5 year Strategic Plan for CHeRI
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Executive Summary

Deer farming is one of the fastest growing industries in rural North America. It generates $8 billion for the US economy and employs >60,000 people. In addition to improving local economies, deer farms have the potential to improve habitat for other wildlife species. The Florida deer farm industry is the third largest in the nation and is vibrant and growing. Florida has approximately 400 deer farms that breed trophy deer and/or provide hunting opportunities to resident and non-resident hunters (Anderson et al. 2017).

In response to Florida stakeholders, the Florida Senate in FY 2014 provided a continuing academic appropriation to UF IFAS to form the Cervidae Health Research Initiative (CHeRI). CHeRI seeks to promote interdisciplinary science, education, and outreach that increases the health and production of captive cervids and bovids in a sustainable manner and promotes the health of native wildlife and the ecosystems in which they live. The cervid farming industry has identified hemorrhagic disease (HD) as a top priority for research and technical assistance from CHeRI. HD includes epizootic hemorrhagic disease virus (EHDV) and bluetongue virus (BTV), which is the most important viral disease of native and captive-farmed North American deer and elk.

HD also decreases production in cattle and is a disease of concern among cattle ranchers in Florida. Small, family-owned farms are disproportionately affected by HD because they are not able to absorb many losses due to the small profit margin that characterizes the commodity industry. We have developed a multi-pronged approach to reduce mortality and increase production in deer and cattle. We are developing an integrated pest management plan and a best farm management plan; we are increasing diagnostic capabilities for detection and management of disease; and we are working with 2 vaccine producers to ensure that new vaccines will be effective in the virus strains that circulate in Florida.

Goals for the next 5 years:

- Engage the deer farm industry in Florida and create a network of cooperators
- Develop best management practices (BMP) for hemorrhagic disease (HD), including determination of disease drivers for acute HD, and development of efficacious vaccines
- Identify and develop BMP for other infectious diseases in fawn and adult deer
- Create an integrated pest management plan for *Culicoides spp.*, the vectors of HD
- Create useful decision-making tools for the livestock industry

Engaging producers in CHeRI

All aspects of CHeRI rely on our ability to connect with deer farmers. As researchers and extension specialists involved in CHeRI, we work directly with deer farmers to better understand the specific needs and practices of the industry.   One of our first goals was to hire a faculty member that is the extension specialist for this industry. That goal has been realized and with the addition of Dr. Juan Campos in 2017, we will continue this dialogue and begin to take quantitative assessment of needs and practices. From its inception, CHeRI research has been driven by our ability to listen to producers to understanding their needs and practices. We have attended trade shows and made dozens of field visits. We regularly hold workshops, focus group studies and surveys with a goal of engaging stakeholders and assessing their needs.

Engagement of stakeholders is also imperative in downstream aspects of research. Our success thus far has and will continue to depend on collaborations with deer farmers to collect data that helps solve problems. Access to animals on deer farms allows us to address questions of health and disease that is not possible in free-ranging wildlife. It also allows us to work with farmers to assess and fine tune best management practices that will help farmers increase production by reducing disease transmission and improving treatment regimes.

Finding and implementing solutions will require additional collaboration with the deer farm industry. Ultimately our goal is provide useful technologies and decision-making tools for best management practices. It is therefore imperative that as we produce products, we continue to build trust and credibility within the industry. As we begin to make research discoveries that support our goals, we will work with farmers to implement new technologies and design the best platforms for decision-making tools. Making science usable and relevant requires listening and involving the producers in solutions in an iterative fashion similar to adaptive management (Figure 1).

Figure 1. Iterative process that defines the CHeRI research agenda
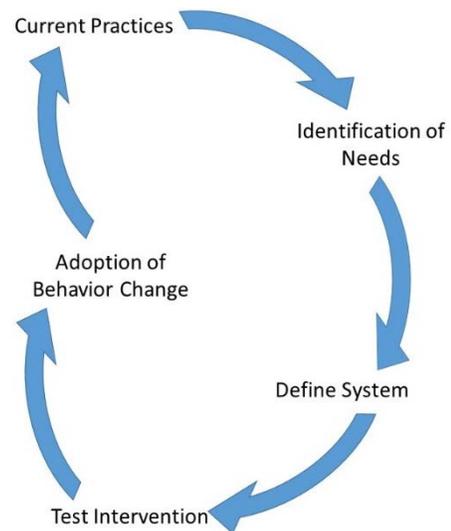
A Focus on Epizootic Hemorrhagic Disease

Key to the success of any farm is the production and maintenance of healthy deer. As reported by the industry, the biggest hurdle to maintaining healthy deer in Florida is epizootic hemorrhagic disease virus (EHDV).

This disease is caused by a virus carried by biting midges (no-see-ums, *Culicoides* spp.) and is prevalent throughout Florida. Captive deer often become sick and die within a few days of the onset of symptoms. Native, free-ranging deer become infected as well, but their population numbers are not threatened by the disease. For this reason, Florida Fish and Wildlife Commission does not actively manage for the disease.

For deer farmers, who manage small numbers of deer, even the loss of a few deer to EHDV can have a large economic impact. In 2012, deer farmers were hit particularly hard by EHDV and many suffered large economic losses (estimated to be approximately $30M statewide). For deer farming to remain a viable industry, solutions to mitigate the devastating effects of EHDV must be found.

Captive deer farmers have partnered with researchers from University of Florida Institute of Food and Agricultural Sciences to better understand EHDV and to find solutions for deer farmers. EHDV is a complex and poorly understood disease, which makes quick solutions impossible. Confounding factors include: a) the presence of multiple co-circulating viral strains in Florida, b) the *Culicoides spp.* that transmit the virus to deer have not been determined, c) multiple cervid species are affected, d) a complex epidemiological picture of the disease including acute, subclinical and chronic forms.

Research is needed to help deer farmers better manage their deer farms and reduce disease outbreaks. Long-term research needs include:

- Development of best management practices to reduce farmed deer mortality from EHDV
- Development of an EHDV outbreak model that predicts in advance when and where EHDV outbreaks will occur, so that deer farmers can prepare and prevent outbreaks
- Development of an efficacious vaccine for EHDV in deer

A major focus of the deer industry nationwide is to better understand the epidemiology of EHDV so that we can break or reduce the cycle of transmission. CHeRI was in fact born from the EHDV outbreak that devastated the industry statewide in 2012. Using the needs-based research model (Figure 1), we have identified the practices and needs of the industry, and the basic research that works towards a solution in combatting EHDV (Table 1).

In 2018, we partnered with two EHDV vaccine developers, MedGene and Kansas State University, to ensure that EHDV strains from Florida will be represented in the vaccine and thus protect Florida deer. We have partnered with multiple producers throughout the state to help us conduct field tests of the vaccine such that we know they will be effective in Florida. In 2016, we conducted a similar field trial of a commercially available vaccine and determined that it was not effective and did not protect animals from EHDV.

In 2018, Bluetongue Virus was the main cause of death in Florda farmed deer reminding us that additional vaccine interventions need to be developed for this virus as well.

A Focus on Reducing Mortality

In 2016, we initiated a dead deer hotline whereby farmers could report a dead animal and submit it for necropsy. In its first year, 15 farms participated and 246 animals were submitted. Necropsies revealed that while many animals did indeed die from EHD, many animals were misdiagnosed from clinical symptoms only. In fact many deer died from severe bronchopneumonia whose clinical symptoms only superficially resembled EHD. In the coming months and years, our extension specialists and researchers will work with deer farmers to identify common causes of death and develop best management practices including diagnosis, treatment and prevention to increase survival of adults and production of fawns. From 2016, we have developed an initial list of disease syndromes and pathogens that need to be evaluated more carefully in coming years (Table 2).

Working Toward Decision-Making Tools for EHD Management

Commodity production increasingly relies on decision-making tools for best management practices. Pesticide application, nutrient application, harvest timing and breeding can all be made more efficient and therefore cost effective if decisions are made based on the best available information about the production system. The best tools are those that are based on industry needs. We will use our iterative process of research design and stakeholder participation to develop decision-making tools that aid Florida deer farmers to increase production and quality of animals. Potential tools include:

- Pesticide application and deer vaccination calendar based on vector and/or virus emergence
- Risk calculator that shows locations of high risk of EHD emergence
- Encyclopedia of common deer farm diseases
- Stocking calculator that allows users to input the cervid species they want to farm and the acreage of their pens/preserves.
- Wildlife Conservation Certification program that deems farms wildlife friendly if they meet certain environmental milestones.

References

Anderson, D.P., Frosch, B.J., Outlaw, J.L. 2017. Economic impact of the United States cervid farming industry. Agricultural and Food Policy Center, The Texas A&M University System. APFC Research Report 07-4.

Table 1. Deer Farm Practice and/or the Needs identified by CHeRI to combat EHDV. The third column identifies the research that CHeRI funds to address those needs and the fourth column identifies the benefit to deer farmers.

Practice	Need	Research Needed	Outcome and Application
EHDV and BTV Vaccination/Treatment	Efficacy Studies of all available vaccines	Field trial Newport Vaccine (completed)	Reduce use of ineffective vaccine. Farm specific field trials likely needed to establish buy-in
		Identification of and collaboration with other vaccine producers (ongoing)	Assess the state of knowledge for vaccine development and production
		Challenge studies with naïve animals using novel subunit vaccines (ongoing collaboration with vaccine makers)	Test promising vaccines to hasten their production and marketing
	Understand HD epidemiology	Longitudinal studies of individual and population serology in white-tailed deer; longitudinal studies of EHDV genetics	Development of transmission and epidemiological models that will aid in predicting risk at the farm, regional, and national scale. Will aid in development of vaccine schedule and composition from year to year
Permethrin spraying is used statewide without guidance on effective application	Efficient, cost effective application of pesticide	Test efficacy of new pesticide products	Field trial of permethrin wrapped fences (completed)
		Vector ecology studies (underway)	Essential to emergence modeling
		Development of vector emergence model that allows farmers to focus timing and location of pesticide application	Essential to integrated pest management and recommendations for pesticide application
		Development of attractants (ongoing)	Can aid in reducing host-vector interaction
		Integrated pest management (additional funding needed)	Management of substrates, pesticide use, attractant use, health effects on deer
		Vector competency studies (completed)	By defining which Culicoides are competent vectors we can focus our ecological studies

		Development of biocontrol agents that do not involve chemical control (additional funding needed)	Species specific pest control that reduces bycatch and increases biodiversity
Comingle exotics	Identification of reservoir hosts	Identify which species are refractory and which are reservoirs. (ongoing)	Make recommendations about which cervids may increase the risk of EHDV to white-tailed deer
		Develop SIR model of host species composition	
High density penned animals	Best stocking density	Prevalence of pathogen/exposure may be different in populations of different density	Recommendations of BMP on stocking density for farmed cervids
		Develop SIR model of different host densities	
Improper diagnosis of EHD	Better, cheaper, faster diagnostics	Develop UF diagnostic pipeline to identify HD and non-HD causes of death and morbidity (ongoing)	Free, reliable diagnostic services for the deer farm industry are now available to Florida deer farmers
Inconsistent vaccination year to year	Understand regional risk of EHD each year		Development of effective vaccines that are delivered to animals in a consistent and therapeutic way.
	Formulate regional vaccines based on predictive modeling of dominant strains	Risk models of EHD emergence	

Table 2. Causes of mortality other than EHDV, the research need, and application to the deer farmer

Pathogen or disease syndrome identified in Florida-farmed deer	Research Needed	Application to deer farmer
Sepsis/enteritis	Novel diagnostics that consider the entire microbiota and coinfections	Better diagnostics will help veterinarians and deer farmers treat deer with appropriate therapies
Co-infections associated with EHDV	Many animals are infected with EHDV but are asymptomatic. Need to understand what makes EHDV pathogenic at the host and pathogen level	Treating the co-infection may increase survival and reduce mortality
Trueperella pyrogenes	Surveillance to understand the true cost of this pathogen	Develop an appreciation for symptoms, treatment and BMP that reduce trueperella infection.
Cervidpox virus	Surveillance to understand the true cost of this pathogen	This pathogen was found in moribund fawns for the first time on a farm in Florida. Increased familiarity with symptoms and appropriate treatment regimes will reduce mortality