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Exposure of a population of invasive wild pigs to simulated toxic bait containing biomarker: implications for population reduction

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April Publications—NWRC

Bevins, S.N. 2019. Parasitism, host behavior, and invasive species. pgs 273-278. In: J.C. Choe, editor. *Encyclopedia of Animal Behavior, 2nd edition, vol 1.* Elsevier, Academic Press. 3048 pp.

Animal behavior and parasitism are inextricable linked. In many cases, host behavior can affect what parasites are encountered. In other cases, parasites can manipulate the behavior of the host in an attempt to maximize their own transmission. These long-standing interactions are now further complicated by species movement around the globe. The list of introduced species that have become invasive includes parasites that have adapted to new hosts in areas of introduction, as well as invasive hosts that alter the association between existing parasite–host assemblages. Researchers have documented differences in rates of parasitism and in the consequences of parasite infection between invasive and native hosts, and sometimes these differences are a result of behavioral differences, either pre-existing host behaviors or host behaviors that are altered as a consequence of infection. Parasites have been shown to mediate interactions between native and invasive hosts; occasionally, these parasites determine the outcome of invasions. The effects on native species can be severe, and to that end, interactions between invasive species, parasites, and behavior have ramifications for conservation biology.

Campbell, K.J., J.R. Saah, P.R. Brown, J. Godwin, F. Gould, G.R. Howald, A. Piaggio, P. Thomas, D.M. Tompkins, D. Threadgill, J. Delborne, D.M. Kanavy, T. Kuiken, H. Packard, M. Serr, and A.B. Shiels. 2019. A potential new tool for the toolbox: assessing gene drives for eradicating invasive rodent populations. pgs 6-14. In: C.R. Veitch, M.N. Clout, A.R. Martin, J.C. Russell, and C.J. West, editors. *Island invasives: scaling up to meet the challenge*. Occasional Paper SSC no. 62. Gland, Switzerland: IUCN. 752 pp.

Invasive rodents have significant negative impacts on island biodiversity. All but the smallest of rodent eradications currently rely on island-wide rodenticide applications. Although significant advances have been made in mitigating unintended impacts, rodent eradication on inhabited islands remains extremely challenging. Current tools restrict eradication eff orts to fewer than 15% of islands with critically endangered or endangered species threatened by invasive rodents. The Genetic Biocontrol of Invasive Rodents partnership is an interdisciplinary collaboration to develop and evaluate gene drive technology for eradicating invasive rodent populations on islands. Technological approaches currently being investigated include the production of multiple strains of *Mus musculus* with a modifi ed form of the native t-complex, or a CRISPR gene drive, carrying genes or mechanisms that determine sex. These systems have the potential to skew the sex ratio of off spring to approach 100% single-sex, which could result in population collapse. One goal proposed is to test the ability of constructs to spread and increase in frequency in *M. musculus* populations in biosecure, captive settings and undertake modelling to inform development and potential deployment of these systems. Structured ecologically-based risk assessments are proposed, along with social and cultural engagement to assess the acceptability of releasing a gene drive system. Work will be guided by an external ethics advisory board. Partners are from three countries with significant regulatory capacity (USA, Australia, New Zealand). Thus, we will seek data sharing agreements so that results from experiments may be used within all three countries and treat regulatory requirements as a minimum. Species-specific, scalable, and socially acceptable new eradication tools could produce substantial biodiversity benefits not possible with current technologies. Gene drive innovation may provide such a tool for invasive species management and be potentially transformative and worthy of exploring in an inclusive, responsible, and ethical manner.

Engeman, R.M., E. Laine, J. Allen, J. Preston, W. Pizzalato, B. Williams, A.S. Kreider, and D. Teague. 2019. Invasive feral swine damage to globally imperiled steephead ravine habitats and influences from changes in population control effort, climate, and land use. *Biodiversity and Conservation* 28(5):1109-1127. doi: 10.1007/s10531-019-01713-y

Steephead ravines are unusual geological features primarily occurring in Florida's panhandle, a biodiversity hotspot. The unique habitats formed by steepheads are extremely valuable biodiversity resources within this larger area of great biodiversity. Eglin Air Force Base (EAFB) is essential for global conservation of steepheads because this vast area holds the greatest number under single ownership. Steepheads are significantly threatened by feral swine rooting damage. A decade-long investigation of EAFB's steepheads assessed the following: (1) severity of swine damage to steepheads, (2) changing levels of swine control on swine population and damage, (3) changing climatic conditions on damage, (4) changing military land use on damage (5) bioeconomics of damage. Swine damage to 21 EAFB steepheads was assessed 5 times over 10 years. Swine populations were indexed 8 times. Damage and population estimates were related to control effort, military land use, and climate variables to assess influences on damage levels. Monetary values were applied to estimates of total damage across all steepheads. Full control staffing rapidly reduced feral swine abundance and steephead damage. Reduced control staffing and reduced access from increased military activities allowed population rebound and increased damage. Drought possibly increased susceptibility to damage because steepheads provide a steady water source despite climatic circumstance. Estimated damage values across EAFB's steepheads (excluding other resources damaged) was 1.5–11.3 times more than annual control costs. Effective swine control greatly reduces steephead damage. Technological advances may overcome access issues from changing land use. Swine control is a cost-effective steephead conservation approach.

Franklin, A.B., S.N. Bevins, J.W. Ellis, R.S. Miller, S.A. Shriner, J.J. Root, D.P. Walsh, and T.J. DeLiberto. Predicting the initial spread of novel Asian origin influenza A viruses in the continental United States by wild waterfowl. *Transboundary and Emerging Diseases* 66(2):705-714. doi: 10.1111/tbed.13070

Using data on waterfowl band recoveries, we identified spatially explicit hotspots of concentrated waterfowl movement to predict occurrence and spatial spread of a novel influenza A virus (clade 2.3.4.4) introduced from Asia by waterfowl from an initial outbreak in North America in November 2014. In response to the outbreak, the hotspots of waterfowl movement were used to help guide sampling for clade 2.3.4.4 viruses in waterfowl as an early warning for the US poultry industry during the outbreak. After surveillance sampling of waterfowl, we tested whether there was greater detection of clade 2.3.4.4 viruses inside hotspots. We found that hotspots defined using kernel density estimates of waterfowl band recoveries worked well in predicting areas with higher prevalence of the viruses in waterfowl. This approach exemplifies the value of ecological knowledge in predicting risk to agricultural security.

Gese, E.M., P.A. Terletzky, J.D. Erb, K.C. Fuller, J.P. Grabarkewitz, J.P. Hart, C. Humpal, B.A. Sampson, and J.K. Young. 2019. Injury scores and spatial responses of wolves following capture: cable restraints versus foothold traps. *Wildlife Society Bulletin* 43(1):42-52. doi: 10.1002/wsb.954

Wolves (Canis lupus) have been captured with foothold traps for several decades to equip them with radiocollars for population monitoring. However, trapping in most areas is limited to spring, summer, and autumn as cold winter temperatures can lead to frozen appendages in trapped animals. In addition, conflicts arise when domestic dogs encounter these traps in nonwinter seasons. An alternative capture method is the use of cable restraint devices (modified neck snares) in the winter. We evaluated injury scores, movement patterns, and space use of wolves captured in cable restraint devices and foothold traps in north central Minnesota, USA, during 2012–2016. Injury scores did not differ between capture techniques; however, movement patterns and space use were different. We found that the movement away from the capture site appeared to plateau by approximately 8–10 days for wolves captured by either foothold traps or cable restraints, but wolves captured in traps travelled farther away. Daily movement rates reached an asymptote approximately 14 days earlier for wolves captured with cable restraints as compared with wolves caught with foothold traps. We found the space use among wolves caught with cable restraint devices plateaued in a shorter time frame than wolves caught with foothold traps whether using days since capture (38 days earlier) or number of locations (149 locations earlier). When we controlled for seasonal effects and the presence of a capture using locational data collected 6 months later, there was no difference in space use. We concluded that wolves captured in cable restraints recovered more quickly from the capture and resumed space use and activity patterns more rapidly than wolves captured with foothold traps.

Grady, M.J., E.E. Harper, K.M. Carlisle, K.H. Ernst, and S.A. Shwiff. 2019. Assessing public support for restrictions on transport of invasive wild pigs (Sus scrofa) in the United States. *Journal of Environmental Management* 237:488-494. doi: 10.1016/j.jenvman.2019.02.107

Wild pigs (Sus scrofa) are a non-native invasive species in the United States that cause significant economic loss, transmit disease, and inflict damage upon natural resources, agriculture, livestock, and property. Geographic distribution of wild pigs in the United States has nearly tripled since 1982, with anthropogenic influences playing a significant role in the expansion. In this regard, there is speculation that a driver of the expansion may be human-mediated movement of wild pigs to new areas for the purpose of sport hunting. In response, states have implemented a variety of wild pig control policies, including legal restrictions on their transport. The success of such policies depends, in part, on their level of public support, which in turn may be influenced by individuals' attitudes concerning wild pigs, their interest in maintaining wild pig populations (e.g., for sport hunting), and their knowledge and awareness of the threats wild pigs pose. Multiple regression was used to analyze data collected from a nationwide survey concerning attitudes toward wild pigs and policies that restrict their transport. Results indicate that a majority of individuals in the United States have negative attitudes toward wild pigs and support policies that restrict their transport and penalize transgressors. Consistent with other invasive species research, findings suggest that as knowledge and awareness of wild pigs increase, so too does support for policies restricting and penalizing transport of wild pigs. Contrary to previous studies, this research also finds that hunters are more likely to support restrictions on wild pig transport than are non-hunters. Overall, these findings suggest that legal restrictions on the transport of wild pigs, even in states with large hunter populations, enjoy broad public support and may help to curb the expansion of wild pig populations.

Snow, N.P., M.J. Lavelle, J.M. Halseth, M.P. Glow, E.H. VanNatta, A.J. Davis, K.M. Pepin, R.T. Tabor, B.R. Leland, L.D. Staples, and K.C. VerCauteren. 2019. Exposure of a population of invasive wild pigs to simulated toxic bait containing biomarker: implications for population reduction. *Pest Management Science* 75(4):1140-1149. doi: 10.1002/ps.5235

BACKGROUND: An international effort to develop an acute and humane toxic bait for invasive wild pigs (*Sus scrofa*) is underway to curtail their expansion. We evaluated the ability to expose a population of wild pigs to a simulated toxic bait (i.e., placebo bait containing a biomarker, rhodamine B, in lieu of the toxic ingredient) to gain insight on potential population reduction. We used 28 GPS-collars and sampled 428 wild pigs to examine their vibrissae for evidence of consuming the bait.

RESULTS: We estimated that 91% of wild pigs within 0.75 km of bait sites (total area = 16.8 km2) consumed the simulated toxic bait, exposing them to possible lethal effects. Bait sites spaced 0.75–1.5 km apart achieved optimal delivery of the bait, but wild pigs ranging ≥ 3 km away were susceptible. Use of wild pig-specific bait stations resulted in no non-target species directly accessing the bait.

CONCLUSION: Results demonstrate the potential for exposing a large proportion of wild pigs to a toxic bait in similar ecosystems. Toxic bait may be an effective tool for reducing wild pig populations especially if used as part of an integrated pest management strategy. Investigation of risks associated with a field-deployment of the toxic bait is needed.

Yackulic, C.B., L.L. Bailey, K.M. Dugger, R.J. Davis, A.B. Franklin, E.D. Forsman, S.H. Ackers, L.S. Andrews, L.V. Diller, S.A. Gremel, K.A. Hamm, D.R. Herter, J.M. Higley, R.B. Horn, C. McCafferty, J.A. Reid, J.T. Rockweit, and S.G. Sovern. 2019. The past and future roles of competition and habitat in the range-wide occupancy dynamics of northern spotted owls. *Ecological Applications* 29(3):e01861. doi: 10.1002/eap.1861

Slow ecological processes challenge conservation. Short-term variability can obscure the importance of slower processes that may ultimately determine the state of a system. Furthermore, management actions with slow responses can be hard to justify. One response to slow processes is to explicitly concentrate analysis on state dynamics. Here, we focus on identifying drivers of Northern Spotted Owl (Strix occidentalis caurina) territorial occupancy dynamics across 11 study areas spanning their geographic range and forecasting response to potential management actions. Competition with Barred Owls (Strix varia) has increased Spotted Owl territory extinction probabilities across all study areas and driven recent declines in Spotted Owl populations. Without management intervention, the Northern Spotted Owl subspecies will be extirpated from parts of its current range within decades. In the short term, Barred Owl removal can be effective. Over longer time spans, however, maintaining or improving habitat conditions can help promote the persistence of northern spotted owl populations. In most study areas, habitat effects on expected Northern Spotted Owl territorial occupancy are actually greater than the effects of competition from Barred Owls. This study suggests how intensive management actions (removal of a competitor) with rapid results can complement a slower management action (i.e., promoting forest succession).