A. Cover Page

1. Project Title: Vector-based, GnRH Immunocontraception Vaccine for Rodent Control

2. Project Leader:

Mohammed Selman, Ph.D.
Chief Scientist
The Amber and Adam Tarshis Foundation
2105 Beverly Blvd, 217A, Los Angeles, CA, 90057
Phone: 323-350-3178
Email: mohammed@tarshisfoundation.org

3. Cooperator(s): NA

4. CDFA Funding Request Amount/Other Funding:

CDFA Funding request:	PY1 (2026) = $50,000
Other funding (Tarshis Foundation):	PY1 (2026) = $45,000

5. Agreement Manager:

Adam Tarshis
The Amber and Adam Tarshis Foundation
2105 Beverly Blvd, 217A, Los Angeles, CA, 90057
Phone: 323-333-2116
Email: adam@tarshisfoundation.org

B. Executive Summary

1. Problem: California farmers and ranchers lose millions of dollars every year because of vertebrate pests. Ground squirrels, roof rats, feral wine, and pest birds such as pigeons destroy crops, damage irrigation systems, and degrade rangeland. Existing tools—trapping, fumigation, and chemical poisons—have serious drawbacks. They are expensive, labor-intensive, and often temporary because pest populations rebound quickly. Poisons also harm non-target species through secondary poisoning, including raptors and carnivores, and create long-term environmental risks. Using immunocontraceptive vaccines that target the reproductive hormone gonadotropin (GnRH) has been shown to effectively induce infertility and help control invasive wildlife populations. For example, GonaCon, a USDA-developed and EPA-approved GnRH vaccine, has been used in wild horses, deer, and feral pigs in the

U.S. However, the limitations of GonaCon and similar vaccines are that they require intramuscular injection and are not species-specific, making them unsuitable for smaller vertebrate pests such as rodents.

2. Objectives, Approach, and Evaluation: The overarching objective of this project is to determine if rodent-specific GnRH-based immunocontraception delivered via an oral bait is a better alternative to current pest control methods and rodenticides. The approach will combine protein engineering, vaccine vector design and *in vivo* testing. Several GnRH fusion proteins have been designed and tested by various research groups for immunocontraception. However, the lack of standardized protocols and the inconsistency in species used make it difficult to compare their utility for rodent-targeted applications, highlighting the need for a direct, head-to-head comparison of available GnRH antigenic proteins. To address this, we have selected three previously tested antigenic carrier proteins for further evaluation, each fused with multiple copies of GnRH to increase antigen density and enhance immunogenicity. These purified recombinant proteins will be assessed both in vitro and *in vivo*, and then inserted into a rodent-specific viral delivery vector, based the Volepox virus, a DNA virus from the poxvirus family. *In vivo* testing of the vaccine candidates will follow a defined immunization and monitoring schedule. Evaluation will be based on each candidate's ability to elicit strong and durable anti-GnRH antibody responses correlated with reduced reproductive hormone levels and reproductive organ size. Comparisons across GnRH protein constructs will identify the most effective antigen, with viral vector delivery benchmarked against our earlier fusion protein results. These studies will provide key outcomes needed to evaluate the feasibility of GnRH-based immunocontraception for rodent population management.

3. Audience: The primary beneficiaries of this work are California growers and ranchers, who face heavy losses from vertebrate pests and need affordable, practical solutions. Pest control professionals will gain a humane tool to add to integrated pest management programs. Wildlife managers and conservation groups will benefit from a method that avoids secondary poisoning of predators and reduces ecological risk. Regulators and policymakers will have a science-based option that balances agricultural productivity with environmental stewardship and animal welfare. This work will generate data and tools that advance vaccination, reproductive biology, and alternative contraceptive research.

References:

Guerrero, S. California almond farms are facing a $310M rat problem. SFGATE https://www.sfgate.com/food/article/california-almond-farms-rat-infestation-20814345.php (2025).

Gov. Newsom Signs Bill Protecting Wild Animals from Super-toxic Rat Poisons. Center for Biological Diversity https://biologicaldiversity.org/w/news/press-releases/gov-newsom-signs-bill-protecting-wild-animals-super-toxic-rat-poisons-2020-09-29/.

C. Justification

1. CDFA VPCRAC Mission and Responsibilities: The California Department of Food and Agriculture's Vertebrate Pest Control Research Advisory Committee (VPCRAC) is charged with addressing research priorities that advance effective, economical, and humane methods for controlling vertebrate pests that threaten California's agricultural economy, infrastructure and natural resources. Guided by the objectives established under the VPCRAC, it seeks to identify and support research that develops alternative pest management tools, generates the scientific data needed to maintain or register control products, and reduces reliance on harmful or outdated toxicants.

   This project directly contributes to the VPCRAC mission by exploring immunocontraceptive vaccines as a sustainable alternative to rodenticides for population-level control of rodent pests in California. By evaluating GnRH protein antigens, advanced vaccine formulations, and vectors capable of oral delivery, the research addresses VPCRAC priorities of investigating new materials, developing humane methods, and generating data to support effective and environmentally responsible vertebrate pest control. In doing so, it supports CDFA's broader mandate to protect California's agricultural productivity, safeguard biodiversity, and promote long-term ecological and public health resilience.

2. Impact: The proposed project has the potential to generate meaningful agronomic, economic, environmental, and public health benefits across California. From an agronomic perspective, fertility suppression in key pest species such as roof rats will directly protect high-value crops, including nut and citrus orchards, vineyards, and rangelands, from destructive feeding and burrowing. By reducing rodent pest populations, growers will see healthier crops, more consistent yields, and less structural damage to irrigation systems and levees that are critical to California's agricultural productivity.

   Economically, the implications are substantial. Current estimates suggest that vertebrate pests cost California growers hundreds of millions of dollars annually through direct crop losses, damage to infrastructure, and ongoing control expenses. Even modest reductions in pest population growth could translate into tens of millions of dollars in avoided losses each year. By decreasing reliance on poisons, fumigants, and repeated trapping, this project offers a cost-effective alternative that helps stabilize farm operating budgets while reducing the labor demands of pest management.

The environmental impact of new methods of pest control is increasingly significant in California, where legislation such as the California Ecosystems Protection Act (AB 1788) has placed strong restrictions on second-generation anticoagulant rodenticides (SGARs) due to their devastating effects on non-target wildlife (Center for Biological Diversity) These poisons not only eliminate rodents but also contaminate the food chain, leading to secondary poisoning in predators such as mountain lions, bobcats, hawks, and endangered species like the San Joaquin kit fox. By shifting the focus [i]from lethal chemical control to a targeted fertility vaccine, this project aligns with California's sustainability and climate-smart agriculture initiatives. It provides a solution that not only protects agriculture but also preserves biodiversity and ecosystem health. (Center for Biological Diversity).

Taken together, the proposed vaccine approach has the potential to provide local benefits to growers, regional benefits to farming communities, and statewide benefits to California's agricultural economy, natural resources, and public health.

3. Long-Term Solutions: This project lays the foundation for a durable, population-level fertility control strategy. Unlike poisons, which require repeated applications and cause quick pest rebound, immunocontraception provides a long-term reduction in reproduction rates. The vaccine platform is adaptable, allowing tailoring to multiple pest species. This positions the project as a pathway to measurable, sustainable suppression of vertebrate pests across California's agricultural landscapes, reducing recurring economic and environmental costs.

4. Related Research: Immunocontraception targeting gonadotropin-releasing hormone (GnRH) has been extensively studied as a tool for managing wildlife and livestock populations (USDA APHIS 2017). This work has led to the development of commercial products such as GonaCon, used in wild species like deer and feral swine, and Improvac, approved for farmed pigs. While these vaccines demonstrate that antibody-mediated suppression of fertility is feasible, a major limitation is their reliance on intramuscular injection, which is effective for large, accessible animals but impractical for smaller vertebrate pests, where capture at scale is not feasible. This challenge has motivated research into new generations of GnRH protein antigens and improved formulations, as well as exploring novel delivery methods. One promising avenue is the use of poxvirus vectors, which combine immunogenicity with stability under field conditions. A notable example is the RABORAL V-RG vaccine, a recombinant poxvirus expressing the rabies glycoprotein, which vaccinates raccoons when consumed orally from specially formulated bait (Maki et al. 2017). Approved by the EPA and deployed in multiple U.S. states, RABORAL V-RG demonstrates the potential of poxvirus-based oral vaccines as scalable platforms for wildlife immunization.

5. Contribution to Knowledge Base: This project will significantly expand both the scientific and applied knowledge base for vertebrate pest management. Building on prior work, our research will compare current protein antigen strategies and investigate poxvirus vectors for oral

delivery, including studies with the rodent-specific Volepox virus (a DNA virus from the poxvirus family), with the goal of advancing understanding of oral vaccination in rodent populations. The research bridges the gap between laboratory innovation, in the fields of reproductive biology, virology, and vaccinology, and landscape-scale pest management, providing essential evidence to guide regulatory and policy discussions around alternatives to rodenticides while supporting California's climate-smart agriculture and biodiversity conservation initiatives.

6. Grower Use: The proposed vaccine platform is designed with grower adoption in mind. By offering an oral bait, the technology has the potential to lower management costs by reducing the need for poisons, fumigants, and repeated trapping. Because the baits are compatible with existing bait station infrastructure, they can be integrated seamlessly into on-farm operations without requiring major new investments. Importantly, the approach provides a regulatory advantage, as it represents a non-lethal, environmentally responsible method that aligns with tightening restrictions on rodenticides (e.g., California's statewide restrictions on second-generation anticoagulants in 2020) (Center for Biological Diversity, 2020) and growing public demand for sustainable agricultural practices. For growers, the most tangible incentive will be improved crop protection and profitability through measurable reductions in pest damage to both crops and infrastructure. For example, rats alone are estimated to have caused $109-310 million in damages to California almond growers in 2024 (Goodhue et al 2025), losses that could be significantly reduced by long-term fertility control. By fitting naturally into existing Integrated Pest Management (IPM) programs, this platform offers a practical, scalable, and grower-friendly solution for controlling vertebrate pests in California.

References:

Maki, Joanne, Anne-Laure Guiot, Michel Aubert, et al. 2017a. "Oral Vaccination of Wildlife Using a Vaccinia–Rabies-Glycoprotein Recombinant Virus Vaccine (RABORAL V-RG®): A Global Review." *Veterinary Research* 48 (1): 57. https://doi.org/10.1186/s13567-017-0459-9.

Gov. Newsom Signs Bill Protecting Wild Animals from Super-toxic Rat Poisons. Center for Biological Diversity https://biologicaldiversity.org/w/news/press-releases/gov-newsom-signs-bill-protecting-wild-animals-super-toxic-rat-poisons-2020-09-29/.

USDA APHIS Wildlife Services-The Use of GonaCon in Wildlife Damage Management (2017) https://www.aphis.usda.gov/sites/default/files/11-gonacon.pdf

CDFA - Plant Health - Integrated Pest Control - Vertebrate Pest Control Research Program. https://www.cdfa.ca.gov/plant/ipc/vertebrates/vertebrates_hp.htm.

Goodhue, R. E., Mace-Hill, K. & Raburn, S. CDFA Memo: Rat Damage in Almond Orchards.

https://www.cdfa.ca.gov/oars/opca/docs/Preliminary_analysis_of_rat_damage_in_almonds_2025_0211.pdf

D. Objectives

1. With this grant application, we are focusing on evaluating three versions of GnRH fusion proteins, testing their efficacy both *in vitro* and immunocontraception *in vivo*, and using the Volepox (VPXV) virus to deliver the vaccine to rodents.

E. Workplan and Methods

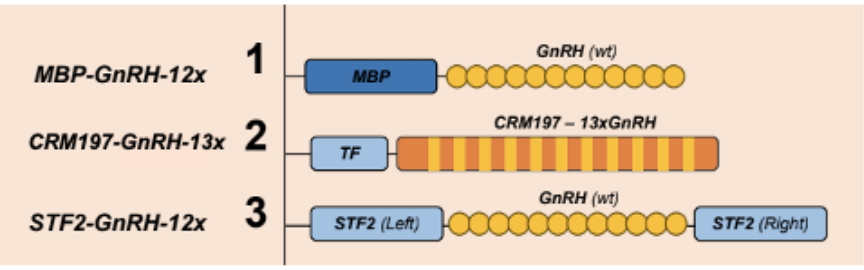

Figure 1. Diagram of GnRH-fusion constructs to be tested under this grant.

1. Work Plan: Our vaccine targets gonadotropin-releasing hormone (GnRH), a key reproductive hormone that regulates fertility. Because GnRH is small (11 amino acids) and poorly immunogenic on its own, it is fused with antigenic carrier proteins to enhance its immunogenicity. Such fusions provide T-cell epitopes, improve antigen processing and presentation, and increase stability and solubility. This strategy ensures that the immune system recognizes GnRH as part of a larger foreign protein, driving the robust antibody production needed for effective immunocontraception. In our internal studies, we have tested a Maltose Binding Protein (MBP) fused with 12 copies of GnRH. Several other antigenic carrier proteins have also been identified and tested in combination with GnRH (Lee et al. 2019, Duan et al. 2024, Zhang et al.). We will test two protein fusion alternatives: STF2(Salmonella typhimurium flagellin)(Lee et al. 2019) and CRM197 (Cross-reacting material 197) (Duan et al. 2024, Cui et al. 2024) (Fig 1). The choice of these antigens is governed by extensive biophysical and structural studies (Lee et al. 2019; Duan et al. 2024) At the same time, we and others have shown that introducing multiple copies of GnRH enhances both antigen density and immune recognition (Duan et al. 2024). Multiple copies also improve antigen presentation and help sustain a more durable immune response, increasing the chances of long-term suppression of reproductive hormones for effective immunocontraception. Based on our preliminary results (see Fig 2), we are optimistic that the new fusion proteins will be even more immunogenic while eliciting GnRH specific immune response.

   After *in vitro* testing, selected protein-encoding constructs will be cloned into the Volepox vector and characterized *in vitro*. Towards this goal, we have already characterized three rodent poxviruses and performed host range compatibility studies, which determined that Volepox

virus is an ideal vector for future testing of oral delivery in rodents. In preparation for poxvirus vector delivery, our lab has successfully engineered a recombinant GFP-labeled variant of Volepox virus with 11 deletions in host immune–related genes, rendering it ready for insertion of the GnRH-coding fusion cassette. Vaccines will be delivered either intramuscularly or orally. Immune and physiological responses will be monitored by measuring anti-GnRH antibody levels, hormone concentrations, and reproductive organ parameters post-immunization.

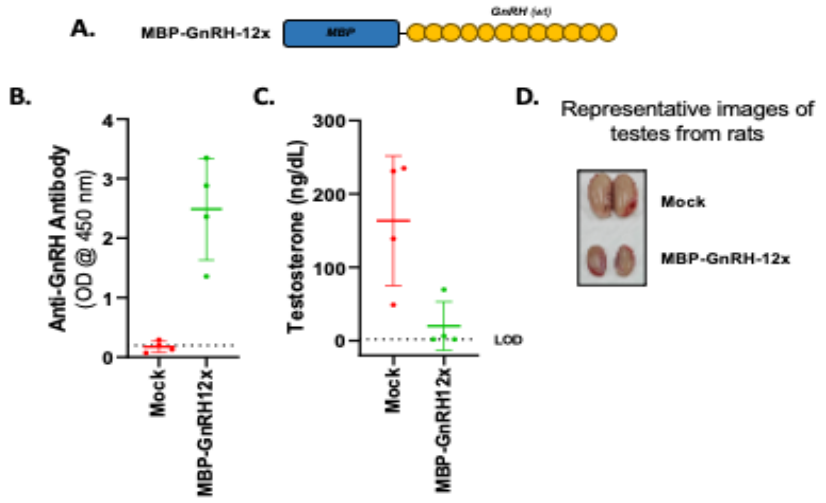

Figure 2. Characterization of the leading Rodent Specific Vaccine Candidate (A) Diagram of MBP-GnRH fusion protein tested *in vivo* in male. (B) Vaccination with MBP-12XGnRH led to a 12X fold increase in anti-GnRH antibody levels as measured by GnRH-specific ELISA. (C) MBP-GnRH resulted in 80% decrease in levels of testosterone in the vaccinated rats. (D) A 30% decrease in testes size was observed 30 days post-vaccination.

2. Methods:

Protein Production and Characterization. Recombinant protein antigens will be produced using an *E. coli* expression system. This process will include the design and construction of plasmid vectors, followed by protein purification using established (Duan et al. 2024; Lee et al. 2019; Gowripalan et al. 2020). All proteins will be purified by a combination of affinity chromatography and size exclusion chromatography (SEC) as a polishing step. Final protein products will be analyzed for purity using SDS-PAGE, and protein concentration determined by absorbance at OD280. Amino acid identity will be confirmed by liquid chromatography followed by mass spectrometry (LC-MS).

Vector Production and Virological Characterization. Our laboratory has extensive experience in the genetic engineering of viral vectors. Antigen-encoding vectors will be generated through homologous recombination and CRISPR-Cas9 gene editing-based selection (Gowripalan et al. 2020). Purified vectors will be characterized *in vitro* using western blotting (to confirm antigen expression), genetic stability testing, and growth kinetics assays.

In Vivo Testing in Rats. Sprague-Dawley rats will be used to evaluate vaccine performance in a GLP-like study. All procedures related to animal handling, care, and treatment will be performed in accordance with guidelines approved by the Institutional Animal Care and Use Committee (IACUC). Animals will be assigned to groups receiving either purified protein antigen (two intramuscular doses) or a single oral dose of the poxvirus vector. Throughout the study, body weights will be monitored and clinical observations recorded daily. Blood samples will be collected at designated timepoints. At the study endpoint, reproductive organs will be collected, weighed, and fixed for histological analysis.

Evaluation of Vaccine Efficacy. Vaccine efficacy will be assessed by measuring both hormonal and immune responses. Serum hormone levels will be quantified by LC-MS/MS, the gold standard in reproductive biology. Antibody responses against GnRH and other antigens will be evaluated by ELISA. Our laboratory has developed optimized GnRH ELISAs following protocols established by the USDA during the development of GonaCon (Massei et al. 2015), ensuring high sensitivity and reproducibility.

References:

Cui, W. *et al.* CRM197-scaffolded vaccines designed by epitope grafting ameliorate cognitive decline in an Alzheimer's disease model. *Int. J. Biol. Macromol.* **281**, 136477 (2024).

Duan, Yurong, Xiaowen Tang, Sha Liu, et al. 2024. "Structure-Guided Design and Evaluation of CRM197-Scaffolded Vaccine Targeting GnRH for Animal Immunocastration." *Applied Microbiology and Biotechnology* 108 (1): 507. https://doi.org/10.1007/s00253-024-13348-3.

Gowripalan, Anjali, Stewart Smith, Tijana Stefanovic, and David C. Tscharke. 2020. "Rapid Poxvirus Engineering Using CRISPR/Cas9 as a Selection Tool." *Communications Biology* 3 (1): 643. https://doi.org/10.1038/s42003-020-01374-6.

Lee, Yong Jae, Eun Jung Jo, Hye Won Lee, et al. 2019. "Evaluation of Infertility Efficacy of the E. Coli Expressed STF2-GnRH Vaccine in Male Cats." *Journal of Veterinary Science* 20 (3): e30. https://doi.org/10.4142/jvs.2019.20.e30.

Massei, Giovanna, Ka-Kei Koon, Steven Benton, et al. 2015. "Immunocontraception for Managing Feral Cattle in Hong Kong." *PLoS ONE* 10 *ONE* 10 (4): e0121598. https://doi.org/10.1371/journal.pone.0121598.

Zhang, Cheng-Qi, et al. "Effect of GnRH active immunization on Reproductive performance of male Sprague Dawley rats." International Journal of Molecular Sciences 25.6 (2024): 3193. https://10.3390/ijms25063193

F. Project Management, Evaluation, and Outreach

1. Management: M. Selman will serve as the PI and oversee all aspects of the project. Protein production and *in vivo* testing will be conducted by Pharmaron, a contract research organization with whom we have successfully collaborated in the past (see attached letter of support). Vaccine construction and antibody characterization will take place in our BSL-2 laboratory in Los Angeles, while hormone assays will be performed by the endocrinology laboratory at UCLA.

2. Evaluation: Project success will be evaluated through defined scientific milestones. These include the successful recombinant protein production of the engineered GnRH antigens and vector, demonstration of immunogenicity and fertility suppression in the initial rat study, and validation of antigen delivery using a poxvirus vector platform.

G. Budget Narrative

a. Personnel Expenses:

Salaries – $28,000. Funds are requested for salary support for one Staff Research Associate (Nikolas Duenas) and one Staff Scientist, who will primarily coordinate data collection, including protein and viral vector production and characterization as well as antibody analysis from the *in vivo* study. Each position is budgeted at 14% effort (0.14 FTE) over the project period.

Fringe Benefits-$3,920

b. Operating Expenses

Supplies-$9,400

Vector production: Supplies include Cas9 protein, cell culture plates, cell media, media additives, and transfection reagents. These are required for the construction and maintenance of vaccine vectors. $6,500

ELISA/antibody characterization: Supplies include recombinant proteins, buffers and solutions, secondary antibodies, and ELISA plates. These materials will support evaluation of immunogenicity and antibody responses. $3,500

Professional/Consultant Services $8,680.00

Hormone quantification: Hormone testing will be conducted by an endocrinology laboratory at the University of California, Los Angeles (UCLA), using LC-MS/MS. Estimated at $90 per sample for 50 samples. $4,500

Protein production: Three GnRH fusion proteins will be produced by Pharmaron (a life science contract research organization) at $2,750 each. $8,250

In vitro testing: Testing of vaccine constructs and vector performance will be conducted through Pharmaron services. $25,000

Please note that the Tarshis foundation will contributes $29,070 towards these services.

c. Other Funding Sources: This project is partially supported by the Tarshis foundation's endowment and by private donations received by the foundation. These funds will complement VPCRAC support and ensure continuity of project activities.

Resume

Mohammed Selman
Ph.D. in Biochemistry
ORCiD: 0000-0002-3265-2009

Virology | Vaccine Development | Genomics | Microbiology | Oncology | Immunocontraception
Reproductive Endocrinology| Biochemistry | Immunology

Education:

Ph.D. in Biochemistry January 2018, University of Ottawa, Ottawa, ON
Dissertation: Pharmacological Improvement of Oncolytic Virotherapy.

M.Sc. in Biology November 2013, University of Ottawa, Ottawa, ON
Thesis: Genomic Analysis of Encephalitozoon Species.

B.Ss. in Biochemistry May 2011, University of Ottawa, Ottawa, ON
Honors Thesis: Effects of NS1 Mutations on Host Range and Virus Fitness in Mouse-Adapted Influenza A Virus.

Current Appointment:

2022 – present **Chief Scientist**, Tarshis Foundation, Los Angeles, CA

Current Research Activities:

- Development of an immunocontraception vaccine for wild boars.
- Research on vector development for companion animals.
- Development of nanobodies targeting reproductive hormones in collaboration with a CRO.
- Testing monoclonal antibodies against poxviruses in collaboration with an academic research partner.

None of these activities require specific time commitments that will interfere with the proposed project.

Research Positions:

2022 – 2022 **Consultant**, Tarshis Foundation, Los Angeles, CA
2021 – 2022 **Senior Scientist**, Meissa Vaccines Inc., CA
2018 – 2021 **Senior Scientist**, Merck, Merck Research Laboratories- *Discovery Oncology*, CA
2018 – 2018 **Postdoctoral fellow**, University of Southern California, CA
2014 – 2018 **Graduate Student (PhD)**, The Ottawa Hospital, Centre for Innovative Cancer Research, Canada
2012 – 2012 **Research Internship**, Kyoto University, Japan
2010 – 2014 **Graduate Student (MSc)**, University of Ottawa, Canada
2010 – 2013 **Laboratory Technician**, University of Ottawa, Emerging Pathogens Research Centre, Canada
2010 – 2010 **Research Internship**, Princeton University, NJ
2009 – 2009 **Research Internship**, McGill University, Canada

Professional Societies:

2025 – present The Wildlife Society
2020 – present American Society of Virology

Presentations:

1. **Selman, M.** Wild boar population control: Utilizing swinepox virus as a viral vector for GnRH immunocastration. (2025) 21st Wildlife Damage Management Conference. Starkville, MS.
2. **Selman, M.** CRISPR-engineered swinepox virus as a vaccine vector for wildlife fertility control. (2025) XXV International Poxvirus, Asfarvirus Conference. San Antonio, TX.

Publication in Preparation:

1. *Duenas, N., Pelin, A., Tarshis, A., & Selman, M.* (2025). Genomic and transcriptomic analysis of porcine cytomegalovirus reveals insights into viral gene expression and host cell responses. *In preparation.*

Selected Publications:

1. Tran, T. Q., Grein, J., **Selman, M**., Annamalai, L., Yearley, J. H., Blumenschein, W. M., ... & Wong, J. C. (2024). Oncolytic virus V937 in combination with PD-1 blockade therapy to target immunologically quiescent liver and colorectal cancer. Molecular Therapy Oncology.

2. Sam, M., **Selman, M**., Zhao, W., Jung, J., Willingham, A., Phan, U., ... & Gao, Q. (2023). Engineering oncolytic coxsackievirus A21 with small transgenes and enabling cell-mediated virus delivery by integrating viral cDNA into the genome. Journal of Virology.

3. Bergeron, A., Kostenkova, K., **Selman, M.**, Murakami, H. A., Owens, E., Haribabu, N., ... & Crans, D. C. (2019). Enhancement of oncolytic virotherapy by vanadium (V) dipicolinates. Biometals.

4. Arulanandam R, Taha Z, Garcia V, **Selman M**, Chen A, Varette O, Jirovec A, Diallo JS. (2020) The strategic combination of trastuzumab emtansine with oncolytic rhabdoviruses leads to therapeutic synergy. Communications Biology.

5. **Selman M,** Ou P, Rousso C, Bergeron A, Krishnan R, Pikor L, Chen A, Keller BA, Ilkow C, Bell JC, Diallo JS. (2018) Dimethyl fumarate potentiates oncolytic virotherapy through NF-kB inhibition. Science Translation Medicine.

6. **Selman M**, Rousso C, Bergeron A, Son HH, Krishnan R, El-Sayes NA, Varette O, Chen A, Tzelepis F, Bell JC , Crans D, Diallo JS. (2018) Multi-Modal Potentiation of Oncolytic Virotherapy by Vanadium Compounds. Molecular Therapy.

7. Le Boeuf F, **Selman M**, Hee Son H, Bergeron A, Chen A, Tsang J, Butterwick D, Arulanandam R, Forbes NE, Tzelepis F, Bell JC, Werier J, Abdelbary H, Diallo JS. (2017) Oncolytic Maraba virus MG1 as a treatment for Sarcoma. International Journal of Cancer.

8. Bourgeois-Daigneault MC, Roy DG, Falls T, Twumasi-Boateng K, St-Germain LE, Marguerie M, Garcia V, **Selman M**, Jennings VA, Pettigrew J, Amos S, Diallo JS, Brad N, Bell J (2016). Oncolytic vesicular stomatitis virus expressing interferon-γ has enhanced therapeutic activity. Molecular therapy oncolytics.

9. **Selman M**, Sak B, Kvác M, Farinelli L, Weiss LM and Corradi N. (2013) Extremely reduced levels of heterozygosity in Encephalitozoon cuniculi suggests the presence of cryptic sex in this relevant vertebrate pathogen. Eukaryotic Cell.

10. **Selman M**, Dankar SK, Forbes NE, Jia JJ, Brown EG. (2012) Adaptive mutation in Influenza A viral NS gene is linked to host switching and induces a novel protein by alternative splicing. Emerging Microbes & Infections.

11. Corradi N and **Selman M.** (2012) Latest progress in microsporidian genome research. Journal of Eukaryotic Microbiology.

12. Pombert JF*, **Selman M*,** Burki F, Bardell FT, Farinelli L, Solter LF, Whitman DW, Weiss LM, Corradi N and PJ Keeling. (2012) Gain and loss of multiple functionally-related horizontally transferred genes in the reduced genomes of two microsporidian parasites. Proceedings of the National Academy of Sciences - USA. 109 (31) 12638-12643. *Contributed equally.

13. Ping J, **Selman M**, Tyler S, Forbes N, Keleta L, Brown EG. (2012) Low-pathogenic avian influenza virus A/turkey/Ontario/6213/1966 (H5N1) is the progenitor of highly pathogenic A/turkey/Ontario/7732/1966 (H5N9). Journal of General Virology. 93(Pt 8):1649-57.

14. **Selman, M**. and Corradi N. (2011) Microsporidia: horizontal gene transfers in vicious parasites. Mobile Genetic Elements. 1(4).

15. **Selman M.**, Pombert JF, Solter L, Farinelli L, Weiss LM, Keeling PJ and Corradi N. (2011) Acquisition of an animal gene by microsporidian intracellular parasites. Current Biology. Volume 21, Issue 15, R576-R577.

Date: 09/26/2025

Dear VPCRAC Committee Members,

I am writing on behalf of Pharmaron to express our support for the Amber and Adam Tarshis Foundation's grant proposal to the California Department of Food and Agriculture's Vertebrate Pest Control Research Program. Pharmaron has been collaborating with the Tarshis Foundation on the evaluation of GnRH antigens through our protein and in vivo teams. We have generated recombinant proteins and tested these proteins for immunization in rats, and we are committed to continuing our support of this important research.

Sincerely,

Signed by:
Katherine Lee
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2024/2025 VPCRAC Project Proposal
Budget Template

Complete the budget template below by filling in information. This template uses formulas to automatically calculate totals.**Do not** alter the formatting or formulas in cells. Rows may be added to accommodate additional personnel or funding sources, if necessary. Contact the CDFA staff at (916) 764-7759 or IPCinfo@cdfa.ca.gov for help filling out this template.

Project Title:	Vector based, GnRH Immunocontraception Vaccine for Rodent Control
Project Leader(s):	Mohammed Selman

	2023-2024	2024-2025	2025-2026	Total
A. PERSONNEL (name, role, % based on full time salary)				
Salary				
Staff Research Associate (N. Duenas) (14%)			$11,000.00	$11,000.00
Staff Scientist (14%)			$17,000.00	$17,000.00
				$0.00
				$0.00
Salary Total	$0.00	$0.00	$28,000.00	$28,000.00
Benefits				
Staff Research Associate (N. Duenas)			$1,540.00	$1,540.00
Staff Scientist			$2,380.00	$2,380.00
				$0.00
				$0.00
Benefits Total	$0.00	$0.00	$3,920.00	$3,920.00
Personnel Cost (A)	$0.00	$0.00	$31,920.00	$31,920.00
B. OPERATING EXPENSES				
Supplies			$9,400.00	$9,400.00
Equipment				$0.00
Travel				$0.00
Professional/Consultant Services(Cannot exceed $65/hour)			$8,680.00	$8,680.00
Other				$0.00
Operating Cost (B)	$0.00	$0.00	$18,080.00	$18,080.00
TOTAL Costs (A+B)	$0.00	$0.00	$50,000.00	$50,000.00
C. Indirect Costs (Cannot Exceed 10% of Total Costs (A+B))				$0.00
TOTAL CDFA FUNDING REQUESTED (A+B+C)	$0.00	$0.00	$50,000.00	$50,000.00
D. OTHER FUNDING SOURCES				
Tarshis Foundation			$45,000.00	$45,000.00
				$0.00
				$0.00
				$0.00
				$0.00
TOTAL OTHER FUNDING (C)	$0.00	$0.00	$45,000.00	**$45,000.00**
TOTAL PROJECT BUDGET (A+B+C+D)	$0.00	$0.00	$95,000.00	$95,000.00

2024/2025 VPCRAC Project Proposal Budget Template