UNIVERSIDAD DE COSTA RICA
OFICINA DE PLANIFICACIÓN UNIVERSITARIA
SISTEMA INSTITUCIONAL PLAN PRESUPUESTO

INFORMACION GENERAL DEL PROYECTO

Unidad:	06080206-SEDE DEL SUR	Proyecto:	Pry01-1802-2021-Development of a RFID-based wireless system for behavioral monitoring of small vertebrates
Código de Inscripción:		Estado:	Editable
Fecha de Inicio:	01/01/2021	Ampliación / Renovación:	
Fecha de Finalización:	31/12/2023	Usuario:	marcelo.araya

Actividad / Subactividad

Investigación — Investigación Básica

Descripción:

The goal of this project is to develop an integrated electronic system to identify and record the behavior of individuals from small vertebrate species, aiming to automatize data collection in behavioral research both in field and laboratory settings. Vertebrates, with their energetically demanding physiology and advanced cognitive abilities, provide a compelling group in which to address questions related to the proximate and evolutionary factors shaping their behavior. Their rapid movements, however, pose unusual technological challenges for identifying individuals and recording behavior in an unsupervised manner. We proposed to develop a system based on radio-frequency identification (RFID) technology, adaptable to monitor a variety of small vertebrates species both in the lab and in field conditions. The system will use low-cost single-board Raspberry-Pi computers (Richardson and Wallace 2012) to integrate the operation of RFID-sensing antennas, loggers and the triggering of video/audio recording components. The proposed model can be easily customized to improve detection performance and optimize media recording algorithms for different species and/or experimental settings, as well as to integrate additional components (i.e. movement detectors) to the system. The system would be tested on three small vertebrate species: rats (Rattus norvegicus, laboratory), Spix's disc-wined bats (Thyroptera tricolor, field) and long-billed hermit hummingbird (Phaethornis longirostris, field). These species are regularly used as study systems in behavior by the researchers involved in this project. RFID systems will be integrated to feeding stations to register visitation, sensitivity and specificity of the detection would be optimized on the different experimental conditions.

Observaciones:

NOTA: en este proyecto se requieren viáticos para estudiantes. Sin embargo no fue posible asignar este rubro a la partida "6029902 SECTOR PRIVADO" ya que esta opción no estaba disponible en el menú. Los montos solicitados para este rubro se detallan en el campo de régimen becario.

Costo Total del proyecto:

Monto estimado UCR: 8,982,617.00

Entes externos: 0.00

Total: 8,982,617.00

Entes externos:

No hay información registrada

Unidades participantes en el proyecto:

020247 CENTRO DE INV. EN NEUROCIENCIAS

06080206 SEDE DEL SUR

Instituciones participantes en el proyecto:

Universidad Universidad de Washington, Estados Unidos

Adscripciones con programas inscritos en las Vicerrectorías:

No hay información registrada

Relación con otros proyectos:

Proyectos	Periodo	Estado
585 Emisión de sonidos de contacto en el murciélago de ventosas, Thyroptera tricolor: ontogenia, variabilidad, e implicaciones para la cohesión de grupo	2018	Aprobado
1541 Acoustic communication for group coordination on the wing	2019	Aprobado

Información acerca de los encargados del proyecto

Tipo Participación	Identificación	Nombre	Grado	Unidad/Inst. Pertenece	Estado en Régimen	Nombramiento	Horas Propias	Horas Adicional
Colaborador / Asociado	111040947	ALEJANDRO RICO GUEVARA	Doctorado académico	CENTRO DE INV. EN NEUROCIENCIAS	Ninguna	N/A	N/A	N/A
Colaborador / Asociado	304870312	Alvaro Vega Hidalgo	Bachillerato universitario	Universidad de Cornell, Estados Unidos	Ninguna	N/A	N/A	N/A
Colaborador / Asociado	109350854	JUAN CARLOS BRENES SAENZ	Doctorado académico	INSTITUTO EN INVESTIG. PSICOLOGICAS	CATEDRÁTICO(A)	N/A	N/A	N/A
Investigador principal / Responsable	111040947	MARCELO ARAYA SALAS	Doctorado académico	CENTRO DE INV. EN NEUROCIENCIAS		N/A	N/A	N/A
Colaborador / Asociado	108350567	GLORIANA CHAVERRI ECHANDI	Doctorado académico	SEDE DE GUANACASTE	ASOCIADO(A)	N/A	N/A	N/A

OBSERVACIONES

Observaciones realizadas al participante: Alvaro Vega Hidalgo

Provide expertise for development of RFID devices and code writing and troubleshooting

ESTRUCTURA DEL PROYECTO

ANTECEDENTES DEL PROYECTO

Animal behavior has been pivotal for our understanding of the biological world. Behavior is the bridge between animal endophenotypic traits and the ecological and social conditions that have shaped them during evolution; it is the link between animals and their environment. Non-surprisingly, research on animal behavior and behavioral ecology has rapidly increased in recent years. While the study of animal behavior is important as a scientific field on its own, it has also made important contributions to other disciplines, with applications to the study of human behavior and culture (Mesoudi 2011), neurosciences (Krakauer et al. 2017), conservation and resource management (Berger-Tal et al. 2016), and the study of animal welfare (Fraser 2009), to name a few.

Behavioral research has largely rely on human observation of animals for data collection. As individuals are often the sample units, assigning observations to specific individuals is a key aspect of the experimental design. Despite the growing popularity of technological tools (i.e. video and audio recording) to register behaviors, the careful classification and/or quantification of behavior as well as the identification of individuals in most cases still require direct human input. In fact, many marking and tagging techniques have been developed to assist human observers to tell individuals apart. External marking techniques include color-coded leg bands (Thomas and Marburger 1964) or foam tags glued to the feathers in birds (Stiles and Wolf 1973; Araya-Salas and Wright 2013), ear tags in mice (Scott 1942) and wing bands in bats (Trapido and Crowe 1946). Because they are attached to the exterior of animals, such techniques have the disadvantage of potentially modify the interactions between animals and their environments (Gibbons and Andrews 2004). The appearance of external tags may affect the behavior of conspecifics toward tagged individuals and in some cases affect the viability of individuals (Zambelli et al. 2009). Tags can also be lost, and sometimes the tag numbers themselves can become illegible. Even in the absence of direct negative effects, relying on human observation can also affect data quality as it makes data collection prone to subjectivity and errors. The dependence on human observers to gather behavioral data remains as the major bottleneck for optimizing data gathering, both in terms of time and monetary costs.

Passive integrated transponder (PIT) tags have emerge in the last decade as an important means for individual tagging that can overcome most of the drawbacks related to external marking. PIT tags are small microchips (a few millimeters, < 0.1 g) encapsulated in a biocompatible glass that protects electronic components and tissues (Gibbons and Andrews 2004). Due to their tiny size and low weight, they can be attached to a wide range of animals, from insects (Streit et al. 2003) to cattle (Gibbons and Andrews 2004). PIT tags use radio-frequency identification (RFID) through electromagnetic fields to communicate their identity to RFID readers. A PIT tag (also known as RFID tag) do not require an energy source as they are activated by the electromagnetic pulse from a nearby RFID reader device, which triggers the transmission of a unique alphanumeric code back to the reader (Bonter and Bridge 2011). This passive nature allows them to last much longer than battery-dependent devices, often as long as the lifetime of the animals (or even longer). Furthermore, PIT tags can be used as part of integrated automated monitoring systems, which can be configured to simultaneously register temporal and spatial information along with other more information-rich data formats as video and audio records. This capability, for obvious reasons, can be particularly useful in the study of animal behavior. Hence, automated systems powered by PIT tags/RFID technology can yield valuable information while at the same time solving some of the issues related to traditional methods of data collection in behavioral research.

The use of PIT tags/RFID technology have allowed researchers to gain important insight on details about behavioral mechanisms and processes that were unattainable under traditional data collection approaches. Pysanenko et al (2018) used a custom-made system based on RFID technology to identify individual rats at the reward-delivering spout in the lab to demonstrate how acoustically enriched environments during postnatal development

can influence basic properties of neuronal receptive fields in the auditory cortex. Similar systems have also been deployed in the field. By attaching RFID readers to bird feeders, Bosse et al. (2017) shown that spatio-temporal usage of feeding resources of greats tits (*Parus major*) are consistent with ongoing selection for longer bills and that this selection has triggered adaptive evolution on the underlying genetic substrate. Aplin et al. (2014) also used RFID readers on feeder stations in the wild to experimentally induce foraging innovations. Innovations were later shown to be transmitted to other individuals in the population through social learning, which persisted over several generations. Similar approaches have been implemented for studying bat behavior in the wild. Hernández-Montero et al. (2020) used RFID powered automatic roost monitoring systems to assess how individually marked, free-ranging Bechstein's bats (*Myiotis bechsteinii*) use associative learning, spatial memory and social information when localizing suitable day roosts. They were able to show how associative learning, spatial memory and social information are used during roost localization in bats under natural conditions. As the above examples demonstrate, RFID technology can revolutionize data collection by automating the recording of animal behavior and movements. Indeed, the volume of data collected can be staggering. Whereas areas in behavioral research have traditionally suffered from small sample sizes, RFID powered systems can record large data sets in a short period of time, such as several hundred visits to feeders per day by ruby-throaded hummingbirds (*Archilocus colubris*; Zenzal and Moore 2019).

Justificación del proyecto:

Our monitoring system will be specifically tailored to the needs of three research groups at the Universidad de Costa Rica. The proposed systems will allowed these groups to automatize data collection while improving data quality and increasing the pace at which it is gathered. This will also optimize the use of human and monetary resources. In addition, this system should improve the quality and quanitity of the data collected, which should have a positive impact on the research products from the collaborative parties involved in this proposal. This project also include the use of the proposed monitoring system for conducting three experimental studies, one for each of the study systems. Each study will generate preliminary data for future research projects (or even for plubications on its own) and demonstrate the feasibility of automatic monitoring for efficiently gathering behavioral observations to the research groups involved.

Descriptores:

16888 - Biología

16934 - Neurobiología

16966 - Ave

17890 - Comportamiento

Áreas de Impacto:

TECNOLÓGICA

DESARROLLO CIENTÍFICO

DESARROLLO TECNOLÓGICO

Biodiversidad

INVESTIGACIÓN

¿En qué consiste el impacto?:

The proposed project will allow researchers to significantly increase the precision in data collection for behavioral monitoring while opening new research avenues by providing low-cost automatic monitoring tools that can be easily customized to a variety of experimental designs and research questions. The improved data collection capacities imply clear advantages over current alternatives (i.e. continuous video recording) that should considerable decrease human input, reducing associated costs and open new research avenues previously unattainable under traditional data collection approaches.

Población Beneficiada Directa:

¿Quién o quiénes se benefician?:

Research community at the Universidad de Costa Rica, including researchers at Centro de Investigacion en Neurociencias, Sede del Sur and Escuela de Biologia

Beneficios para la población:

The project will allow research groups at the Universidad de Costa Rica conducting animal behavior research to optimize the use of human and monetary resources. This aspect is particularly relevant at the current juncture of limited public funding, which has particularly impacted the availability of research funds at the university. The systems developed in this project can be adapted for other applications requiring low power, miniaturized wireless identification, eco-friendly components and intelligent device. Such applications can be found in ecology, agriculture, security, and Internet of Things (IoT), many of which have commercialization potential.

Beneficios para la Universidad:

The monitoring system that will be developed in this project will be specifically tailored to the needs of three research groups at the Universidad de Costa Rica. The proposed systems will allowed these groups to automatize data collection while improving data quality and increasing the pace at which it is gathered. This will also optimize the use of human and monetary resources. The project will also improve the positioning of the Universidad de Costa Rica among the scientific community at the domestic and international levels through the development of state-of-the-art technology for behavioral monitoring research and the publication of results in high impact journals. The university will also benefit from alliances with national and foreign researchers.

Objetivos y Metas

Objetivo general:

The overall aim of this project is to develop an integrated system to identify and record the behavior of individuals from small vertebrate species

Objetivo específico 1 : Investigación

Use Raspberry-Pi single board computers to ensemble an electronic system to read PIT tags and trigger external components for behavioral monitoring

Meta 1 - Cuantitativa - Cantidad: 1.00

Develop a python script to control RFID antennas and to log information on date, time and PIT tag code

Indicador 1

1 python script

Meta 2 - Cuantitativa - Cantidad: 1.00

Optimize detection to increase detection range to at least 10 cm around RFID antennas

Indicador 1

Detection range >= 10 cm

Meta 3 - Cuantitativa - Cantidad: 1.00

Optimize detection to decrease refractory period of RFID readers to less than 1 second

Indicador 1

Refractory period of RFID readers less than 1 second

Objetivo específico 2 : Investigación

Integrate several (at least 5) Raspberry-Pi single board computers as modules into a unified system to control external components for registering video, audio and providing individualized stimuli

Meta 1 - Cuantitativa - Cantidad: 1.00

Develop a python script that will integrate the information from different modules and control external components

Indicador 1

1 python script

Objetivo específico 3 : Investigación

Evaluate performance of the monitoring system for registering behavior of laboratory rats

Meta 1 - Cuantitativa - Cantidad: 6.00

Implant 6 individual rats wit PIT tags

Indicador 1

6 tagged individuals

Meta 2 - Cuantitativa - Cantidad: 10.00

Evaluate monitoring system performance by video taping rat behavior to quantify the number of instances in which the rats were close to the RFID readers and compare this number to the actual reads

Indicador 1

20 video tapes

Indicador 2

97.5% of accuracy in detection

Objetivo específico 4 : Investigación

Test the developed monitoring system on laboratory rats for comparing the effect of noise in spatial memory performance

Meta 1 - Cuantitativa - Cantidad: 60.00

Conduct spatial memory tests under 2 noise conditions for each individual

Indicador 1

60 spatial memory tests for (10 for each individual, 5 on each condition)

Objetivo específico 5 : Investigación

Test the developed monitoring system on bats in the field

Meta 1 - Cuantitativa - Cantidad: 6.00

Implant 6 individual Spix's disc-winged bats with PIT tags

Indicador 1

6 tagged individuals

Meta 2 - Cuantitativa - Cantidad: 6.00

Train bats in flight cages to associate a food source to an object which may be detected acoustically

Indicador 1

6 bats trained

Meta 3 - Cualitativa

Deployed food source and RFID monitoring system next to bat roosts to evaluate differential individual visitation

Indicador 1

Detections of tagged individuals

Objetivo específico 6 : Investigación

Test the developed monitoring system on hummingbirds in the field

Meta 1 - Cuantitativa - Cantidad: 20.00

Implant 20 individual long-billed hermit hummingbirds with PIT tags

Indicador 1

Tagged individuals

Meta 2 - Cualitativa

Integrate RFID readers a feeding station composed of 3 feeders in which only one has nectar

Indicador 1

3 integrated monitoring system + hummingbird feeders

Meta 3 - Cuantitativa - Cantidad: 20.00

Evaluate spatial memory of tagged hummingbirds for recalling the position of the rewarding feeder

Indicador 1

At least 20 detections of visits to the feeders

Ubicación geográfica del proyecto

País	Provincia	Cantón	Distrito	Región
COSTA RICA	SAN JOSÉ	MONTES DE OCA	SAN PEDRO	CENTRAL
COSTA RICA	HEREDIA	SARAPIQUÍ	PUERTO VIEJO	CENTRAL
COSTA RICA	PUNTARENAS	GOLFITO	GOLFITO	BRUNCA
COSTA RICA	PUNTARENAS	GARABITO	TÁRCOLES	PACIFICO CENTRAL

Objetivos y políticas asociadas al proyecto, según catálogo de Políticas Institucionales

Objetivo asociado

2.3.1 - Facilitar la articulación de los programas, proyectos y actividades de docencia, investigación y acción social, mediante el desarrollo de iniciativas integradas, tanto en las unidades académicas como entre estas.

Políticas según ojetivo asociado: Eje/Política: 2.3 - Fomentará la vinculación entre la docencia, la investigación y la acción social, desde el pregrado hasta el posgrado, liderada por las unidades académicas, con la participación estudiantil y la difusión de sus proyectos.

Objetivo asociado

2.6.2 - Fomentar el aprendizaje mediado por las tecnologías de información y comunicación (TIC), de manera que favorezca el éxito académico.

Políticas según ojetivo asociado: Eje/Política: 2.6 - Aumentará la integración de herramientas tecnológicas de información y comunicación, al igual
que la actualización constante en todos sus ámbitos, para su aplicabilidad en las actividades sustantivas.

Objetivo asociado

5.2.1 - Incentivar el desarrollo de proyectos y actividades de trabajo colaborativo multidisciplinario e interdisciplinario entre los programas de posgrado, las unidades académicas y las unidades académicas de investigación.

Políticas según ojetivo asociado: Eje/Política: 5.2 - Impulsará las modificaciones en el ámbito normativo, presupuestario y organizativo para promover la interdisciplinariedad en los estudios de posgrado y lograr una articulación efectiva entre los programas de posgrado y las unidades académicas y de investigación.

METODOLOGÍA DEL PROYECTO

Plan de implementacion

For successful completion of this project, we have brought together a solid research team with a thorough understanding of the study system and expertise in the project's main topics. Our combined experience in successfully carrying out research will guarantee that the project is conducted under the highest standards of scientific rigor. Collaborators are also experienced advisors for graduate students, which will be essential participants throughout the duration of the project. Coordination of activities to guarantee the project's success will be accomplished by constant communication via e-mail or online meetings among members of the research team and others involved in the project, such as undergraduate and graduate students as well as additional volunteers. We will also meet at conferences and at least once a year in Costa Rica at the field site to go over the goals and plans for the year. We will also divide tasks involving manuscript preparation and publication (see dissemination of results below).

Team

Marcelo Araya-Salas (Universidad de Costa Rica)

Provide expertise for acoustic data collection and analysis
Participate during data collection
Participate in data analysis
Participate in manuscript preparation
Gloriana Chaverri (Universidad de Costa Rica)

Provide expertise for bat data collection, including capture and handling of animals and experimental design - Participate during data collection
Participate in data analysis
Participate in manuscript preparation
Juan Carlos Brenes (Universidad de Costa Rica)

Provide expertise for collection rat data in the laboratory
Participate during data collection
Participate in manuscript preparation
Alejandro Rico-Guevara (University of Washington)

Provide expertise for development and deployment of RFID devices
Participate in manuscript preparation
Alvaro Vega (Cornell University)

Provide expertise for development of RFID devices and code writing and troubleshooting

Hardware

Raspberry Pi single-board computer

A Raspberry Pi can be considered as a small system unit from a standard computer. As such, it requires peripherals, such as a mouse, a keyboard that can be directly plugged in the USB ports and a computerscreen that can be connected using the HDMI port without previous configuration. Compatible touch screens that can be powered using the Raspberry Pi are also available, making manipulations in the field easier. The Raspberry Pi is powered via amini-USB port, using a power supply able to provide 5 voltsdirect current (VDC) and a minimum of 1 A (e.g., phonecharger). Each Raspberry Pi will require a microSD card for the operating system and internal storage, and a mini-HDMI to HDMI adaptor and a micro-USB to USB adaptor, to set the system up with a monitor and keyboard.

RFID Reader

This system utilises the 125-kHz RFID reader available from CognIoT 3. This reader connects to the GPIO pins next to the microSD port (1–36, Figure 2). The reader requires input from an antenna tuned to 770 microhenries.

PIT tags

Implanting PIT tags

This is a two person procedure. One person will secure the animal while the second person performs the implantation. The animals will be held in the fingertip hold (thumb and second finger on either side of the animal to prevent movement, and the first finger on the back). Identify the tag insertion area, just to the side of the centerline and between the scapulae, making sure to avoid any superficial blood vessels. Clean site with 70% alcohol and apply Bactine or similar product (Lidocaine 2.5% + 0.13% benzalkonium chloride) as a local anesthetic to the area with a cotton swab. Wait two minutes for the local anesthetic to take effect. Attach the preloaded PIT tag needle to the implanter syringe and push the plunger until it makes contact with the PIT tag in the needle, advancing the tag until it is just inside of the needle orifice. Using forceps, gently lift the skin. Insert the needle of the PIT tag implanter under the skin at a shallow angle. The needle will be inserted with the bevel of the needle facing “up”, as opposed to facing towards the body when inserted. The needle should be inserted deeply enough so that the orifice on the bevel is just inside of the skin. Inject the PIT tag into the animal and remove the needle.

All individuals will be monitored for signs of compromise during handling. Signs of compromise may include: eyes closed, body limp and tongue protruding, excessive vocalizations, or labored breathing, especially a ‘jerky’ spasmodic motion with each breath (which can also be an indication of aspiration). If an animal shows any signs of distress, the implantation process will be suspended immediately. For hummingbirds sugar water will be

offered. If the animal does not improve, then it will be placed in a container where it can recuperate. A hand warmer pack may be placed in the container, so long as the warming pack is covered with a thin sock or some material to ensure that the animal cannot come in direct contact with it. The container will placed in a warm dry place away from noise, wind or other disturbance. The animal's condition will be checked every 5-15 minutes. Once the animal is able to feed, and is no longer showing signs of distress, it will be immediately released.

Testing and deployment

Rats

The developed monitoring system will be tested and optimized for registering rat behavior in the lab before deployment in the field. During the testing stage, 6 rats will be implanted with PIT tags and released in an enrichment cage. The cage will be equipped with a integrated monitoring system composed of 5 Raspberry-Pi, each one connected to a single RFID reader antenna. Readers will be placed closed to entrances of different sectors within the enrichment cage. Cages will be video tape for 1 hour periods which will be later annotated by a human observer. Any event in which individual rats are within the detection range of the RFID readers will be annotated as well as the time and location of these events. Annotations will be then use to evaluate the precision of the monitoring system, measured as the number of events that were actually detected. The monitoring system will be optimized until detection rates reach and acceptable performance (> 90%).

Once the monitoring system has been optimized for laboratory rats, we will conduct an experimental study to assess the effect of noise in the cognitive performance of rats. The experimental design has been previously used for testing spatial memory on small vertebrates (Gonzalez-Gomez and Vasquez 2006; González-Gómez, Vásquez, and Bozinovic 2011; González-Gómez, Bozinovic, and Vásquez 2011).

The experiment will consist of two experimental treatments low background noise (regular noise level at the lab) and high background noise (white noise within the hearing range of rats broadcast at 70dB). The rats will be presented with a food source in which 3 food containers are presented but only one has food. Containers will be refilled at a fixed interval (every 30 min). The spatial memory experiment trials will consist of two phases: a search phase in which visiting individuals identify the rewarding container and a return phase (the first visit after identifying the rewarding container) in which the ability to recall the position of the rewarding container is evaluated. Spatial memory will be tested when the position of the rewarding container is the same in both phases. Only the first visit after the search phase (i.e. the first return) will be evaluated. Performance during the return phase will be coded as a binary variable (0 = fail, 1 = success) in which successful visits required visiting the rewarding container first. A The position of the rewarding container will be changed after most visiting individuals have completed the return phase and the experiment will run until most visiting marked individuals had completed at least 10 trials. The spatial memory test will be conducted on both low and high noise environments. Half of the marked individuals will be tested first on the high noise treatment while the other half will be first tested on the low noise treatment. The change in spatial memory between the two treatments within an individual will be used to evaluate how noise can affect cognitive peformance.

Bats

To test the monitoring system tailored for bat behavior in the field, we will first train 6 bats from 3 different groups to associate a food source to an object which may be detected acoustically. We will attach a plastic hemisphere, similar to the one use by Hernández-Montero et al. (2020), to a feeder inside

the flight cage and allow bats to associate the hemisphere to a food reward (mealworms, Tenebrio molitor). We will then place the same feeder plus hemisphere in the roosting range of these groups and determine if bats, and which bats, visit these feeders. The apparatus will be left in the field for 7 nights, and each day we will monitor the feeders and replace any missing mealworms. This preliminary data will not only allow us to test our system in the field, but to develop a methodological approach to understand various aspects of the feeding ecology of T. tricolor, including whether social foraging occurs, which still remains a very poorly studied topic in this species.

Hummingbirds

In this study we will replicate a design previously used to assess spatial memory in free-living hummingbirds (Gonzalez-Gomez and Vasquez 2006; P. L. González-Gómez, Vásquez, and Bozinovic 2011; P. González-Gómez, Bozinovic, and Vásquez 2011), which closely resembles that experimental design proposed above for testing spatial memory in laboratory rats. Spatial memory will be measured on free-living long-billed hermits at 3 leks. We will place 900 mL commercial hummingbird feeders (Perky Pet #209B) at 1–2 locations surrounding leks. Feeders will be modified to have a single opening for accessing “nectar”. Three feeders arranged in a row (one next to the other) will be made available at a consistent location for each lek. A single feeder will be filled with clear sugar water (the rewarding feeder; ~100 ml of water with 25% sucrose concentration) while the other two will contained water. The experiment trial consists in two phases: a search phase in which visiting individuals identify the rewarding feeder and a return phase (the first visit after identifying the rewarding feeder) in which the ability to recall the position of the rewarding feeder is evaluated. Spatial memory will be assessed when the position of the rewarding feeder is the same in both phases. Only the first visit after the search phase (i.e. the first return) will be evaluated. As long-billed hermits do not defend feeding territories, many individuals could be observed visiting the feeders in a short period of time, Therefore, 20 individuals will be tested simultaneously (i.e. with the same feeder setup during the same days). The position of the rewarding feeder will be changed after most visiting individuals have completed the return phase aiming to evaluate each marked individuals in at least 10 trials. The statistical treatment of the data involves the same steps as those described above for the spatial memory test on lab rats.

For both hummingbirds and bats the monitoring system will include a RFID detection subsystem and a camera control subsystem. We will connect the reader to video recording component compatible with Raspberry-Pi’s. The camera will be triggered when a individual is registered at the feeding source. Recording will continue until the RFID reader detects the bird has left the area All data will be stored in a hard drive.

Dissemination of results

We will publish our results in well-respected and/or high-impact peer-reviewed journals. We predict that at least three publications will result from this project. We will also present results at international conferences.

Participation of graduate and undergraduate students

One important aspect of this project is the involvement of graduate and undergraduate students. We will recruit at least one masters and one doctorate student to be enrolled at the Universidad de Costa Rica (UCR); both will be involved in all stages of the project: design of experiments, field work, genetic analysis, data analysis, interpretation of results, preparation of manuscripts. Undergraduate students, both from the main UCR campus and Sede del Sur, will also be involved in the project, primarily in the development of the monitoring devices and field work, but ideally in other stages depending on their training, interest, and overall contribution. We will also attempt to recruit other graduate and undergraduate students through partner universities (University of Washington).

Referencias

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Recursos con que cuenta el proyecto:

The proposed behavioral monitoring devices will be tested on three study systems in which similar data collection routines have been successfully conducted, either by researchers at UCR or elsewhere. Implanted PIT tags have been used for tracking behavior under enriched laboratory environments in rats (Schuch et al. 2019). The experimental set up described in Schuch et al (2019) are similar to those regularly used at Centro de Investigación en Neurociencias. PIT tags have been extensively used by Dr. Gloriana Chaverri (Universidad de Costa Rica, Sede del Sur) for individual identification of Spix’s disc-winged bats (Thyroptera tricolor) during manipulation (Sagot et al. 2018). Furthermore, many individual Spix’s disc-winged bats at the two populations where GCC carries out research already have implanted PIT tags. Hence, we can test and optimize our monitoring devices on individuals already habituated to PIT tags. Finally, we will also deploy our system on long-billed hermit hummingbirds (Phaethornis longirostris). We have successfully tested a similar system of identification through PIT tags/RFID technology in this species (Ibarra et al. 2015). However, we used a different single-board computer (Arduinos, Arduino 2015; D’Ausilio 2012), which is significantly more limited for incorporating new components to monitoring routines when compared to Raspberry-Pi boards (Monk 2017). In addition, the collaboration with Dr Alejandro Rico-Guevara (University of Washington) will be critical for optimizing our devices for detecting hummingbirds and for deployment in tropical field conditions. Alejandro and his lab have been able to develop and deploy similar systems for behavioral monitoring of free-ranging hummingbirds in tropical conditions.

Animales, seres humanos y biodiversidad:

¿Hace uso de animales?	SI
¿El proyecto trabaja con seres humanos?	NO
¿Requiere acceso a elementos de biodiversidad?	SI

Modalidad:

Proyectos de investigación

EVALUACIÓN

Evaluación del impacto:

The project will be evaluated according to the number of research study systems for which an automatized monitoring system has been developed, the number and quality of the publications that result from the research, and the number of students who participate in the project as assistants or with final graduation or thesis projects.

PRESUPUESTO

Periodo 2021: Montos solicitados a las Vicerrectorías

Objeto del Gasto	Docencia	Investigación	Acción Social	Vida Estudiantil	Administración	Total por Objeto del Gasto
2040100 HERRAMIENTAS E INSTRUMENTOS	0.00	2,250,153.00	0.00	0.00	0.00	2,250,153.00
Totales por Vicerrectoría	0.00	2,250,153.00	0.00	0.00	0.00	2,250,153.00

Periodo 2022: Montos solicitados a las Vicerrectorías

Objeto del Gasto	Docencia	Investigación	Acción Social	Vida Estudiantil	Administración	Total por Objeto del Gasto
1050100 TRANSPORTE DENTRO DEL PAÍS	0.00	120,000.00	0.00	0.00	0.00	120,000.00
1050200 VIÁTICOS DENTRO DEL PAÍS	0.00	1,020,000.00	0.00	0.00	0.00	1,020,000.00
Totales por Vicerrectoría	0.00	1,140,000.00	0.00	0.00	0.00	1,140,000.00

Periodo 2023: Montos solicitados a las Vicerrectorías

Objeto del Gasto	Docencia	Investigación	Acción Social	Vida Estudiantil	Administración	Total por Objeto del Gasto
1050100 TRANSPORTE DENTRO DEL PAÍS	0.00	120,000.00	0.00	0.00	0.00	120,000.00
1050200 VIÁTICOS DENTRO DEL PAÍS	0.00	1,224,000.00	0.00	0.00	0.00	1,224,000.00
Totales por Vicerrectoría	0.00	1,344,000.00	0.00	0.00	0.00	1,344,000.00

Acciones por proyecto

Periodo: 2021

Objeto del gasto: 2040100 HERRAMIENTAS E INSTRUMENTOS

Fuente de financiamiento: Investigación

2,250,153.00

Justificación:

11 Raspberry Pi single-board computers for ensembling 3 monitoring devices , one composed of 5 Raspberry-Pi (rats) and 2 other composed of 3 Raspberry-Pi each (hummingbirds and bats, ¢733903)
1 2TB hard drives for storing scripts , and collected data (¢ 100,000)
50 EM4102 PIT tags for taging rats, bats and hummingbirds (¢50,000)
11 microSD cards (128 GB), one for each raspberry Pi (¢234,000)
11 Poweradd Pilot X7 external batteries, one for each monitoring system (¢ 234,850)
11 waterproof cases., 1 for each Raspberry pi (¢ 50,050)
11 R232-USB cables 1 for each Raspberry pi (¢ 50,350)
11 Pi camera modules, 1 for each Raspberry pi (¢ 228,750)
11 Pi-microphone modules, 1 for each Raspberry pi (¢ 218,000)
11 Generation 2 RFID readers, 1 for each Raspberry pi (¢ 450.250)

The requested equipment represents the basic electronic components to build the proposed monitoring systems for the study species in this project. Each monitoring system will remain with each o the research groups to be used in future projects.

Periodo: 2022

Objeto del gasto: 1050100 TRANSPORTE DENTRO DEL PAÍS

Fuente de financiamiento: Investigación

120,000.00

Justificación:

Transportation for field trips. 6 field trips, 20000 colones each

Objeto del gasto: 1050200 VIÁTICOS DENTRO DEL PAÍS

Fuente de financiamiento: Investigación

1,020,000.00

Justificación:

three10 days Field trips to Golfito and three10 days Field trips to Golfito Baru Biological station for deployment of monitoring system on bats. This field work will generate preliminary data for future research projects (or even for plubications on its own) and demonstrate the feasibility of automatic monitoring for efficiently gathering behavioral observations to the research groups involved.

Periodo: 2023

Objeto del gasto: 1050100 TRANSPORTE DENTRO DEL PAÍS

Fuente de financiamiento: Investigación

120,000.00

Justificación:

Transportation for 6 field trips to Sarapiqui . 20000 colones each.

Objeto del gasto: 1050200 VIÁTICOS DENTRO DEL PAÍS

Fuente de financiamiento: Investigación

1,224,000.00

Justificación:

six 12 day field trips to La Selva Biological Station in Sarapiqui for deploying behavioral monitoring systems at leks of long-billed hermit hummingbirds. These field trips are crucial to testing the proposed monitoring system under harsh tropical field conditions. Furthermore, similar systems have been tested on this hummingbird species. Hence the data produced on these field trips will allow to compare our systems with previous attempts, The data will also demonstrate the feasibility of automatic monitoring for efficiently gathering behavioral observations in tropical biology research.

RÉGIMEN BECARIO

Periodo:2021

Tipo de horas: Asistente

Cantidad de horas: 10.00

Meses: 10.50

Solicitado a: Investigación

Justificación:

One important aspect of this project is the involvement of graduate and undergraduate students. We will use this scholarships to recruit biology and computer science students enrolled at the Universidad de Costa Rica (UCR); both will be involved in all stages of the project: building of monitoring system, field work, data analysis, interpretation of results, preparation of manuscripts. Undergraduate students, both from the main UCR campus and Sede del Sur, will also be involved in the project, primarily in field work, but ideally in other stages depending on their training, interest, and overall contribution. We will also attempt to recruit other graduate and undergraduate students through partner institutions.

Periodo:2022

Tipo de horas: Asistente

Cantidad de horas: 10.00

Meses: 10.50

Solicitado a: Investigación

Justificación:

One important aspect of this project is the involvement of graduate and undergraduate students. We will use this scholarships to recruit biology and computer science students enrolled at the Universidad de Costa Rica (UCR); both will be involved in all stages of the project: building of monitoring system, field work, data analysis, interpretation of results, preparation of manuscripts. Undergraduate students, both from the main UCR campus and Sede del Sur, will also be involved in the project, primarily in field work, but ideally in other stages depending on their training, interest, and overall contribution. We will also attempt to recruit other graduate and undergraduate students through partner institutions.

Periodo:2023

Tipo de horas: Asistente

Cantidad de horas: 10.00

Meses: 10.50

Solicitado a: Investigación

Justificación:

One important aspect of this project is the involvement of graduate and undergraduate students. We will use this scholarships to recruit biology and computer science students enrolled at the Universidad de Costa Rica (UCR); both will be involved in all stages of the project: building of monitoring system, field work, data analysis, interpretation of results, preparation of manuscripts. Undergraduate students, both from the main UCR campus and Sede del Sur, will also be involved in the project, primarily in field work, but ideally in other stages depending on their training, interest, and overall contribution. We will also attempt to recruit other graduate and undergraduate students through partner institutions.

NOTA: en este proyecto se requieren viáticos para estudiantes. Sin embargo no fue posible asignar este rubro a la partida "6029902 SECTOR PRIVADO" ya que esta opción no estaba disponible en el menú. Los montos solicitados para este rubro se detallan en el campo de régimen becario. Se solicitan ¢ 25000 por día para cubrir los gastos de las giras de campo para estudiantes. Serian 10 días de giras para 2 estudiantes para el primer año del proyecto (¢ 500,000) y 25 días para 2 estudiantes para el segundo y tercer año del proyecto (¢1,250,000) para un total de ¢1,750,000 en este

rubro.

CRONOGRAMA DE ACTIVIDADES

Actividades	Fecha Inicial	Fecha Final
Use Raspberry-Pi single board computers to ensemble an electronic system to read PIT tags	01/01/2021	01/11/2021
Integrate several (at least 5) Raspberry-Pi single board computers as modules into a unified system to control external components for registering video, audio and providing individualized stimuli	02/11/2021	01/04/2022
Evaluate performance of the monitoring system for registering behavior of laboratory rats	02/04/2022	01/09/2022
Test the developed monitoring system on laboratory rats for comparing the effect of noise in spatial memory performance	02/09/2022	30/11/2022
Test the developed monitoring system on bats in the field	01/12/2022	15/02/2023
Test the developed monitoring system on hummingbirds in the field	16/02/2023	31/12/2023