Control and eradication of feral cats: field trials of a new toxin

E. C. Murphy[1,2], L. Shapiro[3], S. Hix[3], D. MacMorran[3], and C. T. Eason[3,4]

[1]Research & Development Group, Department of Conservation, Christchurch, New Zealand. <emurphy@doc.govt.nz>. [2]Invasive Animals Cooperative Research Centre, University of Canberra, Canberra, ACT 2601, Australia. [3]Connovation Ltd., 36B Sir William Ave, East Tamaki, Manukau 2013, New Zealand. [4]Faculty of Agriculture and Life Sciences, Lincoln University, PO Box 94, Lincoln, Canterbury 7647, New Zealand.

Abstract Feral cats (*Felis catus*) have caused the decline and extinction of threatened species on islands worldwide. The eradication or long-term control of cats is therefore an essential part of restoring native communities on these islands. In most situations, a combination of lethal techniques is required to remove feral cats, including trapping, hunting and poisoning. Para-aminopropiophenone (PAPP) is being developed as a new, humane poison for feral cats. Mammalian carnivore species appear more susceptible to PAPP than birds, so it potentially has higher target selectivity than other available toxins. A proprietary formulation of PAPP (PredaSTOP) developed by Connovation NZ Ltd. has been shown to kill cats humanely when delivered in a meat bait in pen trials. Two field trials of the formulation were undertaken with radio-collared cats. Toxic baiting was carried out by placing meat baits containing 80 mg PAPP in bait stations. Five of eight radio-collared cats in the South Island study and 13 of 16 radio-collared cats in the North Island study were poisoned. In the latter study, an additional three cats without collars that were monitored using infra-red cameras were also poisoned. Our results indicate that PAPP is an effective toxin for cats in the field, with potential application for their eradication or control on islands.

Keywords: *Felis catus*, field trial, New Zealand, humane, para-aminopropiophenone, PAPP, poison, radio-tracking

INTRODUCTION

Domestic cats (*Felis catus*) were brought to New Zealand from 1769 onwards and transported to many islands where they caused initial extinctions as well as ongoing declines of numerous threatened species (Dowding and Murphy 2001; Gillies and Fitzgerald 2005). Globally, the effects of cats on island vertebrates has been so severe, their eradication or control on some islands has become an essential part of preserving and restoring biodiversity (Courchamp *et al*. 2003; Nogales *et al*. 2004). In most situations, several lethal techniques are required to achieve cat eradication, including trapping, hunting and poisoning (Veitch 1985, 2001; Nogales *et al*. 2004). In a recent review of cat eradications on islands, toxic baits targeting cats were used in 31% of operations where the eradication methods were documented (Campbell *et al*. 2011).

Para-aminopropiophenone (PAPP) is being investigated as a new humane toxin for introduced predators, including feral cats, in both New Zealand and Australia (Marks *et al*. 2004; Fisher *et al*. 2005; Murphy *et al*. 2007; Johnston *et al*. 2011). Previous research on PAPP has explored its potential as a cyanide antidote (Baskin and Fricke 1992), as a radio-protective agent (DeFeo *et al*. 1972), and as a selective toxin for controlling coyotes (*Canis latrans*) (Savarie *et al*. 1983). The toxic effects of PAPP appear to be related to the rapid formation of methaemoglobin in some species. A high concentration of methaemoglobin leads to a rapid and lethal deficit of oxygen in cardiac muscle and the brain, resulting in animals becoming lethargic and unconscious prior to death (Vandenbelt *et al*. 1944; Marrs *et al*. 1991). PAPP has generally lower oral toxicity to birds than to mammalian carnivores, so presents some degree of target selectivity (Savarie *et al*. 1983; Fisher *et al*. 2008; Eason *et al*. 2010). PAPP is rapidly metabolised and excreted and is unlikely to cause secondary poisoning (Wood *et al*. 1991; Eason *et al*. 2010). Dogs (*Canis familiaris*), laboratory rats (*Rattus norvegicus*) and macaques monkeys (*Macaca fascicularis*) given sub-lethal doses of PAPP excreted 75-85% of it within 24 hours (Wood *et al*. 1991). Methylene blue (methylthioninium chloride) is a widely-available and effective antidote for methaemoglobinemia caused by PAPP poisoning (Bodansky and Gutman 1947).

A proprietary formulation of PAPP (PredaSTOP) has been developed by Connovation NZ Ltd. Feral cats fed 80 mg of PAPP in this formulation in meat baits became lethargic after 22-55 minutes, lost consciousness without spasms or convulsions and died after 54 to 125 minutes (Murphy *et al*. 2007). The aim of the study reported here was to determine the field efficacy of PredaSTOP in reducing feral cat numbers, to provide data for registration purposes.

MATERIALS AND METHODS

Study areas

The first trial was undertaken in May 2008 in the South Island, at two sites in North Canterbury: the Patoa pig farm near Culverden (c. 480 ha) and the Kate Valley landfill near Waipara (c. 100 ha). The second trial was undertaken in June 2009 at Ngamatea Station, between Taihape and Napier on the central plateau in the North Island. This site was C. 1500 ha of pasture, pine (*Pinus radiata*) windbreak hedging, and seral vegetation.

Radio tracking

Cats were trapped using Havahart live capture traps and were anaesthetised with intramuscularly injected Domitor (50-100 µg/kg) in the first trial, and Domitor (50-100 µg/kg) and Ketamine (100 mg/kg) in the second trial. Radio transmitters with an external whip aerial were attached to the cats using collars. After securing the collars in the first trial, the cats were injected intramuscularly with Antisedan (125-375 µg/kg) to reverse the anaesthesia until they were fully revived (*c.*10-30 min) and then released. In the second trial, cats were returned to covered cages to recover and released when fully revived (*c.*30-40 min). The radio transmitters (Sirtrack Ltd) emitted 40 pulses per minute with a 'mortality' function that switched to 80 pulses per minute after 12 hours without movement. Tracking was carried out using a TR4 (Telonics, Inc) receiver and a Yagi three-element aerial. Three infra-red motion-detection cameras (DigitalEye12.1 in IR Stealth Flash, Pixcontroller) were used in the second trial to monitor cats visiting bait stations. Cameras were moved around the study area and put at each station for at least two nights in the pre-feeding stage and were then used to check that cats returned to the stations after being radio-collared. Once this was confirmed, the cameras were used to monitor three cats without collars that were consistently identified visiting stations.

Poison baiting

PredaSTOP paste (200 mg) was applied to c.15 g meat baits to deliver 80 mg of PAPP per bait. Meat baits consisted

Pages 213-216 In: Veitch, C. R.; Clout, M. N. and Towns, D. R. (eds.). 2011. Island invasives: eradication and management. IUCN, Gland, Switzerland.

of minced beef (trial 1) and minced rabbit (trial 2) in a ball around the PAPP paste. 'Submarine' bait stations (see Fig 2 in Warburton and Poutu 2002) were used in both trials to minimise non-target interference. Before toxic baiting, pre-feeding was carried out by removing the wire mesh from the ends of the bait stations and placing tracking cards inside. Once prints of cats were found in most feed stations the wire mesh was then attached to either end of the bait station, limiting access to the top entrance.

Trial 1: South Island

Twenty-two bait stations were spread around the pig farm and 10 bait stations were distributed at the landfill. There were three nights of PAPP baiting at the pig farm and eight nights at the landfill. Between one and three baits were placed in each bait station and checked each day to assess condition. Cats were radio-tracked daily to determine whether they were still alive and in the area.

Trial 2: North Island

Toxic baiting was carried out for five nights by placing five baits in each of 22 bait stations spread around the farm. Weather conditions were recorded and baits were checked, counted, removed each morning and replaced each evening. A snow storm on the fourth night meant that this night of baiting was delayed until the following night. As before, cats were radio-tracked daily.

RESULTS

Trial 1: South Island

Eleven cats were captured and radio collared; six were at the Patoa pig farm and five at the Kate Valley landfill. Of the six collared cats at the pig farm, one left the study area before toxic baiting, four were found dead after the first night of baiting, and the remaining cat survived. Four cats without collars were also found dead, three after the first night of baiting, and one after the second night.

Of the five cats collared at the Kate Valley landfill, two were found dead before toxic baiting and appeared to have been crushed by heavy machinery. Of the remaining three collared cats, one was found dead after the first night of baiting and the other two survived. One cat without a collar was found dead after the first night of baiting and a second cat without a collar was found dead after the second night. The additional nights of baiting at the landfill site did not increase mortality amongst the radio-collared cats.

All 11 cats found dead after PAPP baiting (5 radio-collared and 6 without collars) showed cyanosis around the mouth, consistent with poisoning by PAPP. Cats poisoned by PAPP in this trial ranged in weight from 1.31 to 3.35 kg.

Trial 2: North Island

Twenty-one cats were caught and radio-collared; one of these died and four left the study area before toxic baiting. Thirteen of the 16 cats that were alive and in the study area at the time of toxic baiting subsequently died (Table 1). The three cats without collars monitored by cameras were also found dead after toxic baiting. All 16 cats showed cyanosis around the mouth, consistent with poisoning by PAPP. Overall mortality was 0.84 (95% binomial confidence interval 0.60-0.97 for underlying mortality rate) assuming each cat had an equal probability of mortality. Cats poisoned by PAPP in this trial ranged in weight from 1.37 to 4.52 kg.

Over the five nights of toxic baiting there was confirmed bait take by feral cats on 23 occasions, with sixteen of these attributed to the radio-collared and camera-monitored cats. Unidentified cats were therefore also probably poisoned, as bait take and cat prints were recorded from seven bait

Table 1 Details on the feral cats monitored at Ngamatea Station during the poison trial, and their fates. Toxic baiting was carried out for five nights, using five baits in each of the 22 bait stations spread around the site.

Colour/distinctive marks	Sex	Transmitter	Weight (kg)	Fate/days after poison deployed
Black	Female	00	2.60	Died/Night 1
Tabby	Female	22	3.30	Died/Night 1
Tabby	Male	36	2.94	Died/Night 1
Tabby nicked ears	Female	14	2.95	Died/Night 1
Tabby white face	Female	30	3.52	Died/Night 1
Tabby	Female	28	3.32	Died/Night 1
Tabby	Female	66	2.48	Died/Night 1
Tabby white paws	Female	16	2.14	Died/Night 1
Tabby	Female	No collar	1.37	Died/Night 1
Tabby	Male	No collar	4.52	Died/Night 1
Black	Male	24	2.60	Died/ Night 2
Tabby white paws	Male	44	1.73	Died/ Night 2
Tabby	Male	34	2.74	Died/ Night 2
Tabby	Female	76	3.05	Died/ Night 2
Black white collar	Male	38	2.78	Died/ Night 3
Tabby	Male	No collar	1.41	Died/ Night 4
Tabby	Female	20	3.06	Alive
Tabby	Male	46	3.19	Alive
Black white collar	Female	12	3.00	Alive
Black	Female	8	3.01	Outside the trial area
Tabby	Male	32	4.03	Outside the trial area
Tabby	Male	10	4.43	Outside the trial area
Tabby	Male	84	5.75	Outside the trial area
Tabby	Female	88	1.35	Died before the trial began

stations where no carcasses were found. On four occasions, multiple baits in stations were not entirely eaten but a monitored cat was found dead in the vicinity each time.

DISCUSSION

Our results are the first from field trials of PAPP baits targeting feral cats in New Zealand. They support the results of earlier cage trials (Murphy *et al*. 2007), and suggest that PAPP is an effective new tool for feral cat control in the field. Cats also died from partly eaten baits, indicating that using multiple baits in stations could be an effective strategy to overcome the reluctance some cats may have about eating whole baits.

Although feral cats are naturally cautious and can be difficult to trap (Twyford *et al*. 2000; Veitch 1985, 2001), cameras showed that all 21 cats in the North Island trial fed regularly on non-toxic bait from the submarine stations before being captured and collared. Four of the collared cats left the trial area immediately after release, suggesting that these procedures may have changed their normal ranges and behaviour. Although the other cats remained in the area, their foraging behaviour may also have been affected by capture and an association with human presence, possibly explaining why three of them did not enter the bait stations after being collared. In operational poisoning using bait stations, without prior live-capture, a higher bait take and resulting mortality may be achieved.

Nogales *et al* (2004) recommended that feral cats should be routinely eradicated from islands where possible and that new techniques should be developed to do this. PAPP promises to be a useful addition to available tools for cat eradications, especially on larger islands and in the early stages of eradication. After trapping and hunting, the most frequently used technique for eradicating cats from islands is direct poisoning (Nogales *et a*l. 2004). Poisoning can be the most successful and effective technique for reducing the population quickly (Veitch 1985; Twyford *et al*. 2000). The most commonly used toxin for primary poisoning of cats is sodium monofluoroacetate (1080; Campbell *et al*. 2011). Although its use for island eradications of cats has been successful, the use of 1080 can be controversial; it has broad-spectrum toxicity to mammals and birds, and primary and secondary mortality of non-target species can therefore be a concern (Eason 2002; Weaver 2003).

Although mammalian carnivores were more susceptible to PAPP weight-for-weight than most bird species tested, there is some variability (Table 2). Also, as most birds weigh considerably less than cats, some bird species could still be at risk of poisoning if they ingest PAPP baits intended for feral cats (Murphy *et al*. 2005). In Australia, non-target testing has indicated some bandicoots (small marsupial mammals) and varanid lizards are highly susceptible to PAPP (S. Humphreys pers. comm.). Reptiles as a group may be vulnerable to the toxic effects of PAPP, as acetaminophen (paracetamol) is used for control of brown tree snakes (*Boiga irregularis*) on Guam (Savarie *et al*. 2001) and this compound, like PAPP, elevates methaemoglobin to lethal levels in some species. No evidence was found of any non-target species eating PAPP baits in our trials, and we believe the submarine bait stations we used help ensure targeted delivery in our situation.

Other methods are being tested for delivering PAPP to feral cats (and other pests). One example is a tunnel system that uses compressed gas to propel a measured amount of PAPP paste onto the abdomen of pests as they pass over a trigger. Animals become exposed to the paste when they groom their coat. Cage trials have achieved proof of concept for this method as a means of killing stoats (*Mustela erminea*), indicating that a device capable

Table 2 Reported oral LD_{50} values (the dose required to kill 50% of the sample population) for PAPP.

Species	LD_{50} (mg/kg)	Reference
Domestic cat (*Felis catus*)	5.6	Savarie *et al*. 1983
Coyote (*Canis latrans*)	5.6	Savarie *et al*. 1983
Dog (*Canis familiaris*)	7.5	Coleman *et al*. 1960
Stoat (*Mustela erminea*)	9.3	Fisher *et al*. 2005
Bobcat (*Lynx rufus*)	10	Savarie *et al*. 1983
Kit fox (Vulpes velox)	14.1	Savarie *et al*. 1983
Ferret (*Mustela furo*)	15.5	Fisher & O'Connor 2007
Red fox (*Vulpes vulpes*)	< 25.2	Marks *et al*. 2004
Dama wallaby (*Macropus eugenii*)	89	Fisher *et al*. 2008
Badger (*Taxidea taxus*)	c. 100	Savarie *et al*. 1983
Raccoon (*Procyon lotor*)	142	Savarie *et al*. 1983
Rat (*Rattus norvegicus*, albino)	177	Savarie *et al*. 1983
Mouse (*Mus musculus*, albino)	223	Savarie *et al*. 1983
Striped skunk (*Mephitus mephitus*)	> 400	Savarie *et al*. 1983
Brushtail possum (*Trichosurus vulpecula*)	≥ 500	Fisher *et al*. 2008
Guinea pig (*Cavellio porcinus*)	1020	Scawin *et al*. 1984
Mallard duck (*Anas platyrhynchos* Pekin breed)	32	Eason *et al*. 2010
Mallard duck (*Anas platyrhynchos* Pekin breed)	38	Fisher *et al*. 2008
Red-winged blackbird (*Agelaius phoenicus*)	133	Savarie *et al*. 1983
Blackbird (*Turdus merula*)	174	Eason *et al*. 2010
Black-billed magpie (*Pica pica*)	178	Savarie *et al*. 1983
Common crow (*Corvus brachyrhynchos*)	≥ 178	Savarie *et al*. 1983
Coturnix quail (*Coturnix coturnix*)	> 316	Savarie *et al*. 1983
Starling (*Sturnus vulgaris*)	> 316	Savarie *et al*. 1983
Weka (*Gallirallus australis*)	568	Eason *et al*. 2010
Australian magpie (*Gymnorhina tibicen*)	1388	Eason *et al*. 2010

of safely delivering multiple lethal doses of toxin without regular resetting can be produced (Connovation NZ Ltd., unpubl. data).

In conclusion, potential non-target issues for PAPP should be lessened by the development of targeted delivery systems, such as bait stations, tunnel systems, or by specific bait presentations that exploit cat feeding behaviour and physiology (Marks *et al*. 2004; Marks *et al*. 2006; Johnston *et al*. 2011). Few toxins are currently available for the control or eradication of cats. We believe the development of PAPP represents a significant advance. It is humane in comparison to available toxins, more toxic to cats than birds, and presents a low risk of secondary poisoning.

ACKNOWLEDGEMENTS

Thanks to John Dowding for help and advice with the North Canterbury trial and comments on this manuscript. Thanks also to the two referees for their helpful comments and Ian Westbrooke for statistical advice. Thanks to staff at the Kate Valley landfill and the Patoa pig farm for letting us work at their sites and helping with fieldwork. Thanks to Renata Apatu of Ngamatea Station for agreeing to the North Island study and to Martin Benstrum at Central Districts Pest Control for identifying an ideal site. Graham Dixon helped set up the North Island trial and provided ongoing support. Alan Beer and Rod Dixon at Hawkes Bay Regional Council supplied live capture traps and field support. Thanks also to Dr Lynn Booth for QA analyses and Paul Aylett for formulation.

The use of PAPP in these field studies was authorised by the Environmental Risk Management Authority approval numbers HSC000319 and HSC10000. Provisional registration was also obtained from the NZ Food Safety Authority (V9513). All animal manipulations were approved by the Lincoln University Animal Ethics Committee (Approval# 189). The authors acknowledge the funding support of the NZ Department of Conservation under DOC Science Investigation No. 3932.

REFERENCES

Baskin, S.I. and Fricke, R.F. 1992. The pharmacology of *p*-aminopropiophenone in the detoxification of cyanide. *Cardiovascular Drug Reviews 10*: 358-375.

Bodansky, O. and Gutman, H. 1947. Treatment of methemoglobinema. *Journal of Pharmacology and Experimental Therapeutics 90*: 46-56.

Campbell, K.J.; Harper, G.; Algar, D.; Hanson, C.C.; Keitt, B.S. and Robinson, S. 2011. Review of feral cat eradications on islands. In: Veitch, C. R.; Clout, M. N. and Towns, D. R. (eds.). *Island invasives: eradication and management*, pp. 37-46. IUCN, Gland, Switzerland.

Courchamp, F.; Chapuis, J-L. and Pascal, M. 2003. Mammal invaders on islands: impact, control and control impact. *Biological Review 78*: 347-383.

DeFeo, F.G.; Fitzgerald, T.J. and Doull, J. 1972. Synthesis and biologic activity of *p*-hydroxylaminopropiophenone. *Journal of Medicinal Chemistry 15*: 1185-1187.

Dowding, J.E. and Murphy, E.C. 2001: The impact of predation by introduced mammals on endemic shorebirds in New Zealand: a conservation perspective. *Biological Conservation 99*: 47-64.

Eason, C. 2002. Sodium monofluoroacetate (1080) risk assessment and risk communication. *Toxicolgy 181-182*: 523-530.

Eason, C.T.; Murphy, E.C.; Hix, S.; Henderson, R.J. and MacMorran, D. 2010. Susceptibility of four bird species to para-aminopropiophenone. *DOC Research & Development Series 320*. Department of Conservation, Wellington. 15pp.

Fisher, P.M.; O'Connor, C.E. and Murphy, E.C. 2005: Acute oral toxicity of *p*-aminopropiophenone to stoats. *New Zealand Journal of Zoology 32*: 163-169.

Fisher, P.; O'Connor, C.E. and Morriss, G. 2008: Oral toxicity of p-aminopropiophenone to brushtail possums (*Trichosurus vulpecula*), dama wallabies (*Macropus eugenii*), and mallards (*Anas platyrhynchos*). *Journal of Wildlife Diseases 44*: 655-663.

Gillies, C. and Fitzgerald, B.M. 2005: Feral cat. In: King, C.M. (ed.). *The handbook of New Zealand mammals,* pp. 308-326. Second edition. Oxford University Press, Oxford, UK.

Johnston, M.; Algar, D.; O'Donoghue, M. and Morris, J. 2011. Field efficacy of the Curiosity feral cat bait on three Australian islands. In: Veitch, C. R.; Clout, M. N. and Towns, D. R. (eds.). *Island invasives: eradication and management*, pp. 182-187. IUCN, Gland, Switzerland.

Marks, C.A.; Gigliotti, F.; Busana, F.; Johnston, M. and Lindeman, M. 2004. Fox control using a para-aminopropiophenone formulation with the M-44 ejector. *Animal Welfare 13:* 401-407.

Marks, C.A..; Johnston, M.J.; Fisher, P.F.; Pontin, K.M. and Shaw, M.J. 2006. Differential particle size ingestion: promoting target-specific baiting of feral cats. *Journal of Wildlife Management* 70: 1119-1124.

Marrs, T.C.; Inns, R.H.; Bright, J.E. and Wood, S.G. 1991. The Formation of Methaemoglobin by 4-aminopropiophenone (PAPP) and 4-(N-hydroxy) aminopropiophenone. *Human and Experimental Toxicology 10*: 183-188.

Murphy, E.C.; Lavrent, A.; MacMorran, D.; Robbins, L. and Ross, P. 2005. Development of a humane toxin for the control of introduced mammalian predators in New Zealand. *Proceedings of the 13th Australasian Vertebrate Pest Conference*, pp.137-142. Wellington, New Zealand.

Murphy, E.C.; Eason, C.T.; Hix, S. and MacMorran, D.B. 2007. Developing a new toxin for potential control of feral cats, stoats and wild dogs in New Zealand. In: Witmer, G.W.; Pitt, W.C. and Fagerstone, K.A. (eds.). *Managing vertebrate invasive species*, pp. 469-473. Proceedings of an International Symposium, National Wildlife Research Centre, Fort Collins, USA.

Nogales, M.; Martin, A.; Tershy, B.R.; Donlan, C.J.; Veitch, C.R.; Puerta, N.; Wood, B. and Alonso, J. 2004. A review of feral cat eradications on islands. *Conservation Biology 18*: 310-319.

Savarie, P. J.; Ping Pan, H.; Hayes, D. J.; Roberts, J. D.; Dasch, G. J.; Felton, R. and Schafer, E. W. 1983 Comparative acute oral toxicity of para-aminopropiophenone. *Bulletin of Environmental Contamination and Toxicology 30*: 122-126.

Savarie, P.J.; Shivik, J.A.; White, G.C.; Hurley, J.C. and Clark, L. 2001. Use of Acetaminophen for large-scale control of brown tree snakes. *Journal of Wildlife Management 65*: 356-365.

Scawin, J.W.; Swanston, D.W. and Marrs, T.C. 1984. The acute oral and intravenous toxicity of p-aminopropriophenone (PAPP) to laboratory rodents. *Toxicology Letters 23*: 359-365.

Twyford, K.L.; Humphrey, P.G.; Nunn, R.P. and Willoughby, L. 2000. Eradication of feral cats (*Felis catus*) from Gabo Island, south-east Victoria. *Ecological Management & Restoration 1*: 42-49.

Vanderbelt, J.M.; Pfeiffer, C.; Kaiser, M. and Sibert, M. 1944. Methemoglobinemia after administration of p-aminoacetophenone and p-aminopropiophenone. *The Journal of Pharmacology and Experimental Therapeutics 80*: 31-38.

Veitch, C. R. 1985. Methods of eradicating feral cats from the offshore islands in New Zealand. In Moors, P. J. (ed.). *Conservation of island birds: case studies for the management of threatened island birds*, pp.125-142. Cambridge, International Council for Bird Preservation.

Veitch, C. R. 2001. The eradication of feral cats (*Felis catus*) from Little Barrier Island, New Zealand. *New Zealand Journal of Zoology 28*: 1-12.

Warburton, B. and Poutu, N. 2002: Effectiveness of three trapping systems for killing feral cats *DOC Science Internal Series, No. 50*. Department of Conservation, Wellington.

Weaver, S. 2003. Policy implications of 1080 toxicology in New Zealand. *Journal of Rural and Remote Environmental Health 2*: 46-59.

Wood, S.G.; Fitzpatrick, K.; Bright, J.E.; Inns, R.H. and Marrs, T.C. 1991. Studies of the pharmacokinetics and metabolism of 4-aminopropiophenone (PAPP) in rats, dogs and *Cynomolgus* monkeys. *Human and Experimental Toxicology 10*: 365-374.