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Impact of diseases on the NZ deer industry

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ABSTRACT

The financial impact of a range of clinical and subclinical diseases, and mortalities on deer farms is difficult to assess because there are insufficient accurate survey data of their prevalence, causes or production losses on a national basis. However, estimates suggest that clinical disease and current disease control measures may cost the deer industry in excess of $29 million per annum currently, and it may be speculated that at least that amount may be lost due to loss of production from subclinical diseases, resulting in potential costs and losses approaching $60 million per annum. Application of existing knowledge of disease control and prevention on individual farms would significantly reduce this wastage immediately. In addition, investment to improve technology for disease diagnosis, control, prevention and/or eradication, along with adoption of that technology should yield significant dividends for the deer industry.

Keywords: red deer, wapiti, health, disease, production.

INTRODUCTION

Diseases impact on the deer industry in a number of ways. First, there is the most obvious cost of mortality or lost production for the individual farmer. This also impacts on the processing and marketing industries due to reduced volumes and quality of venison, velvet and co-products. There are veterinary and animal health costs associated with the diagnosis and treatment of sick animals and with the costs of vaccines, anthelmintics and trace-element supplementation for the prevention of disease. The risk of specific diseases can influence the choice of deer species, type of pastures grown, and a whole range of other farm management practices. For example, the presence of wildlife vectors for tuberculosis (Tb) and the risk of Tb can influence where farmers decide to farm deer and the type of deer operation that is undertaken. The costs of controlling diseases of national importance, such as Tb, are considerable. Not only do farmers pay directly for the Tb testing of deer, but they also pay a significant contribution to the Animal Health Board (AHB) through a levy, to administer the Tb control programme. Meat inspection at slaughter plants is essential for market assurance, but the cost is directly borne by the farmer. There is also the potential for diseases to be used as barriers to trade. The affects on human health of zoonotic infections contracted from deer are hard to quantify, but are a real cause for concern. This paper, which is largely based on material in the DEEResearch (website: www.deeresearch.org.nz) "Review of Diseases of Farmed Deer" by Mackintosh and Wilson will review available data on disease incidence on deer farms in New Zealand, and examine the impacts of the most important diseases.

Disease and mortality surveys

There is limited data on disease incidence on New Zealand deer farms. A 1980 national postal survey reported health problems on only 52% of farms (Gladden, 1981). Malignant catarrhal fever (MCF), lungworm and yersiniosis were most commonly diagnosed. A Canterbury survey in 1981 (Beatson, 1981) indicated an annual death rate of 2.6%, with MCF diagnosed in 43% of cases. Injury and post-capture myopathy caused 18% of deaths. In a North Island survey, progeny loss rates from birth to weaning ranged from 6-8% and 12-15% for adult and first-calving hinds, respectively (Wilson, 2002). A recent survey estimated annual mortality rates of 5.7% for weaners 3-15 months of age, 1.77% for adult hinds, and 2.56 % for stags 15 months and older (Audigé *et al*., 2001a).

The limited data on causes of perinatal mortality show few infectious diseases. The dystocia rate is approximately 1% (Audigé *et al*., 2001b). Foetal loss rates average 1% (range 0-2.5% between farms (Wilson, 2002)).

The only available data on seasonal mortality rates is shown in Table 1. These data on disease rates on commercial deer farms were collected during a two-year longitudinal observational study of 16 commercial deer farms in the southern North Island by Audigé *et al*. (2001a). Those authors found that yersiniosis in weaners, wasting in hinds, malignant catarrhal fever of stags and misadventure in all classes, were the most common diagnoses in that survey.

TABLE 1: Mortality rates (per 100 deer by season) on commercial deer farms (from Audigé et al. 2001a).

	Season				
Class of deer	**Autumn**	**Winter**	**Spring**	**Summer**	**Annual**
3-15 month old	2.41	2.62	0.42	0.14	5.87
Females> 15 months	0.23	0.67	0.58	0.32	1.77
Males>15 months	0.38	0.83	0.82	0.57	2.60

Although these surveys help direct research to understanding these syndromes, it must be noted that they do not give a true mortality incidence rate for all diseases of deer across the country.

Mortality surveys give little indication of the impact of subclinical disease on animal performance. However, it is commonly believed that economic losses associated with production losses due to subclinical disease such as parasitism or trace element deficiencies of other species, and treatment of non-fatal clinical cases of disease, exceeds losses associated with death and clinical disease *per se*.

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COST AND OTHER IMPLICATIONS OF HEALTH/DISEASE PROBLEMS

The true costs of health/disease problems can only be crudely estimated because for virtually all these problems the prevalence of infection, the incidence of clinical disease, and the production losses due subclinical disease are not known. The following summary is based on estimates using current knowledge.

Bovine tuberculosis (Tb)

There are direct and indirect costs to farmers and to the deer industry. The National Tb Control Scheme requires farmers to test their animals at their own expense and there is no compensation for reactors, so accurate calculation of the cost is difficult. There is also the potential for Tb to be used as non-tariff trade barrier. New Zealand is the only significant international exporter of venison and could be singled out by competitors in the marketplace. At worst, some time in the future, we may find that we are unable to export venison until we are officially "Tb free" as a country. The cost of this scenario would be the entire investment in the deer industry since the industry could not survive a total restriction of trade. At a lower level, importers may insist that venison is certified to have come from "Tb-free" farms, districts or regions.

The direct costs of the Tb scheme are approximately:

Primary Tb test:

- Mid Cervical Test (MCT) $3-5 per animal plus travel

Ancillary tests:

- Comparative Cervical Test (CCT) $15 per animal plus visit fee and travel.
- Blood Test for Tb (BTB) ~$100 per animal plus cost of blood sample and travel.
- ELISA ~$10 per animal plus cost of blood samples plus travel

AHB levy:

- 8.4 and 84 cents per kg carcass and velvet weight, respectively.

Wildlife control on farm:

- variable

Indirect costs include:

- Down-grading of Tb reactor animals to "local consumption". This is usually about $2/kg carcass weight.
- Down-grading to "local consumption" of suspect lesion animals in DSPs, where diagnosis requires culture.

Additional costs for Movement Control farms:

- Movement control restrictions on trade: unknown cost, but high for stud breeders
- Losses in production from diseased animals: unknown cost.

Statistics:

- In the year ending Mar 2002 there were 582,000 deer MCT tests and 982 "reactors".
- Over this period there were 6587 CCTs, 2255 BTBs and 2299 ELISA tests. We estimate that 1000 reactor deer were killed for local consumption.

Estimated costs:	
MCT 580,000 @ $4	$2.3 million
CCT 6587 @ $15	$100,000
BTB 2255 @ $110	$250,000
ELISA 2299 @ $12	$28,000
Reactors killed for "local": est. 1000 @ a loss of $5/kg per 50kg carcass	$250,000
Suspect lesion for "local": est. 1000 @ a loss of $5/kg per 50kg carcass	$250,000
Total estimated direct and indirect costs of Tb testing for 2001/02	$3.2 million
Plus AHB levy 2002 figure (source; NZ Game Industry Board Annual Report)	2,093,705
Plus hidden costs of labour, movement control restrictions and loss of production.	
Total, plus hidden costs	$5.3 million

Johne's disease (JD)

An Agriculture-NZ economic evaluation (Brett, 1998) estimated that JD costs the NZ deer industry $200-340k per annum based on estimated 1998 figures. However, this is likely to be a gross underestimate of the future annual costs, because the disease is spreading and there have been increasing numbers of serious outbreaks in deer aged 8 to 15 months. These outbreaks have generally involved approximately 10% of yearlings in a group and have caused serious economic losses on affected properties, which would amount to $20,000 per season for an average farm with 400 weaners. There are estimated to be 10-20 outbreaks annually. This type of serious outbreak in yearlings is a significant difference between JD in deer and JD in cattle and sheep, where losses are usually confined to two to four-year-old animals and annual mortalities rarely rise above 3% under NZ conditions. Sporadic losses of adult deer have also occurred on farms throughout NZ and it is acknowledged that there is under-reporting of infection. The effects of finding JD on stud farms can also be financially crippling. Thus, the annual costs of JD are projected to increase significantly. Currently JD has been positively diagnosed on over 300 deer farms, which is around 5% of commercial deer farms in New Zealand. The total cost to the industry is likely to be in excess of $500,000 p.a.

Of even greater concern than the direct cost of JD to individual farmers is the potential for JD to be used against New Zealand venison exporters as a non-tariff-trade barrier in the same way that bovine tuberculosis might be. If *M. paratuberculosis* is shown to cause disease in humans then consumers of venison may demand product free of this organism. Such a scenario has major implications for the deer industry in New Zealand. It should be noted that the Food Standards Agency in the United Kingdom has devised a strategy for the control of *M. paratuberculosis* in cows' milk. Of further concern is that consumers and retailers respond to scares or perceived risk, even in the absence of proof of causation.

Yersiniosis

The true incidence of yersiniosis is not known, but the animal health surveillance data from veterinary diagnostic laboratories for 1997-2001 shows that yersiniosis was identified in 14% of ill-thrift cases in deer in 1997, 16% in 1998, 9% in 1999 and 6% in 2000. For the last few years, nearly 500,000 doses of Yersiniavax were sold annually for the estimated 700,000 weaners. With two doses needed per deer, this equates to a maximum of 35% of weaners being vaccinated overall. However, 40-56% of weaners are vaccinated in the major deer- producing areas. The vaccine costs approximately $1.50 per dose to the farmer ($3/deer) and, thus, the total direct cost to the industry is $750,000, plus administration and labour costs.

Experimental evidence (Mackintosh *et al*., 1991; 1992) and anecdotal reports suggest that vaccination has significantly reduced the number of serious outbreaks of yersiniosis in farmed deer. Occasional outbreaks or sporadic losses from yersiniosis do occur in vaccinated weaners (Wilson *et al*., 1999; Brenton-Rule, 2001) due to a variety of reasons, including incorrect vaccination, use of only one dose, concurrent stress or disease, extremely heavy challenge and genetic susceptibility. AgVax NZ Ltd, the suppliers of the vaccine, have data to show that in most outbreaks in vaccinated herds the losses are 3% or less (Brenton-Rule, 2001). By comparison outbreaks in unvaccinated herds usually involve losses of 10 – 30%. However, on a national basis, a 1% reduction in weaner losses is equivalent to a saving of 7,000 calves @ $250 or $1.75 million, which makes vaccination cost effective on an industry-wide basis. On an individual basis, a farmer has to save only one $250 weaner to pay for enough vaccine for 83 animals. The value of security provided by risk management is difficult to quantify.

Leptospirosis

Surveys of deer suggest that infection is widespread throughout deer herds in New Zealand (Wilson *et al*., 1998). The most common serovar is *Leptospira hardjo*, which appears to be relatively non-pathogenic in the endemic situation. Infections with *L. pomona* and *L. copenhageni* cause sporadic outbreaks of haemoglobinurea, jaundice and sudden death in weaners, with high apparent morbidity but usually with low mortality. An analysis of Animal Health records from 1987 – 1992 showed that leptospirosis was a significant cause of death in deer, especially those less than 12 months of age, and particularly in the autumn. Over this period, 345 deer were reported dead in association with evidence of leptospirosis, at an estimated loss of ~$100,000. The deaths of 50 two-year-old stags on one property were attributed to leptospirosis.

Leptospirosis causes abortions and perinatal mortality in cattle and, although there is little direct evidence, it is possible, although yet to be proven, that leptospirosis contributes to the losses of 0.6 - 0.8% that occur in pregnant hinds between pregnancy scanning and calving, as well as perinatal losses of 9 – 17% described above.

Two leptospiral vaccines are licensed for use in deer in New Zealand, but the number of animals vaccinated is not known. If the vaccines are effective, then the high number of lesions seen in deer at DSPs suggests that only a small proportion of deer are vaccinated, and these are probably on individual properties that have experienced clinical outbreaks in the past. Vaccination is becoming more common as farmers attempt to reduce their zoonotic risk. The zoonotic aspects of leptospirosis should not be overlooked. The main driving force for vaccination of dairy cattle and pigs has been to prevent the number of cases of leptospirosis occurring in farmers and other people at risk in the livestock industry, especially livestock transporters and in slaughter plants. This is also a valid reason for vaccinating deer. While there is little risk to handlers or consumers of venison, food safety concerns are often based on perceptions rather than the reality of risk, so the potential cost of the zoonotic nature of this organism if it became an issue in the marketplace should not be overlooked. Thus, the cost of this disease is difficult to assess.

If a bold assumption was made, that 0.1% of weaners were affected annually, this disease could cost $300,000, plus the cost of currently used vaccine.

Pasteurellosis

Sporadic losses occur due to infections with *Pasteurella* spp. but it does not appear to be a major cause of wastage on deer farms.

Colibacillosis and Rotavirus

Some neonatal losses have been attributed to colibacillosis and/or Rotavirus, especially in wapiti and wapiti hybrids, but they are not considered to be a major cause of wastage in the deer industry.

Clostridial infections

Tetanus, pulpy kidney, blackleg, malignant oedema and wound infections occur sporadically at a low level. A small proportion of deer farms routinely vaccinate with multi-strain clostridial vaccines as a form of cheap insurance against losses, although the efficacy of these vaccines has not been demonstrated. Of greater concern is the effect that images of post-velveting clostridial infections could have on the future of velvet antler removal as a farming practice or profit, if they became available to animal welfare activists. Thus, the cost of this disease is difficult to assess.

Fusobacteriosis

This is primarily a problem on fallow deer farms due to the high susceptibility of young fallow fawns to necrotic mouth and foot infections. Outbreaks of foot lesions occur sporadically in red deer and are usually associated with wet, muddy underfoot conditions. Various killed bacterin vaccines appear to have given good protection, but none are currently available in New Zealand because the cost of licensing is too great for the number of doses likely to be sold. Thus, the cost of this disease is difficult to assess.

Brucellosis

To date there have been only a small number of properties where *B. ovis* infections in stags have been

reported (Ridler, 2002). Potentially, this disease could cause widespread problems if it was allowed to spread uncontrolled. However, evidence that there have been no natural occurrences of this disease in the past four years suggests this is unlikely. Evidence now exists that *B. ovis* infections self-cure in the majority of stags (Ridler, 2002). Further, sheep are the primary source of infection and the incidence of this disease in that species is reducing.

Malignant catarrhal fever

When deer farming first started 30 years ago, this was one of the major causes of mortality in adult deer. Subsequently the incidence rate has dropped, but it still causes an estimated 0.25 – 1.0% mortality rate in adult deer throughout the country. The incidence is low in dairying areas but is higher in sheep-farming areas, especially in the South Island. Surveys in the Manawatu/ Hawkes Bay showed the loss rate for hinds was 0.17% and stags 0.52% (Audige *et al*., 2001a), but the incidence is believed to be higher in Canterbury.

Assuming that there are 1.8 million mixed-age hinds and stags, this equates to losses of 5,000 - 20,000 animals per year @ $350 or $1.75 – 7 million p.a.

Parapox

Deer Parapox is caused by a virus similar to orf, or scabby mouth virus, and produce crusty lesions or scabs on the face, velvet, body and legs of affected deer. Clinical Parapox usually occurs as an outbreak in a high proportion of animals when it is introduced onto a farm where it is not endemic, or when a large group of susceptible animals are moved onto a farm where it is endemic. In the endemic state, it does not appear to cause significant problems because the animals get exposed gradually at an early stage of life. The outbreaks can be severe and cause considerable lost revenue if they affect stags in velvet. Some farms have lost virtually their entire crop of velvet for a season. The velvet cannot be sold because of the zoonotic risk and the fact that processing may not kill the virus. There have been some instances of weaners dying, but this is often associated with secondary infection. Overall, deer parapox causes some low-level losses each year but it is not considered a major threat to the industry. If 0.1% of velvet was rejected, this would cost $34,000 annually.

Lungworm

This is the most significant parasite for deer and potentially the biggest threat to weaners in the autumn (Mackintosh & Mason, 1985; Johnson *et al*., 2001). Currently *Dictyocaulus eckerti* can be effectively controlled by good grazing management and regular use of anthelmintics. However, every year, there are cases of clinical disease due to lungworm infection reported by diagnostic laboratories and vets. These may be due to poor management, seasonal differences or misunderstanding that "white" drenches do not have any persistent activity compared with avermectin/moxidectin anthelmintics that continue to be effective for up to six weeks after dosing (Mackintosh *et al*., 1997; 1999), and that levamisole is not effective at all (Mason & Beatson, 1985). There is also a move towards "organic" farming and the avoidance of anthelmintics, and this can lead to problems with lungworms if not managed appropriately. It has been estimated that deer farmers spend up to $10 million annually on anthelmintics, primarily against lungworm. Although lungworm are still sensitive to the current anthelmintics, research should continue into alternative control measures that are more ecologically acceptable and sustainable, including vaccines and "natural" parasiticides.

The cost of anthelmintics for deer is estimated to be $10 million. Production losses of 1% through growth retardation due to lungworm and gut worms, would result in reduction of value of venison of about approximately $2.8 million, based on 2001 export figures.

Gastrointestinal (GI) nematodes

There is anecdotal evidence that these are becoming an increasing problem as deer farming is becoming more intensive and stocking rates are increasing. There is also an increasing frequency of wapiti genes in the breeding stock and wapiti are used as terminal sires. Wapiti are more susceptible to GI parasites and this may result in increasing susceptibility of breeding hinds and weaners to parasitism. Pure wapiti herds, which are generally stud animals or heavy velvet producers, are very valuable and are particularly at risk from the "fading elk syndrome", which results from chronic abomasal parasitism (Waldrup & Mackintosh, 1992; 1993). This increasing susceptibility is likely to result in clinical and subclinical losses and increased cost of anthelmintics used for treatment and prevention.

Elaphostrongylus cervi

There do not appear to be any significant losses associated with clinical disease due to elaphostrongylosis, but there is occasionally some minor loss of product from trimming affected carcasses in deer slaughter plants.

Flukes

There do not appear to be any significant losses associated with clinical disease due to liver flukes.

Ticks

Although ticks have been recognised as a problem for over 20 years, losses are patchy and they have tended to be more prevalent in the upper and eastern North Island. However, they appear to have been spreading further south recently, especially in association with the movement of deer and dairy cattle to the South Island and have been reported in Southland. There have been increasing reports of tick problems on deer farms, especially in young fawns, which can get very heavy burdens and die of extreme anaemia. All classes of animal can carry ticks and, as well as causing loss of production associated with anaemia, they cause damage to hides and velvet antler. With "global warming" developing it is likely that ticks will become an increasingly serious problem on deer farms. Current technology can effectively control ticks, but a longer-acting animal treatment would greatly enhance the

simplicity of tick control.

If 0.05% of calves born died of ticks, this would represent a lost opportunity for 600 venison carcasses at $300: $180,000, plus treatment est. 200,000 doses at $1 = $200,000. Total $380,000

Cryptosporidiosis

Sporadic neonatal deaths attributable to cryptosporidiosis have been reported on a few deer farms, especially in the South Island. Anecdotal reports suggest that at least 20 farms lose up to 20 neonatal deer annually, which would be worth $100,000 as weaners.

Facial eczema

This is a very seasonal problem and is largely confined to well-known risk areas in the North Island where it also affects sheep, cattle and horses. Fallow deer are particularly sensitive to facial eczema. However, when conditions get extreme, clinical disease can occur in red and wapiti deer (Scott, 2002). However, subclinical liver damage can also reduce productivity even when clinical signs are not apparent. Control measures that are effective for sheep and cattle also appear to be effective in deer. It is not possible with current information to assess the cost to the industry, but it is likely to be substantial in some years, due mainly to lowered growth rates, and interference with reproductive performance of hinds.

Ryegrass staggers

Red deer appear to be relatively resistant to ryegrass staggers. However, pure wapiti, and to a lesser extent wapiti hybrids, are very susceptible to this disease (Mackintosh, 1992). With the increasing use of wapiti and wapiti terminal sires, the national herd may become more susceptible to this disease. Global warming may exacerbate the problem by causing more drought stress to ryegrass and increase the amount of toxins. Conversely, the availability of new specialist non-ryegrass pastures and non-endophyte ryegrass cultivars may reduce the amount of toxic pastures. Although not usually directly fatal, ryegrass staggers can result in accidental deaths through misadventure, and so make management difficult. There is also evidence from sheep and cattle that subclinical levels of toxins in the pastures can reduce forage palatability and, therefore, productivity. The cost of this disease is difficult to assess.

Cu deficiency/toxicity

Many areas of New Zealand are deficient or low in available copper. Osteochondrosis in young deer and enzootic ataxia in yearlings and older deer are the main manifestations of copper deficiency. However, the incidence of clinical disease is relatively low, even in herds in which serum samples indicate the majority of animals have very low copper status. Few trials have shown a growth response to copper supplementation in their first year of life in groups under these conditions. However, supplementation may be economic if it prevents clinical disease occurring, even in a small number of animals. Wapiti are more susceptible to deficiency than red deer and have a higher copper requirement. Supplementation of hinds in mid to late pregnancy is the most cost-effective means of preventing osteochrondrosis in young fawns. The long-term effects of copper deficiency on hind productivity are not well understood.

There are a number of methods of copper supplementation, including dosing with copper oxide wire particles (copper bullets), injections, and pasture topdressing. The relative merits of these methods need to be investigated to determine which are the most cost-effective under a range of conditions. It is estimated crudely that in excess of $1.5 million is spent annually on copper supplementation of deer, and a substantial amount would be spent on diagnostic testing and monitoring. If average losses, clinical and subclinical combined were 0.1%, this cost would be about $300,000. Total $1.8 million.

Copper toxicity is diagnosed occasionally and is usually due to over-enthusiastic or poorly controlled copper supplementation.

Se deficiency/toxicity

Most New Zealand soils and pastures are deficient or marginally deficient in selenium. Clinical disease is rarely diagnosed in deer and there is little information on what liver or circulating blood levels indicate “adequate”, “marginal and deficient” states in deer. As insurance against deficiency, it is likely that the majority of farmers supplement their deer with selenium by topdressing pastures with selenium prills, adding selenium to drenches, giving selenium boluses or selenium injections or using pour-on selenium. These are all relatively cheap forms of supplementation compared to the value of the animal.

Incidental/misadventure/”stag death”

The incidence of “stag death” has been estimated at 1 per 1000 anaesthetics. It is likely that less than one third of stags receive xylazine for velvet antler removal. Thus, approximately 100 stags could be lost annually, at a meat value cost of $50,000. However, a number of high-value stud stags die of this condition, so the real cost would be higher. It is possible that the administration of anti-inflammatory drugs may help to prevent the non-specific hypersensitivity that is believed to be the cause of the problem, but there have been not trials conducted. The increasing use of physical restraint and local anaesthetics may reduce the number of cases occurring. Similarly, the development of a drug-free means of analgesia will also eliminate the risk of these deaths.

Other causes of misadventure include stags fighting, especially during the rut, water deprivation, which usually occurs in summer due to natural water sources drying up or an interruption to the piped water supply, and broken legs or necks as a consequence of panic or some stressful procedure. Improvements in management can reduce the likelihood of these occurrences. However, an estimate of the cost of deaths due to injuries can be made, based on data from Audigé *et al*. (2001a). Deaths due to injury accounted for 10% of hind deaths, 16% of stag deaths, 12.5% of weaner deaths, and 3% of calf deaths. At carcass values of $300 and $500 ascribed for hinds and stags,

respectively, (i.e., lost opportunity to achieve optimum production) the total cost approximates $765,000 for 2250 hinds, $600,000 for 1200 stags, $2.5million for 8400 weaners, and $108,000 for 3600 calves. The total cost of injuries is, therefore, estimated at $3,973,000 annually.

Verification of zoonotic risk status of venison

Food safety is increasingly becoming a serious international marketing issue. There are many organisms that have the potential for affecting food safety. These may be involved in a disease process in the animal at the time of slaughter, or they may simply be present in the tissues or blood stream or present in the gut contents or on the skin surface. The most common organisms include: *Yersinia pseudotuberculosis*, *Yersinia enterocolitica*, *Listeria* spp., *Salmonella* spp., *Escherichia coli*, *Campylobacter* spp, *Clostridium* spp, *Mycobacterium bovis*, *M. avium*, *M. paratuberculosis*, Staphylococci, Streptococci, *Leptospira* spp.

A survey of carcass contamination with *Y. pseudotuberculosis* yielded only one organism from more than 300 carcasses, indicating the risk to humans from handling venison is very low. However, food-safety concerns are often based on perceptions rather than the reality of risk, so the potential cost of the zoonotic nature of this organism if it became an issue in the marketplace should not be overlooked.

There are also issues of food spoilage, which will not be discussed in this review.

SUMMARY OF FINANCIAL LOSSES

Financial cost of mortalities, and disease control and prevention

Table 2 is a summary of the major financial losses that can be estimated from current knowledge, with a number of assumptions, to provide a ready relative importance of each.

Financial cost of subclinical disease

Because the real production losses caused by subclinical disease are unknown, only estimates can be made. Subclinical disease causes production losses such as failure of conception, failure to rear progeny, reduced growth rate and its effect on limiting the lifetime production of the individual animal or herd affected, reduced venison production, and failure to achieve potential velvet antler production. It is generally assumed that the total cost of subclinical losses is greater than the cost of mortalities *per se*.

Thus, the total annual cost of subclinical disease may exceed $29 million currently.

Combined, clinical and subclinical disease may be have contributed to annual losses within the deer industry of around $58 million in 2001. This figure will increase as the number of farmed deer increases, unless there is better application of existing technologies to reduce wastage. In the future, new technologies will be devised that have the potential to further reduce losses caused by current diseases. However, the industry must be realistic in its expectations in this regard, because experience indicates that there are always new disease threats arising, and these will inevitably continue to represent a cost to the deer industry into the future.

TABLE 2: Estimated costs of the major deer diseases.

Disease	Estimated cost ($million annually)
Tuberculosis	5.3
Johne's disease	> 0.5
Yersiniosis	2.5
Leptospirosis	0.3
MCF	1.54
Parapoxvirus	0.034
Internal parasites (lung and gut worms)	12.8
Cryptosporidiosis	0.1
Ticks	0.38
Facial eczema	?
Copper	1.8
Injuries	3.97
Other	?
TOTAL	**>$29 million**

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