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Internship in the Entomological Collections in the Smithsonian Institution (SI), National Museum of Natural History (NMNH): A species-level inventory of the superfamily Gelechioidea (Insecta: Lepidoptera).

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Master of Science Degree Project Paper

Entomology 888

From

Sherry V. Spriggs

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Introduction

The vast entomological collections in the Smithsonian Institution (SI), National Museum of Natural History (NMNH) include medically and agriculturally important species, and the collections are a significant source of raw material for systematic research, phylogenetic studies, biogeographic studies, identification of insect pests, and many other uses. The Department of Entomology includes staff comprised of research scientists, museum specialists and technicians employed by the Smithsonian Institution as well as those employed by affiliated agencies including the United States Department of Agriculture's (USDA) Systematic Entomology Laboratory, and the Department of Defense's Walter Reed Biosystematics Unit (WRBU). The Smithsonian Institution, Department of Entomology (USNM) mission is to: 1) describe and understand the evolutionary and ecological diversity of insects and other terrestrial arthropods through global field and laboratory research; 2) care for and improve the world's largest and most comprehensive terrestrial arthropod collection; and 3) make these discoveries known via publication, databases, training, lectures, teaching and consulting, and through museum exhibits. The USDA's Systematic Entomology Laboratory conducts research to: 1) develop comprehensive classifications, hypotheses of relationships, and identification tools for insects on a world basis in support of U.S. agriculture and natural resources; 2) provide identifications and associated taxonomic services to federal, state, and private organizations involved in research and action programs; 3) development and maintenance of cooperation with the Smithsonian Institution, the U.S. National Collection of Insects, a vital resource for insect research and identification services; and 4) develop digital and molecular identification tools and

databases of taxonomic and biological information. The WRBU and SI NMNH have worked together effectively since 1961. During that time the NMNH Mosquito Collection has developed into the largest in the world, comprising over 1.5 million specimens. The WRBU performs collection management activities — maintenance and protection of specimens, handling of transactions including loans, and progress toward improvement of the collection — and provides assistance to SI Research Associates, visiting scientists, and mosquito researchers in locating and examining specimens contained in the NMNH Mosquito Collection. The staff from these agencies works together on the development and maintenance of this vast collection at NMNH.

The site preceptor for this internship was Dr. John Brown. Dr. Brown is a retired research entomologist for the USDA's Systematic Entomology Laboratory. As a USDA Research Entomologist, Dr. Brown's work focused on the systematics and biology of leafroller moths, the family Tortricidae (Lepidoptera), many of which are economically important pests of crops. His systematic work emphasizes primarily morphological characters. The Smithsonian Institution's sponsor for this internship was Dr. Patricia Gentili-Poole, Entomology's Collections Information Manager, who is responsible for all aspects of digitization projects, including collections databases, digital images, and Type Specimens and Species inventories. She is also the primary contact person for Cossoidea and Geometridae in the Lepidoptera collection. These duties include curatorial improvement, identification, responding to queries about the collection, authorizing loans and hosting visitors. Her research Interests include the systematics of the Cossoidea (Lepidoptera).

The internship was completed in the Department of Entomology at the Smithsonian Institution's National Museum of Natural History located in Washington, DC. The internship started November 2014 and ended April 2015 and consisted of working in the collection room one day per week, usually on Tuesdays. One of the goals of the Department of Entomology, National Museum of Natural History, Smithsonian Institution is to compile a comprehensive inventory all of the species in its collections. As a component of this over-arching goal, the primary project of the internship was to compile a species-level inventory of the superfamily Gelechioidea (Insecta: Lepidoptera).

Economic Impact of Lepidoptera

The larvae of the vast majority of Lepidoptera are phytophagous (plant-feeding) and consume virtually all parts of living plants, including roots, trunks, bark, branches, twigs, leaves, buds, flowers, fruits, seeds, galls, and even leaf litter. The larvae of many groups (primarily microlepidoptera, the smaller moths) feed in concealed situations, i.e., wood borers, leaf and bark miners, case bearers, leaf tiers, and leaf rollers. Other groups (primarily macrolepidoptera) are exposed feeders, feeding during the day. In addition to feeding on plants, Lepidoptera larvae feed on a variety of other material such as the wax combs of bees, processed grains, stored products, scale insects, fabric, feathers, fungi, and sloth and bat dung.

As a result of their plant-feeding habits, Lepidoptera are economically important in agriculture, horticulture, and forestry. The armyworm and cutworm are agricultural pests of grains and vegetables. The corn earworm is a serious pest in a long list of crops. The codling moth is a pest in apple orchards. There are a number of moths of

economic importance to agriculture in the state of Maryland. The larvae of the cutworm moth (*Feltia jaculifera*) in the family Noctuidae, feed on produce such as apples, corn, beans and tobacco. The eastern tent caterpillar (*Malacosoma americanum*) in the family Lasiocampidae, feeds on roses and fruit trees such as apple, cherry, and peach. The forage looper moth (*Caenurgina erechtea*) in the family Noctuidae can be found along roadsides and in grassy fields. Its larvae feed on grass, clover, and ragweed. The giant leopard moth (*Ecpantheria scribonia*) in the family Arctiidae, typically live on the edges of woodlands and in fields and meadows where the larvae eat the leaves of shrubs, trees, and woody-stemmed plants.

Maybe the single most important economic and cultural contribution of the order Lepidoptera is silk. Mainly a product of *Bombyx mori* (Linnaeus), this material has been economically important for over 4,000 years, and its early importation to Europe opened up connections between eastern and western civilizations. One of the largest superfamilies of Lepidoptera is Gelechioidea. It includes small moths commonly known as case-bearers, twirler moths, flower moths, curved-horn moths, or gelechioid moths. The superfamily is the most species-rich among the so-called microlepidoptera, and relationships within the group, and to other groups of small moths, are poorly understood. As of the 1990s, this superfamily was composed of about 1,425 genera and 16,250 species. R.W. Hodges, a retired USDA entomologist, estimated that only 25% of this species in this highly diverse superfamily have been described.

The name "curved-horn moths" refer to one of the morphological features found in almost all Gelechioidea - the labial palps (modified mouthparts) are exceedingly long and well-developed (but not thickened), and form a pair of gently up-curved protrusions

with the ends drawn-out to pointed tips. The haustellum (proboscis) is also well-developed, allowing for long-lived imagines (adults); and the proximal part of the haustellum is covered with scales – a feature unique within microlepidoptera (shared only with Pyraloidea, a non-micro group). Gelechioidea vary extensively in habitus; most have small hind wings with long, hairy fringes; these are not easily observed in the living animal as they are tucked under the forewings at rest. The body is compressed, either dorso-ventrally or laterally.

Project goals and objectives

At the beginning of the internship, the Department of Entomology was in the first phase of a three-phase project to inventory the museum's collections. The Species Inventory is the Department of Entomology's response to the need to better manage its enormous collection and account for its holdings. The primary objective is to capture descriptive standard records in the NMNH Collections Information System (CIS), Emu ("E-museum" – the name of the database program used at NMNH), for the estimated 400,000 species in the main Lepidoptera collection. These standards include the following fields: Family, Genus, Species, Author, Year of publication, Number of specimens, Bioregion, and Location. Recommended capture information included: Country distributions (with State if USA), and images of both sexes when available.

Because of the heterogeneity of the collection in degree of use, curatorial level and storage types, the project plan is to accomplish the creation of these standard records in multiple passes. The first pass is to create new records: 1) Pre-capture preparation of the collection: checking nomenclature and updating scientific names against current classification, producing and inserting labels for storage units (trays,

drawers, cabinets); 2) Capture a basic taxonomic lot record in a template: to include the following fields: Family, Genus, Species, Author, Year of Publication, and Location; and 3) Migration of these records into EMu by staff from the Collections Information Management Unit in Entomology. The collection will then be ready for the second pass involving the standardization of records: capture of number of specimens, Bioregion and Country distribution directly into the record in EMu; and the third pass will involve capturing digital images of both sexes to illustrate the species and the creation of surrogate records in EMu. The species inventory will subsequently be used to better manage their collection and account for their holdings.

Scope of Work

I worked with nine Gelechioidea family-level taxa during this internship, as follows:

Cosmopterigidae are called cosmet moths because they are small moths with narrow wings. Their tiny larvae feed internally in leaves, seeds, and stems of their host plants. There are about 1,500 described species. Although worldwide in distribution, the family is most diverse in Australia and the Pacific region with about 780 species. The family consists of three subfamilies: Antequerinae, Chrysopeleiinae and Cosmopteriginae.

Gelechiidae are referred to as twirler moths or gelechiid moths. They are the namesake family of the superfamily Gelechioidea. Most are very small with narrow, fringed wings. The larvae feed internally on various parts of their host plants, sometimes causing galls. The three included subfamilies are Dichomeridinae, Gelechiinae and Pexicopiinae.

Peleopodidae (Peleopodinae: Oecophoridae) is a small group recognized by Hodges (1998) as a subfamily of Oecophoridae. Its taxonomic rank (e.g., family, subfamily, and

tribe) is uncertain, but the group probably is best treated as a subfamily of Oecophoridae.

Amphisbatidae (Amphisbatinae: Depressariidae) were recognized by Hodges (1998) and others as a distinct family. However, recent systematic work (Heikkilä et al. 2013) suggests that members of this group belong elsewhere, mainly in Depressariidae.

Autostichidae is another small group whose taxonomic rank has been unstable.

Although probably best considered a distinct family (Heikkilä et al. 2013), the group has been treated as a subfamily of Blastobasidae and Coleophoridae.

Coleophoridae are a family of small moths known as case-bearers, case bearing moths, or case moths owing to the larval habit of feeding from a case-like shelter composed of silk and plant parts. They are slender moths with "fringe" hairs on the margins of their wings. Larvae initially feed internally on leaves, flowers, or seeds of their host plants, but later larval stages construct a protective silken case, which is discarded and replaced by a new one as they grow and molt.

Blastobasidae are small, slender moths with a dull color, usually gray, pale brown, or reddish-brown, without streaks or large wing spots. Although many are known to be scavengers in the larval stage, several species are known to feed on the living tissue of their host plants.

Momphidae are a family of moths with over 115 described species. They are small moths with a wingspan of up to 21 mm. When at rest the wings are held folded over the body.

Pterolonchidae are a very small family of moths in the superfamily Gelechioidea and are commonly called lance-wing moths.

During my time at the Department of Entomology at the Smithsonian Institution's National Museum of Natural History, I recorded 2,483 species in the nine Gelechioidea groups (Table 1).

Table 1. Gelechioidea family groups in USNM's Lepidoptera inventoried, with the number of described species, the number of species represented in the collection, and the percent of the world fauna

Family	Number of Described Species Worldwide	Number of Species in USNM Collection	Percent of World Fauna in USNM Collection
Cosmopterigidae	1,792	521	29
Gelechiidae	4,700	1,483	31.5
Peleopididae	28	19	67.8
Deparessariidae	600	235	39
Autostichidae	638	95	14.9
Coleophoridae	1,386	0	0
Blastobasidae	377	70	18.5
Momphidae	60	54	90
Pterolonchidae	8	1	12.5

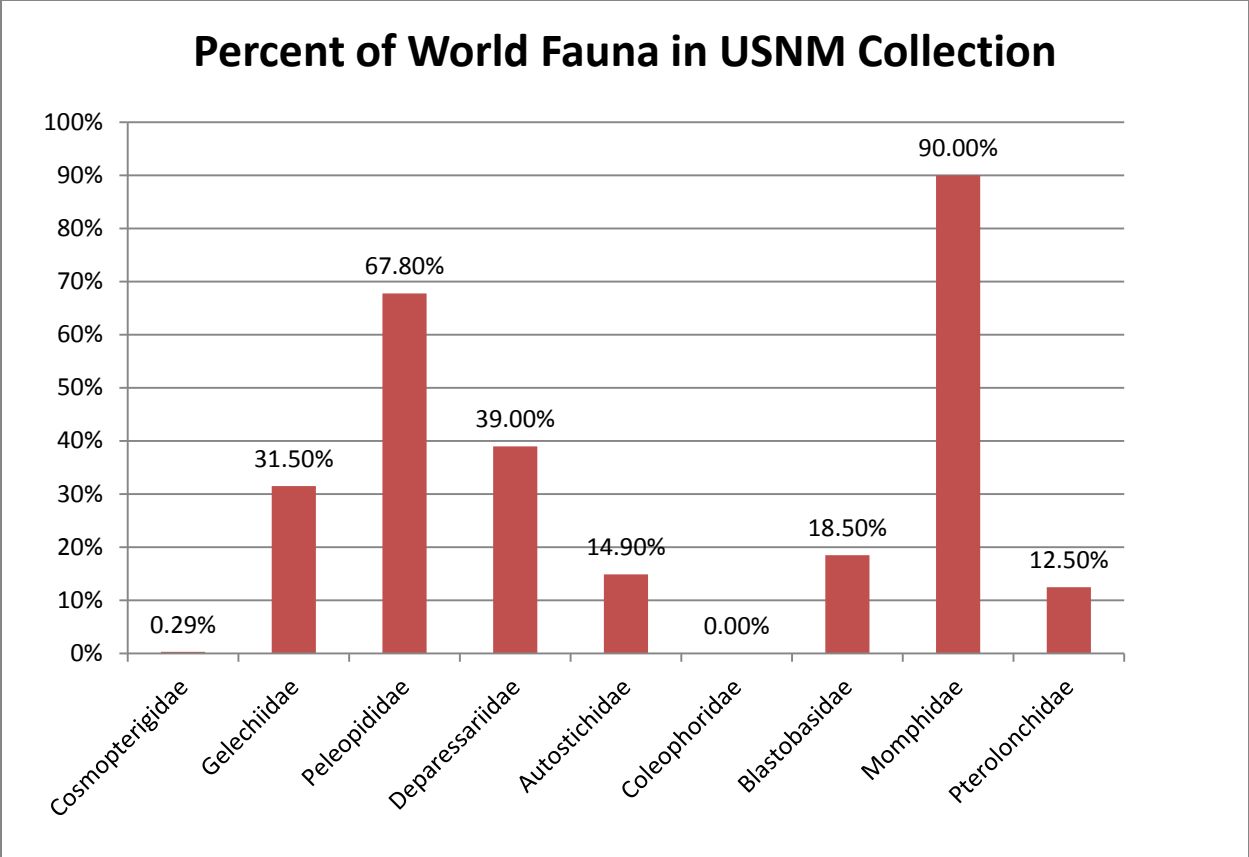


Chart 1: Percent of World Fauna in the USNM Collection

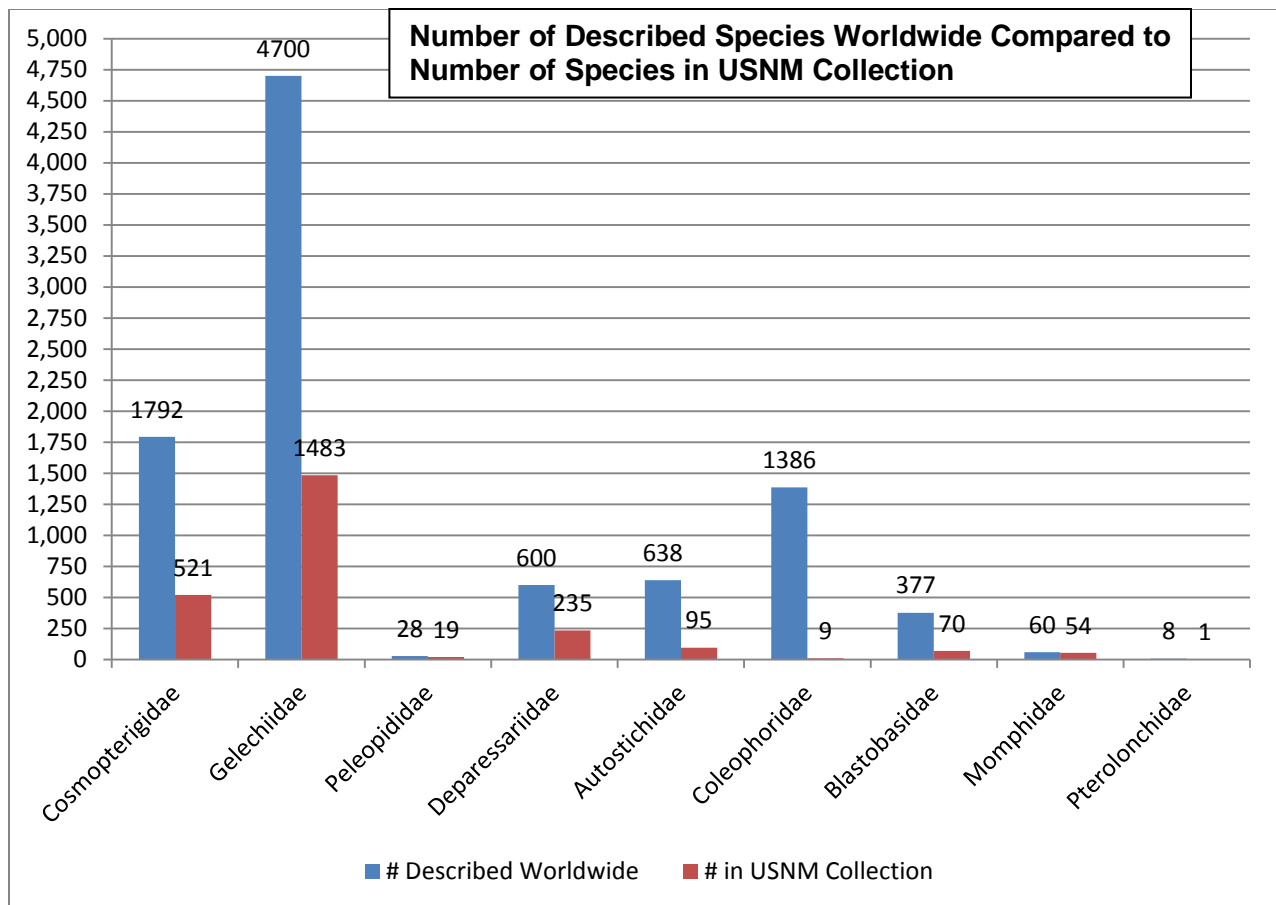


Chart 2: Comparison of number of described species worldwide to number of species in USNM collection :

Conclusion

I derived many benefits from working on the USNM collection that included gaining a better knowledge of insect diversity, insight into how insects are described or named (i.e. taxonomy), and an understanding of how large collection of natural history artifacts are organized and cataloged. Also, I further expanded my knowledge of insect nomenclature and the proper placement of pinned insects. My work benefited the USNM collection by allowing them to know which species and what percent of the world fauna are represented in their collections. After completion of this internship, I feel that I have met the learning objectives of the Smithsonian Institution Office of Fellowships and

Internship which was to learn insect nomenclature, gain a better understanding of insect cataloging, and have exposure to fascinating and interesting species from all over the world. I encourage any undergraduate, graduate or post graduate student looking for an exciting and rewarding internship or fellowship to consider the Smithsonian Institution.

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Hallway to entomology collection (SI/5th Floor)



Cabinets L & M (L on left; M on right)

L 1 - 30

YPONOMEUTOIDEA

GLYPHIPTERIGIDAE	L 30
HELIODINIAE	L 30
LYONETIIDAE	L 30 - 29
ARGYRESTHIDAE	L 29
EPERMENIIDAE	L 29 to P 16
PROTEM	L 28 - 27

GELECHIOIDEA

ELACHISTIDAE		COLEOPHORIDAE	
Stenommatinae	L 26 - 23	Coleophorinae	L 12 - 11
Ethmiinae	L 22 - 21	Momphinae	L 10
Depressariinae	L 21 - 20	Blastobasinae	L 10 - 7
Elachistinae	L 19	Pterolonchinae	L 6
Agonoxeninae	L 19	AUTOSTICHIDAE	
Hypertrophinae	L 18	Holcopogoninae	L 6
XYLORYCTIDAE		Autostichinae	L 6
Xyloryctinae	L 18	Synanthocinae	L 6
Scythridinae	L 18	PERIDIDAE	L 5
CHIMBACHIDAE	L 17 - 16	ASTIDAE	L 5
GLYPHIDOCERIDAE	L 16	COSMOPTERIGIDAE	
SCHISTONOEIDAE	L 16	Cosmopteriginae	L 5 - 2
OECOPHORIDAE		Chrysopeleinae	L 3
Oecophorinae	L 16 - 14	Antequerinae	L 3
Stathmopodinae	L 13	GELECHIIDAE	
LECITHOCERIDAE	L 13	Gelechiinae	L 1
BATRACHEDRIDAE	L 13 - 12	Anomologinae	L 1

M 1 - 30

GELECHIOIDEA

GELECHIIDAE

Gelechiinae	M 1 - 7
Anacompsinae	M 7 - 9, 13
Chelariinae	M 9 - 10, 13, 15
Dichomeridinae	M 10, 13, 15
Anomologinae	M 12
Gelechiinae	M 12 - 15

<i>Protem</i>	M 16 - 24
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RESEARCH - Adamski	M 25 - 26
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Inside look at a typical cabinet



Moths sorted into unit trays in a drawer



Me in the collection room, entering specimens into database

Tentative Offer Letter



Smithsonian
National Museum of Natural History

14 October 2014

Sherry Spriggs
106 Ferndale Hill Lane
Glen Burnie, MD 21061

INTERNSHIP APPOINTMENT TENURE: Start Date: 27 October 2014 End Date: 1 May 2015

Dear Sherry,

This letter confirms your tentative selection for an internship appointment with the National Museum of Natural History, Smithsonian Institution, located in Washington, DC. Although a conditional offer, unless you hear otherwise, you are to report for duty as scheduled. This tentative offer is conditional, subject to your successful completion of a pre-appointment / pre-arrival background investigation for a non-critical sensitive position. Please begin this process immediately so that your investigation will be completed by the starting date of your appointment. Note that the background investigation process takes 10-14 working days to determine suitability once all documents are received by the OPS office. Please plan accordingly.

Enclosed you will find an OF 306, *Declaration for Federal Employment*. This form applies to appointees being considered for all academic appointments as well as employment. The form is also available online at <http://www.opm.gov/forms>.

If you will be in Washington, DC you may hand-deliver your forms and be fingerprinted at the Smithsonian Office of Protection Services. **You should initiate this process within 5 business days of receiving this notification.**

You must bring this letter, your completed form OF 306, and if you are under the age of 18 you must also bring a signed copy of the Parent/Guardian Investigation Release Form with you to:

Smithsonian Institution, Office of Protection Services
Personnel Security and ID Office
Capital Gallery Building
600 Maryland Avenue SW, Suite 4310
Washington, DC 20024

Office Hours are Monday through Friday, 8:00am to 4:30pm. Capital Gallery is located at the corner of 7th Street SW and Maryland Ave SW. The Metro stop is L'Enfant Plaza, Capitol Gallery exit; follow the exit for Maryland Avenue.

If you are unable to travel to Washington DC prior to your start date to initiate the investigation in person take the SF 87 (*Fingerprint Chart*, arriving in the mail to you) to a local law enforcement office, police station, or court house to be fingerprinted. You should then mail the SF 87, completed form OF 306, and if you are under the age of 18 the signed copy of the Parent/Guardian Investigation Release Form, along with a copy of this letter to:

For US Postal Service:

Smithsonian Institution
Office of Protection Services
Personnel Security Division
P.O. Box 23793
Washington, DC 20026-3793

For delivery service (FedEx, UPS, etc):

Smithsonian Institution
Office of Protection Services, Personnel Security Division
Capital Gallery Building
600 Maryland Avenue SW, Suite 4160
Washington, DC 20024

Please select First Class mail at a minimum. We suggest USPS Priority Mail and advise that you request "Delivery Confirmation" to track and confirm delivery of your submission.

If you can't initiate the investigation prior to your start date, this will be done as part of your registration but your access to work spaces may be limited. Please note, you will NOT receive prior notification of your clearance status and we ask that you NOT contact our offices to check on your clearance status. Unless you hear otherwise, you can assume you cleared the investigation.

Sincerely,

E-mail: sangreym@si.edu

Attachments: **OF 306** *Declaration of Federal Appointment*, **SF 87** *Fingerprint Chart*, Parent/Guardian Investigation Release

Copy to: Patricia Gentili-Poole, Supervisor
Personnel Security and ID Office, 202-633-1598 or ops.pso@si.edu