is primarily a plague-like disease of wild lagomorphs and rodents. It is transmitted by a wide variety of ectoparasites, by direct contact with infected animals and contact with environmental contamination. The disease occurs in Europe and Asia and serological evidence of infection has been demonstrated in mule and white-tailed deer in North America. It has not been demonstrated in United Kingdom or Australia. A human case of tularaemia was associated with dressing a mule deer carcass in USA.[8]

Tularaemia in humans is characterised by sudden onset of chills and fever, swollen lymph nodes and lung involvement. Infection responds to streptomycin and one of the tetracyclines.

All imported deer from infected countries should be tested (agglutination test) and treated with a tetracycline.

Campylobacter hyointestinalis infection has been reported once in Moluccan rusa deer on two farms in south-east Queensland. Signs of disease included ileitis and persistent diarrhoea with chronic wasting. The significance of this disease is not known. Only clinically healthy deer should be imported.

Protozoal diseases

Anaplasmosis *(Anaplasma marginale)* is widely distributed in ruminants in most parts of Africa, southern Europe, USSR, Asia, the Middle East, Australia, North and South America. Infections in black-tailed, mule and white-tailed deer have

been described in North America[15] and infections in red deer occur in Australia.[3] Experimental infection has been reported in rusa deer.[30]

Natural transmission is by various biting insects, including flies, mosquitoes and a wide range of ticks, especially *Dermacentor, Boophilus* and *Haemaphysalis* spp, although *Haemaphysalis longicornis*, present in New Zealand, is believed incapable of transmitting anaplasmosis.[3] Hypodermic needles contaminated recently with blood may transmit infection.

Infected deer do not usually show signs of disease, unlike cattle which usually develop anaemia and up to 50% mortality. Diagnosis depends on the demonstration of *Anaplasma* bodies in the red blood cells in a smear, and various agglutination tests of varying sensitivity and specificity have been developed. Intravenous tetracycline antibiotics in combination with dithiosemicarbazone given twice at 24 or 48 hour intervals have been shown to eliminate *A. marginale* from splenectomised calves.

Babesiosis (*Babesia* spp) has been recorded in red deer in Austria[15] and there is serological evidence of infection in Scottish red deer.[2] *B. bovis* which occurs in southern Europe, Middle East and Asia, has been reported in roe and red deer. Enigh and Friedhoff[9] transmitted *B. divergens* to splenectomised red, fallow and roe deer. They considered that wild deer may serve as natural reservoirs for *B. divergens* which occurs in northern Europe. The same researchers also discovered a new species, *B. capreoli* of roe deer, which was apparently not transmissible to sheep or cattle. *B. bigeminia*, which may be infective for white-tailed deer, is found in Central and South America, Africa, Australia and southern Europe.

The vectors for *Babesia* spp include *Ixodes, Boophilus, Rhipicephalus* and *Haemaphysalis* spp.

Babesiosis in deer is usually subclinical, although acute fatal cases have been observed in roe deer and Pere David's deer.[12] However, deer may act as reservoirs of infection for cattle which may show severe haemoglobinuria, anaemia and emaciation and may die. *B. divergens* and *B. bovis* are less severe than *B. bigemina* in cattle.[37]

It is possible that the only tick in New Zealand, *Haemaphysalis longicornis*, is not suitable as a host for *Babesia*. Nevertheless, infected animals should not be imported.

All imported deer should have a number of blood smears examined for the presence of *Babesia* spp. A complement fixation test could also be used. Routine treatment of all deer may also be considered.

Theileriosis (*Theileria cervi*) is endemic in white-tailed deer in North America. It cannot be transmitted experimentally to sheep, cattle[37] or fallow deer.[23] *Theileria* spp have also been identified in fallow, red and roe deer in Austria[12] and probably occur in most European deer although the host specificity of these species is unknown. *Theileria* have been reported in rusa deer in New Guinea.[30] Infections appear to be subclinical, and are transmitted by ticks commonly affecting deer in Europe, but which are not present in New Zealand. It is probably unimportant.

Trypanosomiasis (*Trypanosoma spp*) has been reported in Polish red deer and moose[21], fallow, roe and red deer in Germany[14,21], and all species of cervids in North America.[22] The identities, host specificities and cycles of infection are not known for all these species. *T. evansi* occurs in the Middle East, Asia, South East Asia and Central and South America, and infects a wide range of hosts including deer causing the disease surra.[37] Transmission is by biting flies, with severe disease occurring in horses, camels, elephants and domestic livestock.

The *Trypanosoma* spp occurring in Europe appear to be relatively benign but efforts should be made to exclude infected animals from shipments to New Zealand until more is known about them. Effective treatment should be investigated. Deer should not be imported from areas where *T. evansi* occurs.

Eperythrozoonosis as a naturally occurring latent infection has been described in black-tailed, white-tailed, mule deer and elk in North America.[16] It is thought to be transmitted mechanically by anthropod vectors. Contaminated needles may transmit disease. Infections, generally subclinical, are probably unimportant. Suitable vectors are probably present in New Zealand (as transmission occurs with *E. ovis* in sheep).

Besnoitia are protozoa closely resemble *Sarcocystis* spp and utilise two hosts: a carnivorous host in which sexual reproduction occurs and an intermediate host prey in which asexual reproduction occurs. *B. tarandi* occurs in reindeer and caribou in Alaska and Canada and causes bones and tendons to become roughened.[5] This disease is probably of no importance to New Zealand unless reindeer or caribou are imported.

A new species of **coccidia** (*Eimeriidae*) occurring in epididymal semen in elk in Canada was described recently.[17] Its significance is not known. Semen imported into this country should be certified free of protozoa.

Endoparasites

There are a variety of exotic **nematodes** which infect deer in other countries. They include:

a) Nematodes in the family **Protostrongylidae** which involve either the lung or CNS and are found in Europe, Australia and North America.[37] Treatment for these parasites may be difficult because *Muellerius* and *Elaphostrongylus*, which are in this family and are present in New Zealand, are not very susceptible to anthelmintics such as benzimidazoles and ivermectin. Thus eliminating these nematodes from imported deer may be impossible and therefore all imported deer should be tested specifically for these species.

Elaphostrongylus cervi also occurs in red, fallow and roe deer in Europe and wapiti in North America. Although it occurs in New Zealand it would be sensible to ensure all imported deer are free of it. [A comprehensive review article on *Elaphostrongylus cervi* appeared in *Surveillance 16(1)*:3-10.]

b) Nematodes in the family **Filariidae**, whose larval forms are microfilariae, are transmitted by biting mosquitoes, fleas, flies. This group includes *Elaephora, Wehrdikmansia* and *Onchocerca* spp whose adult forms occupy blood vessels or subcutaneous sites.[37] They may result in damage to hides or blemishes to subcutaneous tissue on carcasses. There is often pruritis associated with the lesions. They are commonly found in deer throughout the world. Intermediate hosts are not always known. Treatment with ivermectin is probably effective, especially against the microfilaria, as it is used successfully for human onchocerciasis.

c) Nematodes in the **Trichostrongylidae** family including *Marshallegia, Nematodirus* and *Haemonchus* spp have been reported in wapiti, red and fallow deer in Europe and North America.[37]

d) *Setaria* spp occur in the peritoneal cavity of deer in Europe, USSR and North America. No clinical signs have been ascribed to infection with this parasite but fibrous lesions in the abdominal cavity are often seen post mortem. Erratic migrations involving occlusion of the oviduct in a cow have been reported.[37] The significance of infection and effective treatment should be investigated.

e) *Gongylonema* spp are present in deer and other animals in Asia and North America. The adults inhabit the wall of the oesophagus or rumen but the significance and effective treatment are not known.

There are a number of exotic **trematodes** found in deer overseas. *Fascioloides magna* is present at high endemic levels in North America and Europe and has a life-cycle similar to *Fasciola hepatica*. It has been reported in wapiti, red, white-tailed, black-tailed, fallow and sambar deer and moose.[37] It causes fibrous cysts in the liver. Bovidae may be unsuitable hosts for this parasite which fails to reach maturity. However, sheep, which are also unnatural hosts, may suffer severe liver lesions.

Fasciolicidal drugs are probably effective. In USA deer movements are controlled where they share grazing with domestic livestock.

It is important that this parasite is not introduced into New Zealand.

Dicrocoelium dendriticum occurs in the bile ducts of a variety of livestock and wildlife including deer in North America and Europe. The intermediate hosts are both snails and *Formica* ants. Benzimidazoles and/or other fasciolicidal drugs may be effective against this parasite.

Parafasciolopsis fasciolaemorpha is found

in the bile duct and small intestine of deer in eastern Europe and USSR. The intermediate host is *Planorbis corneus* found in swamps and the parasite is unlikely to be important in New Zealand. Fasciolicidal drugs are probably effective.

There are number of exotic **cestodes** of deer but most of them are probably of little significance with respect to deer imported into New Zealand.

Ectoparasites

New Zealand is fortunate not have many of the serious deer ectoparasites including warbles, nasal bots, keds, ticks (*Ixodes, Dermacentor, Otobius, Boophilus* spp), head flies, etc.

It is important that deer are treated thoroughly on a number of occasions with ectoparasiticides which are effective against all these ectoparasites.

A combination of ivermectin orally and topical application of coumaphos, administered during quarantine overseas and on at least two occasions 3 weeks apart in New Zealand quarantine, is probably sufficient.

Other disease agents

In addition to the diseases discussed above, there are a number of diseases present in New Zealand of which there are exotic strains which affect deer overseas. It is important that these strains are not introduced into New Zealand. They include some *Mycobacteria* and *Pasteurella*.

In the last 3 years there has been a serious outbreak of **Johne's disease** *(Mycobacterium paratuberculosis)* involving yearling red deer in Scotland. This appears to be a particularly virulent strain adapted to deer (H. Reid, pers. comm).

A number of cases of generalised **tuberculosis** attributed to *M. avium* (avian TB) have occurred in red deer in the United Kingdom (H. Reid, pers. comm). Such cases are rare in red deer in New Zealand and it is likely that these are different strains.

Epidemics of **haemorrhagic septicaemia** and sudden death associated with *Pasteurella multocida* serogroup B, somatic serotypes 3 and 4 have occurred in fallow deer herds in the United Kingdom.[20,33] Kummeneje[24] reported epidemics of *P. multocida* infection causing acute pneumonia in reindeer calves.

Deer should not be imported from herds which have suffered clinical disease associated with *M. paratuberculosis, M. avium* or *P. multocida*.

Embryos and semen

Recent advances in superovulation of deer, embryo recovery, semen collection, embryo and semen freezing, will make the importation of frozen deer embryos and semen a very practical alternative to live deer. Not only should it be cheaper and simpler but it will also reduce or eliminate many of the disease risks. It has been shown for cattle embryos that an intact zona pellucida surrounding the embryo is an effective barrier against a number of important disease organisms [See *Surveillance 15 (5)*: 10-11].

Appropriate washing procedures have been devised using enzymes and antisera to remove certain viruses from bovine, ovine and porcine embryos. However, some viruses enter pores and sperm tracks in the zona and resist removal.[36] Also, none of these procedures have been verified for deer embryos and it is dangerous to assume that they will work for all species. Therefore, each virus of interest should be tested to determine whether it can be transmitted by washed deer embryos. Nevertheless, so long as normal quarantine procedures are fulfilled for donor deer in their country of origin there is no greater risk with importing frozen embryos and, in fact, the risk is almost certainly reduced by standard washing procedures.

In addition, a period of monitoring of the donor animals after embryo recovery or semen collection should ensure that they were not incubating any diseases at the time of collection. This is especially relevant for virus infections with long incubation periods such as rabies. If deer embryos are recovered in the northern hemisphere during their natural breeding seasons the frozen embryos or semen could simply be held for 6 months before implantation or insemination during our breeding season, easily allowing post collection monitoring of donor animals.

Frozen semen cannot be washed in the same way as embryos and it carries greater risk of transmitting diseases. However, it carries no greater risk than live animals so long as similar testing and quarantine standards apply.

The biggest advantages of embryo and semen importation are the elimination of parasite transmission, the reduction in risk associated with many bacteria, and the dramatically reduced transport costs.

Conclusions

If deer and deer embryos and semen are to continue to be imported into New Zealand, it is necessary that high standards of disease surveillance, certification, testing and treatment are carried out. In the absence of information on specific diseases, a conservative approach must be taken.

Import protocols should be routinely reviewed in order to cope with changing circumstances, new information of disease occurrence overseas, recent research findings, new emerging diseases, new tests and new treatments.

Protocols for deer importation should go beyond the standard International Zoo-Sanitary Code[18], which deals with common diseases of domestic livestock and zoonoses, and ensure the continued safety of our farmed deer population which is around 0.5 million and should be 1 million by 1991. We have a responsibility to ensure that our deer are free from serious diseases so that deer farming can be maintained as a viable enterprise. There is also great potential in the future for the export of live deer, embryos and semen from New Zealand. The absence of serious diseases will facilitate this.

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C G Mackintosh
MAF Technology
Invermay Agricultural Centre