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AGENCIA ESTATAL DE INVESTIGACIÓN

AYUDAS RAMÓN Y CAJAL
CONVOCATORIA 2017

Turno de acceso general

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Título:

Biomarkers of Health and Welfare

Resumen de la Memoria:

The applicant performed her degree veterinary studies (DVM) at the Lithuanian Veterinary Academy (LVA), in Lithuania, where she initiated her research activities in the Department of Veterinary Pathology. The results of this research were recognized with the first prize of the Annual Student Congress of Health Sciences in Kaunas and the Lithuanian National Prize for the best research work performed by students of Higher Education Institutions. In addition, the applicant obtained the Extraordinary Award for the best DVM student of the Lithuanian Veterinary Academy. Afterwards, the applicant obtained a Master Degree in Companion Animal Internal Medicine at University of Murcia (UMU), Spain, with a Grant for Master studies funding of the Regional Government of Murcia. Later she performed PhD studies at UMU with a Fellowship for Predoctoral Training of this university. Her PhD studies were focused on biomarkers of obesity in serum of dogs and cats. During this period she performed two stays at University of Bologna (Italy) as a as part of the transversal activities spending a total time of five months and producing three papers during the stays. The PhD studies led to a Thesis including 22 papers published in journals with Journal Citation Report impact factor, being in all of them the applicant a first author. This PhD thesis was recognized with three awards.
The applicant develops her post-doctoral investigations at Autonomous University of Barcelona (UAB) and UMU with the grants Juan de la Cierva and Juan de la Cierva Incorporacion, respectively. During the research period at UAB, the applicant has been focused on the use of biomarkers for monitoring health and disease in different tissues of companion and farm animals, wildlife, and marine species, with special emphasis on non-invasive biomarkers of oxidative stress and inflammation. At UMU the applicant is intensifying her research in the field of biomarkers of health and wellbeing in different species.

The main research line of the applicant is focused on the study of Biomarkers of Health and Welfare, which comprises the analytes that are used for monitoring the health status and the level of stress in different species and tissues. This line could be divided into three areas that are closely interconnected. Namely, (1) biomarkers in obesity, (2) biomarkers of inflammation and oxidative stress in different species, and (3) One Health approach for the study of biomarkers.

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Resumen del Currículum Vitae:

During her research career, the applicant has published a total of 115 articles (58 [50%] of them as a key author, occupying first, second or last positions), and 59 [51%] of them with international collaborators, with a total of 741 citations (Scopus 13 01 2018). In addition, she has presented 10 invited presentations and 66 communications at different congresses. The applicant leaded two research projects, signed one research contract with a private international company, and participated in 18 research projects as a member of research group (10 [56%] of them funded by international bodies). The researcher performed her pre-doc as well as post-doc studies in the countries other than her country of origin (a total of 10 years in Spain, out of them 7 months in Italy).
The applicant co-directed three PhD Thesis, one receiving the award for the best PhD Thesis in Health Sciences at UMU. She has also supervised two Master Thesis and three end-of-degree projects. In five occasions the applicant has participated in the court of the Doctoral Thesis defenses.
The applicant is an Associated Editor in the BMC Veterinary Research journal, which is a leading journal of Veterinary Science category. She also participated as topic editor and guest editor in the journals Frontiers in Veterinary Sciences and BioMed Research International, respectively. Furthermore, she has revised 28 papers for 21 different journals.
In addition, the applicant has obtained seven awards: the Extraordinary award for veterinary studies at LVA, the Best abstract presented at LVA students congress, the Best scientific work performed by students of Higher Education Institutions of Lithuania, three awards for the PhD Thesis, and one for the best abstract presented at an international congress (European College of Veterinary Internal Medicine Congress 2012).

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Título:

Assisted reproductive techniques in domestic species: physiology of in vitro fertilization and optimization of gamete and embryo cryopreservation

Resumen de la Memoria:

My research has been focused in assisted reproductive techniques (ARTs) in mammalians (predominantly in the horse), with emphasis on sperm cryopreservation, in vitro fertilization (IVF) and fertilization-related events. My pre-doctoral research was funded by a grant from the Subprograma de Formación de Personal Investigador (Ayudas Formación del Personal Investigador; BES-2008-001880) from the Spanish Ministry of Science and Innovation; I studied the fatty acid profile of horse sperm as well as the lethal and sub-lethal changes induced by volume excursions and glycerol addition in equine sperm. In view of the high toxicity of glycerol, alternative cryoagents were used resulting in the patent of a new equine freezing extender (ES 2402510 A1). I also worked in advanced reproduction techniques in stallions such as sperm sorting or colloidal selection of equine spermatozoa using Androcoll-E®. In 2011, as a postdoctoral researcher at Texas A&M University (USA) and afterwards in 2013 at the University of Porto (Portugal; Funded by a Bolsa de Post-doutoramento from the Fundação para a Ciência e a Tecnologia. SFRH/BPD/84354/2012) I started working in equine sperm capacitation and hyperactivation as well as in equine oocyte retrieval, in vitro maturation and embryo culture. A profound research in the ionic channels and proteins regulating hyperactivation (such as CatSper, Calmodulin and Calmodulin Kinase II) and intracellular pathways leading to sperm capacitation (including novel research on Focal Adhesion Kinases and Calcium Sensing Receptor) were initiated. In parallel novel studies were conducted aiming to elucidate if glucose consumption is associated with the meiotic competence of equine oocytes (COCs) and how fertilization medium affects equine IVF outcome. In 2016 I was awarded with a Juan de la Cierva Incorporación contract (Ref. IJCI-2014-19428) and joined the Assisted Reproduction Unit of the Centre for Minimally Invasive Centre Jesús Usón. In 2018 the project entitled Optimización de la fecundación in vitro equina: caracterización y uso del fluido oviductal en el diseño de medios (Ref. AGL201784681-R; Proyectos Retos 2017) in which I am the principal investigator was funded; in addition a second project entitled Optimización de protocolos de ovum pick up y vitrificación de oocitos en el Asno Andaluz presented to the 2017 Call Proyectos de investigación en Centros Públicos de I+D+i de Extremadura (Ref. IB16159) in which I am also the Principal Investigator was proposed for funding, and my future efforts will be directed to study in depth the composition of equine oviductal fluid and to develop effective protocols for oocyte vitrification in the Andalusian donkey.
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Resumen del Currículum Vitae:

My research has been focused in assisted reproductive techniques (ARTs) in equine and bovine predominantly, with emphasis on sperm cryopreservation and study of fertilization-related events. During my PhD, my research was focused on the deleterious effects that osmotic shock exerts on equine sperm during cryopreservation. A profound research on fatty acid composition of equine sperm, sperm volume variations, reactive oxygen species production and ultrastructural changes related to anisosmotic enviroments and cryoprotectant addition was conducted. As a result, 6 papers as first author were published between 2009 and 2012, one of them during a 6 month research stay carried out under Dr. Jane Morrell's mentoring at the Swedish University of Agricultural Sciences, SLU, Uppsala (Sweden) in 2010. All the results obtained were used to develop and patent the Cáceres equine sperm freezing extender. In my second predoctoral research stay at the College of Veterinary Medicine at Texas A&M University with Dr. Katrin Hinrichs, I started working in the physiology of sperm capacitation and hyperactivation as well as in oocyte retrieval and maturation in the horse. My PhD was defended in 2011 with the European Mention, was awarded as Cum Laude and also distincted with the Extraordinary prize by the University of Extremadura. From August of 2011 to December of 2012 I did my first postdoctoral stay at Texas A&M University, and this stay resulted in various publications in high impact journals and my first project as PI awarded by Texas A&M University in the College of Veterinary Medicine Postdoctoral Trainee Research Grant call. The project entitled The role of protein kinase A and calcium-calmodulin signaling in the regulation of hyperactivated motility of equine sperm, was funded with 10.000 $ and resulted in various congress abstracts and one paper. In 2013, I was awarded with a postdoctoral grant by the Fundação para a Ciência e a Tecnologia (Portugal) and started working with bovine oocytes and embryos until 2016. During this term various papers as last, corresponding and first author were published in equine and bovine fertilization-related events. In 2016 I moved to the Centro de Cirugía de Mínima Invasión Jesús Usón (Cáceres, Spain) with a Juan de la Cierva Incorporación grant. I have signed a research contract with the Consejería de Medio Ambiente y Rural, Políticas Agrarias y Territorio de la Junta de Extremadura. I have worked independently of my PhD research group as demonstrated in various publications with groups from Spain, Sweden, Portugal, USA and Iran and participated in national and international research projects. I have mentored 2 student projects, 1 PhD student that obtained the maximum score awarded (sobresaliente Cum Laude with International mention) and 1 Erasmus + student. I have also participated in international teaching at Universities in Colombia, Portugal, USA and also at the University of Extremadura (Spain) and in 4 different master programs in Spain and Portugal. I have published 52 peer-reviewed papers, (51 of them indexed in the JCR), 32 of them as first, second or last author; 35 of the previously referred publications are in the Q1. My H index is 21, the

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sum of the times cited is 949 and I have 105.2 cites per year according to the Scopus database.

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Turno de acceso general

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Título:

Cronobiología de peces

Resumen de la Memoria:

My area of expertise is fish chronobiology. One of my lines of research has focused on clock genes. Thus, I used a molecular and transcriptomics approach to study photo- and feeding entrainment of clock genes in seabass and seabream. For this, I cloned several clock genes in these species and studied their daily rhythms of expression under different light-dark and feeding time conditions in various tissues. The effect of thermo- and photocycles on the ontogeny of the circadian axis of fish has also been a line of interest for me, whereas another line has investigated the synchronising capacity of environmental factors on melatonin rhythms in fish. Consequently, I described daily rhythms of plasma melatonin in tench (under different light intensities) and sharpsnout seabream before focusing on seasonal rhythms of plasma melatonin and reproduction (spawning and sexual steroids) in Senegal sole, an aquaculture species which reproduction in captivity presents several challenges. My first postdoctoral fellowship allowed me to deepen my knowledge on the mechanisms involved in photoentrainment and I pursued my interest in the regulation of melatonin rhythms, specifically trying to elucidate the effect of light intensity and spectrum. A third line of research has studied light and feeding entrainment of physiological and behavioural rhythms. In this context, I studied photoentrainment of behavioural rhythms in tench, sharpsnout seabream, Nile tilapia and African catfish whereas in goldfish I investigated feeding entrainment of behaviour and daily rhythms of digestive physiology. After that my research focused on welfare in aquaculture, resulting in the study of the effect of light on fish retinal damage and stress. Later, I investigated the time-dependent variations in the stress response of seabream. Then, I started a new line of research on toxicity rhythms in fish, for which I performed several trials to investigate the chronotoxicity of anaesthetics in seabream and zebrafish. Since 2013 I have been working at the Institute of Aquaculture of the University of Stirling (UK) and one of my lines of research focuses on studying the chronotoxicity of aquaculture therapeutants in Atlantic salmon. In addition, the molecular mechanisms underlying and regulating these toxicity rhythms in fish have been investigated for the first time in zebrafish. I have also been involved in a fish nutrition project funded by the EU, ARRAINA, where I investigated a) the effect of plant-based diets with different micronutrient supplementation and b) the effect of early nutritional programming in Atlantic salmon. Finally, in 2017 I started working in an INNOVATE UK/BBSRC project, SALMOTRIP+, which seeks to overcome welfare concerns and production bottlenecks associated with the farming of reproductively sterile triploid Atlantic salmon in order to reduce the environmental impact and increase the sustainability of the aquaculture industry in the UK.
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Resumen del Currículum Vitae:

In 2002 I started my PhD in the Laboratory of Chronobiology at the Physiology Department of the UMU, for which I obtained a predoctoral fellowship (FPI program, Spanish Ministry of Science and Technology). My doctoral thesis focused on fish biological rhythms. During that period I stayed for 4.5 months at the Laboratoire Arago of the Observatoire Océanologique Banyuls sur Mer (France) and collaborated with several Spanish institutions. During my PhD I participated in 2 joint national projects and produced 7 research peer reviewed papers (4 of them as 1st author). My PhD received the European mention and was awarded with the PhD with distinction 2006 by the UMU (Premio Extraordinario de Doctorado).

In 2007 I moved to the Institute of Aquaculture (IoA) at the University of Stirling (UoS) (UK), where I worked for 2 years with a postdoctoral fellowship granted by Fundación Séneca. During this period I deepen in the mechanisms involved in photoentrainment in fish. During my postdoctoral stay I participated in 2 European research projects and produced 5 indexed publications (4 as 1st author and 1 as co-author) and I co-supervised a Bachelor of Science (BSc) project and trained a PhD student.

In 2009 I returned to the University of Murcia, with a postdoctoral fellowship (Saavedra Fajardo Program) granted by Fundación Séneca and then with a Juan de la Cierva fellowship granted by the Spanish Ministry of Education and Science. During this period I also stayed for 6 weeks in the University of Ferrara (Italy), granted by an Integrated Action. In these 4 years I was involved in 5 research projects, 2 international scientific networks and produced 13 peer reviewed papers and 1 book chapter. On the other hand, I co-supervised 2 doctoral theses, 1 BSc project (proyecto fin de carrera) and 3 master theses.

In September 2013 I came back to the IoA (UoS) after being awarded an IMPACT fellowship and research grant to develop and coordinate a project focusing on chronotoxicity of xenobiotics in fish. Three papers have been published. In 2015 I started working as a postdoctoral researcher in a European project, ARRAINA, which resulted in the publication of 2 papers (3 more are in preparation). Finally, in 2017 I started working in an INNOVATE UK/BBSRC project, SALMOTRIP+, and 1 paper derived from this work is currently in preparation.

I have participated in the teaching program of my departments and I have given a total of 281 hours.

In summary, during my career I have produced a total of 30 indexed publications in SCI, 21 of which are in the Q1 of their categories (4 more papers are in preparation). In 23 of these publications I am first, second or last author. I have also published 1 book chapter and several popular articles. I have an H-index of 14 and my publications have been cited 509 times. I have participated in 5 international

research projects (in 1 of them as the Principal Investigator) and 7 national projects and contributed to conferences with 37 communications (including invited talks). In addition I have been involved in 3 international scientific networks. During my PhD and postdoctoral appointments I have stayed in several internationally recognised centres (a total of 83 months at the call deadline) and have co-supervised 2 doctoral thesis, 3 master thesis and 2 BSc projects.

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Título:

Modelling ruminant livestock systems in a changing climate: pathways towards sustainabilty

Resumen de la Memoria:

With a PhD in Biology (2007) (NEIKER, Wageningen) I have worked at BC3 (2009-) leading a small team on modelling climate change and agriculture (emphasis on ruminant production systems). Before, I held a post-doc and then promoted to senior researcher positions at IGER, North Wyke Station (2002-2009) (currently Rothamsted Rs, UK).

My main objective has been on the methodological aspect of developing and programming innovative mathematical simulations models (>10 models) in order to understand:

- how to represent the main interactions (e.g. on nutrient cycling) amongst livestock farm components (e.g. animal, plant, soil, management) and how to capture and integrate the internal feed-backs and loops between those components.
- the holistic effect of ruminants farming systems on climate change and potential for mitigation.
- how climate change affect farm performance (productivity and environment) and strategies for climate change adaptation.
- the associated side-effects and conflicts on sustainability attributes (e.g. economics, other pollutants, animal welfare, product quality, biodiversity).
- how experimental work at the animal and plant level can be translated at higher systems level (e.g. farm or regional level) (e.g. new plant/ animal breeds, novel feeding).
- how to close nutrient loops by connecting livestock, feeding, food, waste management/treatment, bioenergy, etc

Although the basic principle has been to follow the Systems-based modelling approach, the types of models vary in complexity and functionality: from the more mechanistic to empirical models or from the field, whole-farm to the landscape level or regional scale. Also, I have developed deterministic and statistical models. Through collaboration with BC3 colleagues, I have also explored approaches using alternative frameworks (e.g. ecosystem services and goods linked with artificial intelligence).

Most of my work has been carried out through multi/interdisciplinary frameworks under the umbrella of R+D Sci. projects (EU:7, UK: 29, Spain:16), which I have coordinated (6) (e.g. Spanish National R+D or UK-DEFRA) or I have been WP leader (e.g. H2020 ISAGE, EU Optibarn, UK-DEFRA) and raised >800K (last 5 years).

Most modelling work has been published in high impact journals (26 Q1, 81%) and has been instrumental to provide policy-relevant information (e.g. IPCC-Lead Author, UNEP- controlling emissions to protect Climate and the Ozone layer, Sci. coordination for Spanish national nutrient balances of cattle, member of EU-EIP Agri Focus group).

Additionally, in my early career I measured soil N2O and NOx emissions from grassland systems (grazed and mown) using different techniques and instrumentation. Within an EU project I assessed how management (e.g. fertilisation, tillaging), technologies (e.g. nitrification inhibitors) or soil environment (e.g. water, temperature) affected both N2O and NOx emissions and their underlying processes (e.g. nitrification or denitrification).

Networking with experimentalists and other disciplines (e.g. socio-economists) has been key. I promoted/initiated (coordinator/president: 2012-2017) the Spanish national sci. network REMEDIA on climate change mitigation from agriculture, livestock and forestry sectors. This resulted in numerous R+D outputs (see extended doc) (e.g workshops, projects, articles and special issues in Q1 journals).

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Resumen del Currículum Vitae:

Agustin currently leads a modelling team in the Basque Centre For Climate Change (BC3). He is also currently an IPCC Lead Author for the 2019 Refinement to the 2006 IPCC Guidelines for National GHG Inventories. Before, he held post-doc and senior researcher positions at IGER, (currently Rothamsted, UK), where he became the modelling theme leader of their Strategic Programme.

His main area of expertise is the development/programming of mathematical simulations models (>10 models) to assess sustainability from agriculture (livestock in particular). He has participated in 52 research projects (EU:7, UK: 29, Spain:16), coordinating 6 (e.g. Spanish National R+D or UK-DEFRA) or being WP leader (e.g. H2020 ISAGE, EU Optibarn, EU ANAEE, UK-DEFRA) or PI (8). He has raised project funding for about 1 million .

With 32 JCR papers (16 of them as first or last author and Q1-81%) and over 70 conference papers, some as invited speaker (e.g. Greenhouse Gases and Animal Agriculture 2013, EGF2014), he is also editor in Animal and Grass and Forage Science Journals.

He has intense networking activity.He is responsible for promoting and initiating (coordinator/president: 2012-2017) the national sci. network REMEDIA on climate change mitigation from agriculture, livestock and forestry sectors. REMEDIA has established a national/international inter/multidisciplinary network with different groups that crosscut sectors and disciplines, and with important outputs (e.g. 5 workshops, 2 special issues in Q1 journals and a strong dissemination role though their social media: e.g. blogging).

Internationally, amongst other networking, he is the Spanish co-representative in the Global Research Alliance on Agricultural GHG for

livestock and has actively participated (e.g. organising a Modelling and Research Colloquium in 2014) in the Knowledge Hub MACSUR I and II (over 40 EU research centres), an initiative from FACCE JPI, on Modelling livestock and climate change.
His work is focused on providing policy makers with relevant scientific information. He has strong engagement with them, directly or indirectly, through different activities: IPCC-Lead Author, only Spanish author for UNEP- controlling emissions to protect Climate and the Ozone layer work, Sci. coordination for Spanish national nutrient balances of cattle, member of EU-EIP Agri Focus group on cattle emissions. He also participated (as Spanish scientific expert) in mapping meetings for the EU Joint Programming Initiative on Food Security, Agriculture and Climate Change (FACCE JPI). Additionally, he was UK representative for working group UK-Australasia- British High Commission.
He is currently supervising 3 PhD students and he was the main supervisor of 2 successful PhD thesis, one having recently obtained the price for best thesis in Climate Change topic in Mediterranean Spain. He has recently coordinated the postgraduate IAMZ course GHG assessment and mitigation in agriculture and has been part of the organizing committee at 3 international conferences and some national ones.
Amongst others measures of self-esteem he was ranked first in Juan de La Cierva (2008) and selected for INIA-doc (2008) National Programmes. Before, whilst at IGER, he got promoted through the Biotechnology and Biological Sciences Research Council (BBSRC) system and obtained 2 award merits for individual performance.

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Turno de acceso general

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Título:

Mechanisms of RNA viruses to counteract the host immune response and development of novel therapeutic approaches to combat viral infections.

Resumen de la Memoria:

Currently, I am a Research Assistant Professor at University of Rochester. My research interest during my scientific career has been focused on the molecular biology and pathogenesis of RNA viruses. During this period, I have acquired training in cellular, molecular biology and virology and good skills in a wide range of laboratory techniques. I have extensive knowledge in state-of-the-art plasmid-based reverse genetics techniques for rescuing viruses to investigate viral and host factors that control virus infection as well as for the generation of live-attenuated viruses for their implementation as vaccines or vaccine vectors; virus-based bioassays; the generation and characterization of single-cycle infectious and replication-competent viruses expressing reporter genes to evaluate host factors involved in viral replication, the identification and validation of therapeutics both in vitro and in vivo for their use to treat viral infections; in vivo models of viral infection; and the development of new molecular approaches for the generation of attenuated viruses for their implementation as vaccines.

The study of viruses that infect animals is important from a veterinary viewpoint because many of these viruses cause diseases that are economically devastating. Moreover, animal viruses are also important for the human population, since they can cross the species-barrier by acquiring gene adaptations that confer optimal virus replication, transmissibility and immunologic stealth, leading to pandemics in immunologically naive populations. Therefore, during my research I have worked with viruses affecting both humans and other mammalians, such as swine, dogs, horses and rodents, since the molecular mechanism of pathogenesis follow similar characteristics.

I completed my PhD in the laboratory of Dr. Luis Enjuanes in the Centro Nacional de Biotecnologia (Spain). My research projects focused on the study of viral and cellular host factors involved in coronavirus (CoV) replication and encapsidation of the replication complex into the viral particles. CoV infections cause a variety of enteric and respiratory diseases relevant in animal and human health. Therefore, we used as models the porcine coronavirus TGEV (relevant in animal health because it causes transmissible gastroenteritis in swine) and the human coronavirus SARS (leading to death in 10% of infected people).

In 2013, I started my postdoctoral appointment in the laboratory of Dr. Luis Martinez-Sobrido at the University of Rochester. During the last years I have developed an extensive research activity in understand the molecular mechanism responsible for influenza virus pathogenesis and the development of novel therapeutic (antivirals and vaccines) approaches to combat human, canine, equine, and avian influenza viruses. Infection with influenza virus poses a threat to human and animal health and results in significant negative economic impacts on society every year. In addition to my major research on influenza virus infections I have also be involved in several research projects related with other viruses, including but not limited to, arenaviruses (LCMV and Lassa virus), flaviviruses (Zika and Dengue viruses) and poxviruses (Vaccinia virus).

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Resumen del Currículum Vitae:

I finished my BS degree in Biochemistry at the Universidad Autonoma de Madrid and received my PhD from the same university under the co-direction of Profs. Luis Enjuanes and Fernando Almazan at the Centro Nacional de Biotecnologia (Madrid, Spain). Importantly, my PhD thesis obtained the highest grade of Sobresaliente cum laude. In January, 2013, I moved to University of Rochester (USA) to the laboratory of Prof. Luis Martinez-Sobrido, as a postdoctoral fellow. Recently (May 2017), I have been promoted to Research Assistant Professor.

My research interest has been focused on the molecular biology, virus-host interaction, and pathogenesis of negative- and positive-stranded RNA viruses as well as the development of novel vaccination or therapeutic approaches to prevent or combat viral infections.

As a result of my research trajectory, my scientific activity have resulted in more than 40 manuscripts published in international peer-reviewed journals, most of them (36) in the first quartile in their respective areas. Remarkably, from these articles, I am first or co-first author in 19 of them. Furthermore, my findings have been presented in more than 40 international meetings. Importantly, I have been funded by three grants: the University of Rochester research award, and two National Institute of Health (NIH)-CEIRS training awards. These funded research projects demonstrate my ability to work as an independent investigator, leading new lines of research. Thanks to this funding and to the multiple collaborations that I have established with different research groups worldwide, I have been a visiting fellow at the University of Georgia (USA) and at the University of Atlanta (USA) learning new skills. Furthermore, I have received numerous awards, including the University of Rochester Vaccine Fellowship (2013), the best poster presentation at the 5th annual Lung Biology and Trainee Day (2013), the University of Rochester outstanding postdoctoral mentor award (2015), the best poster presentation 1st Immune Imaging Symposium (2015) and the University of Rochester outstanding postdoctoral researcher award (2017).

In addition to my scientific production, I have been a reviewer for several indexed international journals, and I have participated in the mentoring and supervision of multiple PhD students at the University of Rochester as well as other junior and senior researchers that have

visited the laboratory.
Finally, I am co-inventor of 6 international patent applications to develop vaccines or potential treatments against human, equine and canine influenza viruses. Valuably, some of these technologies related with the generation of novel vaccine approaches to protect dogs against influenza infections, are being explored by international companies.