



Invasive Species and Toxoplasmosis: A Case for Hawaii's Native Wildlife

Invasive Species in Hawaii

Invasive species pose a direct threat to the survival of Hawaii's native wildlife and the health of our unique island ecosystems. Biodiversity on the remote volcanic islands in the Hawaiian archipelago evolved in total isolation over many millennia. Today, Hawaii is recognized as the endangered species capital of the nation, and is a global extinction hotspot. Our high extinction rate can be attributed, in large part, to the introduction of non-native species in this tropical paradise. Because none of their natural predators exist here in Hawaii, invasive species such as the coconut rhinoceros beetle, feral pigs, feral cats, ungulates, rosy wolfsnails, and countless plant species, successfully outcompete our native species for resources such as prey, space, and nutrients. Invasive species also transmit and serve as reservoirs for introduced diseases that native Hawaiian species never evolved protections against (DLNR, 2020).

The damage done by invasive species can be found throughout the entire Hawaiian island chain, but the effects are magnified on the most densely populated island of Oahu. Federal and state agencies have implemented regulatory measures and initiated management actions for many invasive species and diseases, such as red fire ants, the Miconia tree, ungulates, invasive sea weed species, and the fungus that causes Rapid Ohia Death (*C. fimbriate*). Perhaps the most injurious species, at-large* cats, have proven to be an extraordinary regulatory and management challenge in Hawai'i and throughout the world.

Cats are believed to have been introduced in the Hawaiian Islands from sailing ships that arrived in the early to mid 1800's. In the absence of predators, they quickly established feral colonies throughout the islands and just as quickly became a significant threat to our native wildlife. Listed as one of the most harmful invasive species on the planet by the International Union for the Conservation of Nature (IUCN), at-large cats have been determined to be responsible for the extinction of 33 species and are considered the principle threat to 8% of critically endangered birds, mammals, and reptiles worldwide (Medina et al. 2011) (DLNR 2020). At-large cats disrupt Hawaii's ecological balance by preying on native wildlife, including ground nesting seabirds such as the Newell's shearwater, Hawaiian petrel, and Laysan Albatross. They also play a pivotal role in spreading a zoonotic disease (meaning it can affect both animals and people) called Toxoplasmosis. The combination of the direct predation and disease caused by at-large cats pose one of the greatest threats facing Hawaii's endemic species (species that only exist in Hawaii) including marine mammals, and has become the leading cause of disease related mortality for the endangered Hawaiian monk seal.

Cats and Toxoplasmosis

Animals in the family Felidae (including domestic cats) play a crucial role in the life cycle and transmission of the protozoan parasite *Toxoplasma gondii*, the organism that causes toxoplasmosis. Cats are the only host species in which the parasite can produce an infectious stage (called an Oocyst) that is distributed into the environment (this is called a definitive host).

*At-large cats include feral and abandoned cats, and cats that are permitted to roam freely outside.



While many other species can be infected by *Toxoplasma*, it cannot complete its life cycle to produce the infectious stage that is deposited in the environment (these species are called intermediate hosts) (CDC 2020, Hill & Dubey 2002). Although *Toxoplasma* can infect many different species it disproportionately impacts the health of mammals, including humans and marine mammals (Tenter 2000).

Domestic cats are the only definitive host species present in Hawaii, and therefore the only animals that can shed the infectious Oocysts into the environment in their feces (CDC 2020, Hill & Dubey 2002, Tenter et al. 2000). These microscopic oocysts contaminate the environment where they can be ingested by wildlife, and sometimes even humans, causing infections in those intermediate hosts. While ingestion of Oocysts is the most common route of infection, Toxoplasmosis can also be contracted by eating undercooked meat of intermediate hosts, such as feral pigs, deer, goats, and other mammals (Tenter et al, 2000).

Toxoplasmosis and Marine Mammals

Toxoplasmosis is the leading cause of disease related death in Hawaiian monk seals and is one of the two leading threats to the survival this endangered species. Toxoplasmosis has been linked to fatal organ failure and brain damage in monk seals and other marine mammals, to reproductive failure in domestic and wildlife species, and to declines in terrestrial and aquatic wildlife populations (Barbieri et al 2016; Shapiro et al 2016; Sharma et al 2018).

But if cats live on the land, how does *Toxoplasma* infect marine mammals? At-large cats deposit oocysts throughout the environment in their feces. The Oocysts are washed into our streams, waterways, ground water, and storm water systems and then flushed into the ocean. Thus, the beautiful topography and heavy rainfalls that help make these volcanic islands a tropical paradise also contribute to the widespread distribution of toxoplasma oocysts throughout the ecosystem, as water makes it way from mountain tops to the sea. Once Oocysts are introduced into the marine ecosystem, monk seals may ingest them directly or, like many other marine mammals, they may be exposed by eating contaminated or infected prey.

Control Measures:

Is Trap-Neuter-Release Enough?

While there is no way to know the exact number of feral cats in the Hawaiian Islands, the most recent estimate, conducted by Hawaii Humane Society in 2015, showed up to 300,000 feral cats on the island of Oahu alone. Their population growth has been unregulated since then and the current population numbers are likely much higher. One of the approaches to managing feral cats is called Trap-Neuter-Release or Trap-



*At-large cats include feral and abandoned cats, and cats that are permitted to roam freely outside.



Neuter-Return (TNR) and involves trapping feral cats, spaying or neutering them, and then releasing them where they were trapped. This approach has many proponents however careful review of the scientific literature reveals that TNR programs alone are not effective in controlling population growth in feral cats. Moreover, the TNR programs that did report success in stopping population growth or decreasing colony sizes included trapping and removing all kittens from the colonies and euthanasia of any sick cats that were trapped as part of the TNR program.

TNR also fails to resolve the problem that every cat released back into the population still has to find prey and eat, every day for the rest of their lives. For TNR initiatives to have the desired effect of decreasing feral cat populations it would require sterilization of more than 90% of the entire population, and more than 50% of the total population every year (Miller et al, 2014; Andersen et al, 2004; Schmidt et al, 2009; Levy et al, 2014). There is simply not enough capacity, financial support, or infrastructure to achieve this in at-large cat populations.

It is not only feral cats that pose a threat, even our beloved pet cats will kill native wildlife and can become infected with, and spread, toxoplasma if they are allowed to roam outside. All at-large cats pose a serious threat to native wildlife because they hunt and kill vulnerable and endemic species and because they are the only species in the Hawaiian Islands that can shed infectious oocysts into the environment and waterways.

Global Management Approaches

At-large cat populations are a threat to native ecosystems worldwide, and especially on islands (Medina et al. 2011). Other countries, such as Australia and New Zealand, have undertaken comprehensive measures to control at-large cat populations and decrease their damage to the ecosystem. Both New Zealand and Australia have declared feral cats to be pest species and have implemented multi-modal control techniques that include removal through trapping and lethal poisoning (Australia DWLA, 2020; New Zealand GDC, 2020). Public perspectives about at-large cats and how to address the problem varies widely between different cultures, and this has proven to be one of the challenges in Hawaii. Rallying support for broad-based management that includes removal as part of a comprehensive approach to addressing at-large cat populations has proven to be a major impediment in Hawaii.

The Need for Education

Extensive education and outreach are needed on the island of Oahu, precisely because it has the highest population of people, and likely of at-large cats, in our island chain. Many people are unaware of how severely at-large cat populations impact the health of our island ecosystem, our endangered wildlife, and our residents. It is critically important that people throughout Oahu's communities are engaged and provided with accurate information so that we, as a community, can come together to overcome the impasses that have historically prevented implementation of effective management and conservation efforts. Providing community members with the information needed so that people can make their own informed decisions will be essential for successfully implementing broad-based species management programs to support recovery of native wildlife and to bring Hawaii's endemic species back from the brink of extinction.

*At-large cats include feral and abandoned cats, and cats that are permitted to roam freely outside.



What You Can Do to Help

Large-scale, complex problems such as protecting Hawaii’s wildlife, our ecosystem, and our citizens from toxoplasmosis and successfully managing at-large cat populations, require comprehensive solutions and collaboration between community members, organizations, and local, state, and federal agencies. However, it is the cumulative effects of decisions that we, as individuals, make every day that determine the success of all conservation efforts. As informed stewards of our ocean and island ecosystem, you can take simple measures to minimize the impacts of at-large cat populations on Hawaii’s native wildlife and to decrease the risk of toxoplasmosis in animals and people.

If you are a cat owner and also want to support Hawaii’s native wildlife and environment:

1. Spay and neuter your pet cats
2. Keep your cat indoors or confine them when “outside” such as in a “Catio”
3. Microchip your cat so that if they do escape or get lost, you can be reunited quickly
4. If you can no longer care for your pet cat, please surrender it to an animal shelter where it can find another loving home rather than turning it loose outdoors or adding it to a colony of feral cats

If you do not own a cat but want to support Hawaii’s native wildlife and environment:

1. Never feed at-large cats, especially feral cat colonies
2. Continue learning about this subject and help to educate your friends and family about the impacts of invasive species on native environments
3. Support broad based species management by writing to your government representatives and speaking out to let decision makers know that this is important to you
4. Volunteer with the Hawaiian Humane Society to support their efforts, including Trap-Neuter-Release as a component of an integrated management plan
5. Volunteer with Hawaii Marine Animal Response (HMAR) so we can continue to monitor the Hawaiian monk seal population and identify health or behavior concerns that may be tied to an animal’s infection with Toxoplasmosis.
6. Promote adoption of cats that will be kept indoors

*At-large cats include feral and abandoned cats, and cats that are permitted to roam freely outside.



References

- Australian Government Department of Water, Land, and Agriculture. Feral Cats. Retrieved from: <https://www.environment.gov.au/biodiversity/invasive-species/feral-animals-australia/feral-cats>
- Center for Disease Control. Parasites: Toxoplasmosis (Toxoplasma infection). U.S. Department of Health & Human Services. Retrieved from: <https://www.cdc.gov/parasites/toxoplasmosis/biology.html>
- Division of Land & Natural Resources. Invasive Species. Hawaii Invasive Species Council. Retrieved from: <https://dlnr.hawaii.gov/hisc/info/>
- Hill, D., Dubey, J.P. 2002. Toxoplasma gondii: transmission, diagnosis, and prevention. *Clinical Microbiology and Infectious Disease* (8): 634-640.
- Medina, F., Bonnaud, E., Vidal, E., Tershy B., Zavaleta, E., Donlan, J., Keitt, B., Corre, M. Horwath, S., Nogales, M. 2011. Global review of invasive cat impacts on endangered invertebrates. *Global Change Biology* (2011) 17, 3503–3510, doi: 10.1111/j.1365-2486.2011.02464.x
- Tenter, A., Heckerroth, A., Weiss, L. Toxoplasma gondii: animals to humans. 2000. *International Journal for Parasitology* 30(12-13): 1217-1258.
- Feral Cats. 2020. New Zealand Government Department of Conservation. <https://www.doc.govt.nz/nature/pests-and-threats/animal-pests/feral-cats/>
- Walker, J., Bruce, S., Dale, A. 2017. A Survey of the Public Opinion on Cat (Felis catus) Predation and the Future Direction of Cat Management in New Zealand. *Animals* 7(7): 49.
- Barbieri, M.M., Kashinsky, L., Rotstein, D.S., Colegrove, K.M., Haman, K.H., Magargal, S.L., Sweeny, A.R., Kaufman, A.C., Grigg, M.E., and Littnan, C.L. 2016. Protozoal-related mortalities in endangered Hawaiian monk seals Neomonachus schauinslandi. *Dis. Aquat. Organ.* 121(2): 85–95. doi: 10.3354/dao03047. PMID: 27667806.
- Shapiro, K., Miller, M.A., Packham, A.E., Aguilar, B., Conrad, P.A., Vanwormer, E., and Murray, M.J. 2016. Dual congenital transmission of Toxoplasma gondii and Sarcocystis neurona in a late-term aborted pup from a chronically infected southern sea otter (Enhydra lutris nereis). *Parasitology*, 143(3): 276–288. doi: 10.1017/S0031182015001377. PMID: 26494610.
- Rajnish Sharma, Lisa L. Loseto, Sonja K. Ostertag, Matilde Tomaselli, Christina M. Bredtmann, Colleen Crill, Cristina Rodríguez-Pinacho, Dayna Schultz, Dongyun Jung, Kshitiz Shrestha, Prateek Jindal, Emily J. Jenkins. Qualitative risk assessment of impact of Toxoplasma gondii on health of beluga whales, Delphinapterus leucas, from the Eastern Beaufort Sea, Northwest Territories *Arctic Science*, 2018, 4:321-337, <https://doi.org/10.1139/as-2017-0037>
- Miller PS, Boone JD, Briggs JR, Lawler DF, Levy JK, Nutter FB, et al. Simulating free-roaming cat population management options in open demographic environments. *PLoS ONE* (2014) 9:e113553. 10.1371/journal.pone.0113553
- Andersen MC, Martin BJ, Roemer GW. Use of matrix population models to estimate the efficacy of euthanasia versus trap-neuter-return for management of free-roaming cats. *J Am Vet Med Assoc.* (2004) 225:1871. 10.2460/javma.2004.225.1871

*At-large cats include feral and abandoned cats, and cats that are permitted to roam freely outside.



Schmidt P, Swannack T, Lopez R, Slater M. Evaluation of euthanasia and trap-neuter-return (TNR) programs in managing free-roaming cat populations. *Wildlife Res.* (2009) 36:117–25. 10.1071/WR08018

J.K. Levy, N.M. Isaza, K.C. Scott. Effect of high-impact targeted trap-neuter-return and adoption of community cats on cat intake to a shelter. *Veterinary Journal* (2014), 201, (3), pp269-274, ISSN 1090-0233, <https://doi.org/10.1016/j.tvjl.2014.05.001>.