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REFLECTING ON ETHICAL AND LEGAL ISSUES IN WILDLIFE DISEASE

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ABSTRACT

Disease in wildlife raises a number of issues that have not been widely considered in the bioethical literature. However, wildlife disease has major implications for human welfare. The majority of emerging human infectious diseases are zoonotic: that is, they occur in humans by cross-species transmission from animal hosts. Managing these diseases often involves balancing concerns with human health against animal welfare and conservation concerns. Many infectious diseases of domestic animals are shared with wild animals, although it is often unclear whether the infection spills over from wild animals to domestic animals or vice versa. Culling is the standard means of managing such diseases, bringing economic considerations, animal welfare and conservation into conflict. Infectious diseases are also major threatening processes in conservation biology and their appropriate management by culling, vaccination or treatment raises substantial animal ethics issues. One particular issue of great significance in Australia is an ongoing research program to develop genetically modified pathogens to control vertebrate pests including rabbits, foxes and house mice. Release of any self-replicating GMO vertebrate pathogen gives rise to a whole series of ethical questions. We briefly review current Australian legal responses to these problems. Finally, we present two unresolved problems of general importance that are exemplified by wildlife disease. First, to what extent can or should 'bioethics' be broadened beyond direct concerns with human welfare to animal welfare and environmental welfare? Second, how should the irreducible uncertainty of ecological systems be accounted for in ethical decision making?

Inevitably, most discussion of bioethical issues concerning infectious disease has concentrated on disease in humans. However, disease in wildlife raises a number of important ethical questions that have not been widely considered. For several reasons, this is an important omission. Wildlife diseases are of direct concern to human wellbeing. Almost all emerging diseases of humans are zoonotic: that is, they occur in humans by cross-species transmission from an animal host.[1] Examples of current interest include Ebola virus, which appears to have transferred to humans from the great apes in East Africa,[2] HIV, which appears to have taken a similar route into the human population,[3] SARS, which appears to have a variety of wild mammalian hosts in southern China,[4] and avian influenza, which occurs in wild waterfowl and is transferred to humans by domestic poultry.[5] Wildlife diseases may also be of significance to domestic stock. For example, bovine tuberculosis is a major problem in the dairy industry and is thought to have wildlife as reservoirs[6] (badgers in the United Kingdom and brush tailed possums in New Zealand). As well as these routes of transfer from wild populations to domestic animals or human populations, transfer may also occur in the reverse direction. For example, the lion population in the Serengeti National Park is currently endangered by canine distemper, which has been transferred to the lions from the domestic dog populations,[7] and African wild dogs are threatened with rabies, also transferred from domestic dogs.[8] Finally, wildlife disease may be a significant threatening process to a number of endangered species.[9] In this

[1] P. Daszak, A.A. Cunningham & A.D. Hyatt. Emerging infectious diseases of wildlife – threats to biodiversity and human health. *Science* 2000; 287: 443–449. H. Kruse, A.-M. Kirkemo & K. Handeland. Wildlife as source of zoonotic infections. *Emerging Infectious Diseases* 2004; 10: 2067–2072.

[2] E.M. Leroy et al. Multiple Ebola virus transmission events and rapid decline of central African wildlife. *Science* 2004; 303: 387–390.

[3] J. Mittler, R. Antia & B. Levin. Population dynamics of HIV pathogenesis. *Trends in Ecology and Evolution* 1995; 10: 224–227.

[4] R.A. Weiss & A.R. McLean. What have we learnt from SARS? *Philosophical Transactions of the Royal Society of London B Biological Sciences* 2004; 359: 1137–1140.

[5] R.J. Webby & R.G. Webster. Are we ready for pandemic influenza? *Science* 2003; 302: 1519–1522.

[6] M.G. Roberts. The dynamics of bovine tuberculosis in possum populations and its eradication or control by culling or vaccination. *Journal of Animal Ecology* 1996; 65: 451–464; P.C.L. White & S. Harris. Bovine tuberculosis in badger (*Meles meles*) populations in southwest England: The use of a spatial stochastic simulation model to understand the dynamics of the disease. *Philosophical Transactions of the Royal Society of London B Biological Sciences* 1995; 349: 391–413.

[7] C. Packer et al. Viruses of the Serengeti: patterns of infection and mortality in African lions. *Journal of Animal Ecology* 1999; 68: 1161–1178.

[8] S. Cleaveland. The growing problem of rabies in Africa. *Transactions of the Royal Society of Tropical Medicine and Hygiene* 1998; 92: 131–134.

[9] H.I. McCallum & A.P. Dobson. Detecting disease and parasite threats to endangered species and ecosystems. *Trends in Ecology and Evolution* 1005; 10: 190–194.

paper, we will discuss the ethical issues that each of these aspects of wildlife disease raises.

First, however, we will briefly review some of the principles of epidemiology and control of infectious disease as these underlie most of the ethical issues that we will be discussing. A central concept in the control of infectious disease in any population is R_0, or the basic reproductive rate of the disease,[10] which is the number of secondary cases produced per primary case when the disease is first introduced to a population. If this exceeds one then the disease will increase in the population. Otherwise, it will die out. Attempts to control disease in wildlife populations therefore concentrate on reducing R_0 to below one. R_0 can take various forms depending on the disease and its mode of transmission, but in general it is the infection rate per unit time, multiplied by the time infection persists in an infected individual. The infection rate per unit of time can be reduced by decreasing contacts between potential hosts by reducing overall host density (by culling), or by reducing the chance of disease transmission per contact by vaccination. The time infection persists in infected individuals can be reduced either by treating the infection, or by removing infected individuals from the population by culling. These are principles common to disease in humans and domestic stock as well as wildlife. However, in free-ranging animal populations, the feasibility of potential control options is restricted compared to either domestic animals or humans. Treatment of infected individuals on a population scale is often impossible, as it involves capture, detection of infection, successful treatment and then release. Animal welfare groups attempt this, but it is rarely possible on a scale that will affect the dynamics of the disease in the population: it may alleviate suffering in individual animals, and may satisfy the wildlife carer, but is unlikely to prevent or slow the rate of progress of an epidemic. Release of animals that have spent time in close association with humans (and often with animals of other species: wildlife carers in Australia seem to maintain veritable menageries) may have substantial negative impacts on the wild population, including cross-species disease transmission and disruption of social structure.

Vaccination is similarly a disease management strategy that is difficult to apply to wildlife relative to domestic animals or humans, although there have been some notable successes. For example, wild foxes in Europe are vaccinated against rabies, as

[10] R.M. Anderson & R.M. May. 1991. *Infectious diseases of humans*. Oxford. Oxford University Press.

are raccoons in the NE USA (to prevent zoonotic disease in humans) by distribution of oral vaccine in chicken heads or prepared baits. Although a high proportion of the target is successfully vaccinated, many of the baits are taken by non-target species. As the rabies vaccine is a recombinant self replicating entity, this does raise ethical questions concerning potential hazards to other species,[11] but rabies is such a severe threat to human health that broad scale distribution of the oral vaccine is widely used as a control strategy.

Given the difficulty in wildlife of applying the treatment and vaccination options (which are the main strategies used in disease control within human populations), control of disease in wildlife tends to concentrate on culling, with the objective of either reducing transmission rates through reducing host density, or of reducing the time infected animals remain able to infect other animals. Culling is, of course, entirely unethical in human populations, but is very widely applied to control disease in domestic stock. A recent example is the large scale culling used in the British foot and mouth disease epidemic.[12] This did itself raise serious ethical issues in relation to both animal welfare issues and the impact on farmers. However, culling wildlife raises a range of issues additional to those in domestic stock. Some relate to the difficulty in humanely killing wild animals on a sufficiently large scale. More fundamentally, total extirpation of local populations is the explicit goal of culling programs to control disease in domestic stock. Re-establishing herds or flocks after an appropriate period is financially difficult but biologically straightforward. Total local extinction of any wildlife population is more problematical, as reintroduction is difficult and often (perhaps even usually) fails.[13]

ZOONOTIC DISEASE

We have already mentioned a number of diseases of humans that are transferred from animals. Control of many of these is attempted by culling the animal populations that are thought to be the reservoirs of the disease in question. This raises obvious

[11] C.E. Rupprecht, C.A. Hanlon & T. Hemachudha. Rabies re-examined. *The Lancet Infectious Diseases* 2002; 2: 327–343.

[12] N.M. Ferguson, C.A. Donnelly & R.M. Anderson. The foot-and-mouth epidemic in Great Britain: pattern of spread and impact of interventions. *Science* 2001; 292: 1155–1160.

[13] J. Short, S.D. Bradshaw, J. Giles, R.I.T. Prince & G.R. Wilson. Reintroduction of macropods (Marsupialia: Macropodoidea) in Australia – a review. *Biological Conservation* 1992; 62: 189–204.

ethical problems in weighing the potential benefit to humans against the negative consequences, both in terms of suffering and conservation impact, to the animal population. Whilst many would argue that human welfare must be paramount, mere identification of an animal as a reservoir host of a human pathogen is not sufficient reason to cull those animals. For example, whilst it is fairly clear that the proximate animal reservoirs involved in transferring Ebola to the human population are the great apes (Gorillas and Chimpanzees), few would argue that culling these animals is an appropriate or ethical response.

Flying foxes have been implicated as the reservoirs for three fatal diseases of humans in Australia and South East Asia: Nipah virus,[14] Hendra virus,[15] and bat Lyssavirus.[16] However, these bats are protected species in Australia. Any attempt to control these diseases through large-scale culling would therefore introduce a conflict between conservation and human health. Determining where the balance between these two goals ought to be struck raises difficult ethical questions. Even from a purely human-centred perspective, flying foxes are important pollinators and seed dispersers, so reductions in their numbers might have substantial negative consequences for human welfare. Fortunately, in Australia at least, Lyssa virus and Hendra virus remain very rare indeed in the human population, despite high levels of seropositivity (which indicates previous exposure to the viruses) in bat populations. These emerging diseases are therefore more appropriately managed through reducing those bat-human contacts that might result in transfer of infection rather than through trying to eliminate or reduce bat populations.

WILDLIFE AS RESERVOIRS FOR DISEASE OF DOMESTIC ANIMALS

As with human zoonotic disease, a standard response to wildlife reservoirs of disease in domestic stock is to suggest culling of the wildlife population. In some cases, culling may even be counterproductive. One example is the practice in Britain of culling badger populations in order to reduce transmission of bovine

[14] M. Enserink. Malaysian researchers trace Nipah virus outbreak to bats. *Science* 2000; 289: 518–519.

[15] K. Halpin, P.L. Young, H. Field & J.S. Mackenzie. Newly discovered viruses of flying foxes. *Veterinary Microbiology* 1999; 68: 83–87.

[16] C.R. Tidemann, M.J. Vardon, J.E. Nelson, R. Speare & L.J. Gleeson. Health and conservation implications of Australian bat Lyssavirus. *Australian Zoologist* 1997; 30: 369–376.

tuberculosis to dairy herds. A large-scale experimental study found that removal of badgers had the paradoxical effect of increasing transmission to cattle.[17] Badgers are a strongly territorial animal and removal of some members of the population caused increased rates of movement amongst the remaining animals as they sought to establish territories in the areas vacated by animals that have been removed. The effect of this increased movement was to increase the rate at which the pathogens were transmitted.

In many other cases where domestic animals and wildlife share pathogens, it is unclear whether the wildlife are reservoirs for infection that then 'spills over' into the domestic animals, or whether the reverse is the case.

INFECTIOUS DISEASE AND CONSERVATION

Again, culling is a central issue when considering control of disease in populations of conservation significance. For example, Tasmanian devils are currently affected by a facial tumour disease that appears to be infectious, and which has greatly reduced populations in some areas to the extent that the survival of some populations is in doubt.[18] At this stage, there is no known treatment, nor is the identity of the agent known. One of the only possible control strategies is to cull animals. One option would be to remove all diseased animals, but it might even be advisable to remove all animals from infected areas, in an approach analogous to that used for domestic stock infected by foot and mouth disease. Determining when or whether it is ethically appropriate to cull a species of special conservation significance, in the face of a great deal of uncertainty concerning whether such a strategy would even be successful, is a daunting issue.

There are also many ethical issues associated with attempting to treat or vaccinate wild populations of rare species. An example is the case of the African wild dog, which is a critically endangered species and is threatened in some areas by rabies infection.[19] There has been a continuing controversy over whether it is

[17] C.A. Donnelly et al. Impact of localized badger culling on tuberculosis incidence in British cattle. *Nature* 2003; 426: 834–837.

[18] Disease Affecting Tasmanian Devils. 2005. http://www.dpiwe.tas.gov.au/inter.nsf/WebPages/LBUN-5QF86G?open (accessed 23 May 2005).

[19] S.C. Gascoyne, M.K. Laurenson, S. Lelo & M. Borner. Rabies in African wild dogs (*Lyacaon pictus*) in the Serengeti region, Tanzania. *Journal of Wildlife Diseases* 1993; 29: 396–402.

appropriate to catch wild animals and vaccinate them against rabies, with suggestions being made that the process of capture and handling of the animals itself leads to the disappearance of entire packs.[20]

USE OF INFECTIOUS DISEASE TO CONTROL PEST POPULATIONS

One of the potentially most difficult ethical issues in wildlife disease concerns the use of infectious disease as a biological control agent. The best-known current example of this is the use of myxomatosis[21] and more recently rabbit haemorrhagic disease[22] to control rabbit populations in Australia, New Zealand and Europe. In these cases, the ethical issues involve balancing of any benefits to agricultural production and biodiversity conservation with the undoubted animal welfare issues associated with introducing a pathogen, which leads to the prolonged and probably painful death in the rabbits.

However, there are more significant ethical issues associated with the proposed use of genetically modified pathogens to control the vertebrate pest populations. In Australia, such agents are in the process of being developed for rabbits, house mice and European foxes.[23] In New Zealand, research is currently in progress to develop agents to control Australian brush tail Possum populations.[24] There have also been some suggestions that it may be possible to develop such agents to control kangaroo populations in Australia. Most of these programs involve so-called 'immunocontraceptive' technologies, in which the objective is to

[20] J.R. Ginsberg et al. Handling and survivorship of African wild dog (Lycaon pictus) in five ecosystems. *Conservation Biology* 1995; 9: 665–674; R. Burrows, H. Hofer & M.L. East. Population dynamics, intervention and survival in african wild dogs (lycaon pictus). *Proceedings of the Royal Society of London – Series B: Biological Sciences* 1995; 262: 235–245.

[21] F. Fenner & B. Fantini. 1999. *Biological control of vertebrate pests: the history of myxomatosis; an experiment in evolution*. Wallingford, Oxon, UK; New York, NY, USA. CABI Publishing.

[22] B.D. Cooke & F. Fenner. Rabbit haemorragic disease and the biological control of wild rabbits, *Oryctolagus cuniculus*, in Australia and New Zealand. *Wildlife Research* 2002; 29: 689–706.

[23] H.I. McCallum. Immunocontraception for wildlife population control. *Trends in Ecology and Evolution* 1996; 11: 491–493; Anonymous. International issues in the use of GMOs for the management of mammal populations. *Biocontrol News and Information* 2005; 25: 37N–41N.

[24] N.D. Barlow. Modelling immunocontraception in disseminating systems. *Reproduction Fertility and Development* 1997; 9: 51–60.

engineer a transmissible agent so that it effectively sterilises the target species.[25] This should then eliminate some of the animal welfare issues associated with lethal control, and in fact this technology has been seized upon and advocated by elements of the animal welfare lobby in Australia.[26] However, it raises a range of additional ethical issues, including the general principle of whether it is wise to release genetically modified infectious agents into the environment and also the possibility that such agents may affect species other than those targeted, either within the same region in which the release takes place or, in the case of brush tail possums in New Zealand, by transfer of the pathogens from the region in which it has been released to a region in which the target species is not a pest.

CONSTRUCTING A LEGAL FRAMEWORK FOR ETHICAL ISSUES IN WILDLIFE DISEASE

As Michael Selgelid[27] has noted, there appears to be an attention deficit in bioethics with respect to infectious disease. By this view, other high-profile topics have dominated the bioethics literature – particularly abortion, stem cell research, cloning, euthanasia, etc. – with comparatively little attention paid to infectious disease despite its history of human destruction.

If there is a deficit in the bioethics literature there is a comparable deficit in the legal domain. While Flood and Williams[28] have made major contributions from Canada, as has Gostin[29] from the United States, there is as yet an undeveloped legal literature in the infectious disease context in many other jurisdictions. In Australia, recent contributions have been made by Bennett in the

[25] C.K. Williams. Development and use of virus-vectored immunocontraception. *Reproduction Fertility and Development* 1997; 9: 169–178; D. Cowan & H. McCallum. Discussion session: Is fertility control an option? *Reproduction Fertility and Development* 1997; 9: 61–64; C.H. Tyndale-Biscoe. Virus-vectored immunocontraception of feral mammals. *Reproduction Fertility and Development* 1994; 6: 281–287.

[26] G. Oogjes. Ethical aspects and dilemmas of fertility control of unwanted wildlife: an animal welfarist's perspective. *Reproduction Fertility and Development* 1997; 9: 163–168.

[27] M.J. Selgelid. Ethics and infectious disease. *Bioethics* 2005; 19(3): 272–289.

[28] C.M. Flood & A. Williams. A tale of Toronto: national and international lessons in public health governance from the SARS crisis. *Michigan State Journal of International Law* 2005. In press.

[29] L.O. Gostin et al. The model state emergency health powers act: planning for and response to bioterrorism and naturally occurring infectious diseases. *Journal of the American Medical Association* 2002; 288: 622–628.

context of responses to human infectious diseases such as SARS, and by McSherry[30] in the context of responses to detention in related situations such as that of predisposition toward 'dangerousness'. There is as yet little written on the area of legal responses to infectious disease in wildlife populations.

The legal framework within which release of GMOs for control of wildlife in Australia would be regulated is provided by a range of intersecting acts. Federal 1984 (Cth) and State Biological Control Acts, once an agent is declared as a 'biological control agent', limit the capacity to sue to prevent release or to recover damages from the consequences of release. The federal Gene Technology Act 2000 (Cth) is the primary legislation regulating release of GMOs in Australia, and it is the Office of the Gene Technology Regulator established under this legislation which would ultimately be responsible for deciding whether such a release would be approved. Most of the species proposed to be controlled by GMO pathogens are listed as Key Threatening Processes under federal and state Biodiversity Conservation Acts. The Quarantine Act 1908 (Cth) as amended by the Quarantine Amendment (Health) Act 2003, empowers quarantine officers, in the human context, to determine whether a person is, or is likely to be, infected with a quarantinable disease or quarantinable pest, or a source of infection with a quarantinable disease or quarantinable pest. In making that determination they may seek the opinion of a medical practitioner and if they order a person into quarantine they must inform the person of the right to request an independent medical assessment. The Act also provides powers to quarantine domestic stock or crops within Australia and to limit their import. What its implications might be for wildlife populations within Australia is less clear. Internationally, any release of a GMO biocontrol pathogen would have implications under the Cartegena Protocol on Biosafety.[31] However, Australia is not among the 119 countries that have so far

[30] B. Bennett. Travel in a Small World: SARS, globalisation and public health laws. Paper presented at the 28th International Congress on Law and Mental Health, Sydney, 2003; Bernadette McSherry. Indefinite and preventive detention legislation: From caution to an open door. *Criminal Law Journal* 2005; 29: 1–18. See also B.A. Hocking. Emerging infectious disease governance: Canadian responses to SARS; a contribution to building modern liberty? Paper presented at the Association for Canadian Studies in the Netherlands Conference, Midelburg, 2005.

[31] Secretariat of the Convention on Biological Diversity. 2000. *Cartagena Protocol on Biosafety to the Convention on Biological Diversity: text and annexes*. Montreal: Secretariat of the Convention on Biological Diversity.

signed or ratified the protocol.[32] As far as we know, the Office of the Gene Technology Regulator has not been asked for, and nor has it yet provided, an advisory opinion on whether or under what conditions release of a GMO pathogen for biocontrol of vertebrates might be approved.

REMEDIES

Restrictions imposed by quarantine officers have been litigated in Australia as breaches of statutory duty and in negligence. An example of the former is *Tilba Tilba Stud (WA)* v *Executive Officer of Agriculture Western Australia*.[33] The action arose from a decision taken in October 1999 by a stock inspector with the Western Australian Department of Agriculture to issue a quarantine order under powers invested in him by statute. The order was issued after samples from two of the plaintiff's rams tested positive to foot-rot disease. The property remained under quarantine until it was sold in May 2000. Some sheep were moved to another property and released from quarantine. The plaintiffs brought an action against the Department alleging that the quarantine order was negligently issued and maintained and that they suffered financial loss as a result. It was suggested that the breach of duty lay in the failure to exercise due diligence and to inform them of other viable alternatives to the quarantine, and in the insistence that the animals undergo foot bathing treatment. The action failed, suggesting that issues of proof in such cases will be particularly difficult for any potential, aggrieved, plant and animal owners. Indeed, a counter-argument may arise in nuisance where property-owners refuse to comply with quarantine directives and hence contribute to persistence of the disease or pest.

From the ethical perspective perhaps the most contentious dimension to control over emerging disease threats in the plant and animal context lies in the impact those controls may have on humans in transit. Restrictions on plant and animal movement need to be justified in terms that clearly distinguish them from humans seeking migration or refugee status. Yet in Australia in particular there has been an implicit form of analogous reasoning, with one politician inadvertently suggesting during the last

[32] Cartagena Protocol on Biosafety. Montreal, 29 January 2000. Status of Ratification and Entry into Force. 2005. http://www.biodiv.org/biosafety/signinglist.aspx?sts=rtf&ord=dt (accessed 31 May 2005).

[33] Tilba Tilba Stud (WA) v Executive Officer of Agriculture Western Australia. *Australian Torts Reports* 2004; 81: 736.

election campaign that there was little difference between quarantining cats and dogs coming in from overseas and detaining asylum seekers. With an emphasis on national purity and security, the human welfare aspect is diminished. Ian Duncanson[34] has explored the national anxieties that this mood articulates, and comments:

> Like the contemporaneous infections spreading across much of the world, 'mad cow' disease and foot and mouth disease, against which Australia successfully quarantined itself, the asylum seekers are signifiers of the pollution of Australian purity, which is in need of defense.

DISCUSSION AND FUTURE DIRECTIONS

One of the major general problems underlying all of the previous case studies is that there is currently no general ethical basis on which to make decisions regarding environmental or ecological ethics. Over the last few decades, many ethicists have moved beyond an entirely anthropocentric view of environmental ethics.[35] Nevertheless, the extent to which humans might have duties towards populations, species and ecosystems, and the extent to which these entities might have rights beyond those of the individual organisms within them is debatable. As ecology (and epidemiology as a subset of ecology) is fundamentally concerned about processes that arise at these higher levels of organisation, this is an important and unresolved issue, which is now receiving attention both from ecologists and ethicists.[36] This problem is nowhere more evident than when considering wildlife disease, where issues of human health, animal welfare and ecological conservation intersect.

Resolving ethical conflicts in this field, as in others, requires weighing up the consequences of alternative actions. A central feature of all ecological systems (and any host-pathogen interaction is essentially an ecological system) is the high level of intrinsic

[34] I. Duncanson. Telling the Refugee Story: the 'Ordinary Australian', the State of Australia. *Law and Critique* 2003; 14: 29–43.

[35] C. Palmer. 1997. *Environmental Ethics*. Santa Barbara. ABC-CLIO; P. Singer. Neither human nor natural: ethics and feral animals. *Reproduction Fertility and Development* 1997; 9: 157–162; P.W. Taylor. 1986. *Respect for Nature: a Theory of Environmental Ethics*. Princeton. Princeton University Press.

[36] B.A. Minteer & J.P. Collins. *Ecological ethics: a call for a new field.* (unpublished).

uncertainty.[37] Not only do human welfare considerations need to be balanced against conservation and animal welfare, but the consequences in each of these dimensions of any given management action are uncertain. There are established ways in which uncertainty can be included in decision-making,[38] but these require a common currency for all costs and benefits of alternative management actions. The contrasting and apparently incompatible dimensions of ethical considerations for human health, animal welfare and conservation make the application of such tools to wildlife disease extraordinarily challenging.

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[37] D. Ludwig, M. Mangel & B. Haddad. Ecology, conservation and public policy. *Annu. Rev. Ecol. Syst.* 2001; 32: 481–517; J. Harwood. Risk assessment and decision analysis in conservation. *Biological Conservation* 2000; 95: 219–226.

[38] R.C. Jeffrey. *The Logic of Decision.* 1983. Chicago. University of Chicago Press.