

# Contributions of entomologists and a taxonomical bibliography of insects and other arthropods in Puerto Rico<sup>1</sup>

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## ABSTRACT

This work is a compilation of the taxonomic contributions of scientists who have worked with the insect fauna of Puerto Rico and provides a bibliography of core research papers that were key to increasing knowledge of the island's insect fauna. The contributions of George N. Wolcott, Luis F. Martorell, Francisco Seín Jr., José A. Ramos-Aleamar, Jenaro Maldonado-Capriles, Silverio Medina-Gaud, Juan A. Torres, José A. Mari-Mutt and Julio A. Micheli are discussed to establish how their work expanded the knowledge of the island's insect fauna. In addition, a total of 349 articles offering taxonomic information are listed, comprising all taxonomic contributions published in Puerto Rico through 2015.

**Key words:** Taxonomic research, taxonomic bibliography, entomological research, Puerto Rican taxonomists, Puerto Rican entomologists

## RESUMEN

**Contribuciones de entomólogos y bibliografía taxonómica de insectos y otros artrópodos en Puerto Rico**

Este trabajo provee una compilación de las contribuciones taxonómicas de científicos que han trabajado la fauna insectil de Puerto Rico y una bibliografía de artículos científicos que han sido clave para aumentar el conocimiento de la fauna insectil de la isla. Las contribuciones de George N. Wolcott, Luis F. Martorell, Francisco Seín Jr., José A. Ramos-Aleamar, Jenaro Maldonado-Capriles, Silverio Medina-Gaud, Juan A. Torres, José A. Mari-Mutt y Julio A. Micheli son discutidas para establecer cómo sus trabajos aumentaron el conocimiento de la fauna insectil de Puerto Rico. Además, se incluye una lista de 349 artículos que proveen información taxonómica con el fin de reunir todas las contribuciones taxonómicas que han sido publicadas en la isla hasta el 2015.

**Palabras clave:** investigaciones taxonómicas, bibliografía taxonómica, investigaciones entomológicas, taxónomos puertorriqueños, entomólogos puertorriqueños

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## INTRODUCTION

Taxonomy is the theory and practice of classifying organisms (ICZN, 1999). Its goal is to discover and describe new organisms, which is essential to the fundamental understanding of biodiversity, conservation practices and sustainable management of resources. Taxonomical works also serve as an inventory of local fauna that over time help determine which species have died, declined, are new to science, or represent a new report for an area. Considering the relevance of this science to other fields such as biodiversity, ecology, agriculture, conservation and medicine, it is important to know the taxonomic research in entomology that has been conducted in Puerto Rico, the influence of those taxonomic studies, and which contributions have produced the greatest increase of knowledge of the insect fauna of the island.

In Puerto Rico, research on insect taxonomy began with the creation of the Insect Collection and insect surveys conducted in the early 20th century. During the early years of the Agricultural Experiment Station (AES), established in 1910, entomologists affiliated with the institution carried out studies primarily centered on economic entomology.

Their studies rested on a comprehensive taxonomical base, recognizing the need for this research. At the same time, the New York Academy of Sciences initiated a scientific survey of Puerto Rico, which included entomological surveys that have served as the basis for successive taxonomic work. Over the years, many entomologists have contributed to the knowledge of insect fauna of Puerto Rico.

This study aims to provide a summary of the contributions of insect taxonomists, entomologists and other scientists to the field of insect taxonomy of Puerto Rico as well as to provide a complete bibliography of the taxonomical work that has been published in Puerto Rico.

## METHODOLOGY

Contributions of those scientists whose work served as a basis for other taxonomical studies were selected, and the role their work played in increasing the knowledge of the insect fauna of the island is discussed. Publications, biographies, and in some cases, obituaries were examined to gather information on their contributions.

The initial taxonomic bibliography gathers all contributions in the field of insect taxonomy published on the island through 2015. To assemble the bibliography, *The Journal of Agriculture of the University of Puerto Rico* (JAUPR), as well as other publications, were reviewed. Ninety-nine volumes of JAUPR (from 1917 to 2015) were examined; articles that contain descriptions of new genera or species, descriptions of any developmental stage, new records of insects, taxonomical

keys, taxonomical revisions, systematic accounts, checklists of species, distribution records, classifications, nomenclature, annotated lists, or taxonomic techniques were included in the bibliography.

## CONTRIBUTIONS

### *History and Legacy of the Agricultural Experiment Station*

The Agricultural Experiment Station (AES) was established in 1910 by the Sugar Producers' Association of Puerto Rico. Initially, research was devoted entirely to sugarcane. In 1914, the station was transferred to the Insular Government and renamed the Insular Experiment Station. In 1917, the Jones Act was passed, and the Insular Experiment Station became a division of the newly created Department of Agriculture and Labor of Puerto Rico. As a result, other crops and activities started to receive attention. In 1933, the entity was placed under the University of Puerto Rico and became the Agricultural Experiment Station of the College of Agriculture of the University of Puerto Rico, as we know it today. Cook and Otero (1937) documented these changes in a publication about the history of the AES, which is essential in understanding how these changes influenced research and sparked the interest of the scientific community affiliated with the institution.

The greatest contribution of the AES to Puerto Rican taxonomy has been the Insect Collection established in 1910 by a group of entomologists affiliated with the newly founded experiment station. These entomologists were D.L. Van Dine, W.V. Tower, E.G. Smyth, C.E. Hood and G.N. Wolcott. They began the insect collection creating the Insect Research Collection of the AES (AES-IRC), as it is known today. In the beginning, the collection housed insects collected from sugarcane research; but as different disciplines influenced research activities in the island's agriculture, the scope changed. Over the years, this collection has served as the depository for special collections, such as the Mona Island Insect Collection; insects collected by researchers on visits to other countries; Voucher Specimen Collections from ecological, biological control, and chemical control research carried out by AES researchers and faculty members of the University of Puerto Rico at Mayagüez (UPRM). The collection is also a depository for insects collected by researchers who contributed to maintaining and developing the collection. Since 1997, the Museum of Entomology and Tropical Biodiversity (MEBT, by its Spanish acronym) has been the custodian of the AES-IRC (Figure 1). This collection holds approximately 200,000 organisms representing the 26 orders of insects known to occur in Puerto Rico (Franqui et al., 1997). The AES-IRC is available to researchers, faculty, and students as a reference resource.



**FIGURE 1.** Lepidoptera Collection of the Agricultural Experiment Station Insect Research Collection (AES-IRC) at the Museum of Entomology and Tropical Biodiversity.

A significant number of entomologists working at the AES, some of them with a dual preparation in entomology and botany, have contributed detailed studies leaving a legacy of ecological observations (Figure 2), voucher specimens, graphic material and documents. This legacy is available today thanks to the culture of publishing peer-reviewed articles, circulars, bulletins, annual reviews, notes and newspaper articles.

#### *The Scientific Survey of Porto Rico and the Virgin Islands*

In 1913, three years after the establishment of the AES, the New York Academy of Sciences initiated its scientific survey of Puerto Rico and the Virgin Islands to document the natural history of the islands. Skilled investigators conducted the survey over an extended number of years in collaboration with the Departments of Agriculture and Commerce of Porto Rico and the University of Porto Rico, as “Puerto” was spelled in the early 20th century. This survey included studies in geology, invertebrate zoology, botany, mycology, plant ecology, ornithology, mammalogy, herpetology, ichthyology, archeology, and meteorology. The results were published in 19 volumes entitled “The Scientific Survey of Porto Rico and the Virgin Islands” (New York Academy of Sciences, 1946). The four volumes dedicated to entomology covered the following groups: Diptera (Curran, 1928); Heterocera except Noctuidae,



<i>Ligyрус tumulosus</i> Burm.		AC. NO.: 7-1910.
COMMON NAME: Scarabaeid.		
COLLECTED BY: D. L. Van Dine.		DATE: Sept. 29, 1910.
LOCALITY: Santa Rita (Guanica), P.R.		
HOST:		
REFERRED TO: Dr. L. O. Howard.		
Spec. taken to States June 26, 1913, by D. L. Van Dine.		
DETERMINED BY: E. G. S. 1917.		
NOTES: at roots of "bledo" in cane field.		
1 ♂ adult pinned.		

FIGURE 2. Catalog card of the AES-IRC with ecological observations.

Geometridae and Pyralidae (Forbes, 1930); Heterocera supplement (Forbes, 1931); Odonata (Klots, 1932); Homoptera except Sternorrhyncha (Osborn, 1935); Hemiptera (Barber, 1939); Noctuidae, (Schaus, 1940a) Geometridae and Pyralidae (Schaus, 1940b); Papilionoidea and Hesperioidea (Comstock, 1944). At that time these publications were among the most comprehensive annotated lists of the insects of Puerto Rico. The information in each volume varies from author to author, but most include descriptions and diagnosis for genus and species, collection date, notes from the authors, drawings, photographs and revised keys to genera and species. It is a taxonomic reference that has served as a basis for successive taxonomic works. Unfortunately, some orders of insects such as Coleoptera and Hymenoptera were not examined.

In 1996, the New York Academy of Sciences published a revision entitled "The Scientific Survey of Puerto Rico and the Virgin Islands: An Eighty-Year Reassessment of the Island's Natural History". It provides a summary of the status of the data for each discipline, the accomplishments and lacunae of the survey, and recommendations for further work (Berríos-Ortiz, 1997).

#### *Dr. George N. Wolcott*

George N. Wolcott has been recognized as the Father of Puerto Rican Entomology. His legacy includes more than 200 scientific publications

and manuscripts (Lawrence, 2000) that serve as a constant reference for scientists. In addition, he contributed to an increase in accession numbers in the AES-IRC, a continuous cadaster of insect fauna of the island and descriptions of species of major economic importance. He left a rich legacy of scientific collaboration and contributions to Puerto Rican and Caribbean entomology. His research on the mole crickets, white grub, and other pests provided solutions to entomological problems in the Caribbean that benefited agriculture in Puerto Rico and the continental United States (Lawrence, 2000).

In 1923, Wolcott published the first preliminary list of insects of Puerto Rico titled "Insectae Portoricensis". In 1936, he published "Insectae Borinquenses", a revised and corrected list of "Insectae Portoricensis". In 1948, he published "The Insects of Puerto Rico", an annotated list of four volumes with descriptions, collection data, collectors and collection methods for 16 orders. The "Insects of Puerto Rico" is considered his greatest taxonomic legacy (Lawrence, 2000). Wolcott's publications have contributed to a better knowledge of the local fauna and have served as a basic reference for researchers following him.

#### *Dr. Luis Francisco Martorell*

Luis Francisco Martorell's legacy includes 93 peer-reviewed publications, 28 in taxonomy, and approximately 450 newspaper articles about horticulture, entomology, botany, zoology and general gardening (Medina-Gaud, 2002). Martorell was the first Puerto Rican to obtain a doctoral degree in entomology. While studying for his doctorate at Ohio State University, he met Dr. John S. Caldwell, a North American entomologist and classmate, with whom he later worked for two years studying the Homoptera of Puerto Rico and adjacent islands (Medina-Gaud, 2002). This work appears in several taxonomic publications about the Auchenorrhynchos of Puerto Rico.

Martorell noticed that host plant information for each insect species was variable and incomplete, an observation that influenced him to record host plant relationships in all of his manuscripts. In 1945 he published "A survey of the forest insects of Puerto Rico- Part I & II", a compilation of insect species affecting forest, shade and ornamental trees. This publication was an attempt to assemble all the information available in the literature about Puerto Rican insect and host plant relationships (Martorell, 1976). Later he published "Annotated Food Plant Catalog of the Insects of Puerto Rico" (1976) to cover the insects affecting shrubs, vines, weeds, grasses, palms, trees and other plants. In this publication Martorell indicates that he only includes insects of economic importance or capable of inflicting dam-

age to the host plant, leaving a gap of information about other insects associated with the pest or host plant such as parasites or predators (Martorell, 1976).

In 1973, he published "The Insects of Mona Island, Puerto Rico" as part of an assessment of the natural and historical resources of Mona and Monito islands; this assessment was conducted by the Environmental Quality Board of Puerto Rico. Martorell used as a reference previous studies conducted on Mona Island by Ramos (1946). He summarized the scientific activity on Mona Island and reported all new species found during previous expeditions. He used biodiversity and endemism to recommend the conservation of the island, providing a good example of how taxonomy served as a basis for conservation. Two other major contributions, co-authored by Martorell, are "Preliminary list of the insects of Desecheo Island, Puerto Rico" (1974) and "The insects of Caja de Muerto Island" (1974), both annotated lists of the insect fauna of the islands, considered great contributions to the knowledge of insect fauna of the Archipelago of Puerto Rico.

Under his leadership, recognized entomologists from different universities and museums in the United States came to Puerto Rico to study insects and other arthropods of economic importance, increasing knowledge of the fauna of the island (Medina-Gaud, 2002). Due to his continuous interest and collaboration with other entomologists, he has been honored with one genus, 11 insect species, and one species of mite bearing his name (Medina-Gaud, 2002). In 1972 the Board of Trustees of the University of Puerto Rico granted him the distinction of Emeritus Professor at the College of Agricultural Sciences, Mayagüez Campus, for his contributions to entomological knowledge.

#### *Francisco Seín Jr.*

Francisco Seín Jr. obtained a bachelor's degree in entomology from Cornell University in 1920 becoming the first Puerto Rican entomologist. He worked as an assistant entomologist at the Agricultural Experiment Station where he collaborated closely with Wolcott. His contributions to taxonomy include two peer-reviewed articles and two circulars, on the topics of sugarcane insects (1930), fruit flies (1933), cockroaches (1923), and bees (1923), respectively. He also coauthored many other publications, but his drawings and aquarelles of insects, some used by Wolcott in his publications, were his biggest legacy. Seín's aquarelle of an adult of *Scapteriscus didactylus* (labeled *S. vicinus*), *Larra bicolor* (labeled *Larra americana*) and that of the larva of *Larra* on *Scapteriscus* have been preserved under the custody of MEBT.

*Dr. José A. Ramos-Alemar*

The studies of José A. Ramos-Alemar on the taxonomy of Homoptera are considered a genuine contribution to scientific knowledge, earning him grants from the National Science Foundation and the Shell Company. Among his earliest contributions the following publication stands out: "The Insects of Mona Island West Indies" (1946). It is a remarkable revision of the insect fauna of the island including distributions, richness and host plants. This publication supported information Martorell (1973) used to justify the preservation of Mona Island. Later in his career Ramos-Alemar specialized in the taxonomy of auchenorrhynchous hemipterans (Franz and Yusseff-Vanegas, 2009). In 1957 he published "A Review of the Auchenorrhynchous Homoptera of Puerto Rico", covering the families Membracidae, Cicadidae, Cercopidae and Kinnaridae, which completed the revision of Auchenorrhyncha initiated by Caldwell and Martorell in 1950 (Ramos, 1957).

José A. Ramos-Alemar officially established the UPRM Insect Collection in 1946 and acted as its primary curator until the late 1980s (Franz and Yusseff-Vanegas, 2009). According to Franz and Yusseff-Vanegas (2009), he was responsible for acquiring more than 60% of all the insect specimens housed at UPRM, proving him to be an outstanding insect taxonomist and collector. In 1989 the Board of Trustees of the University of Puerto Rico granted him the distinction of Emeritus Professor of the College of Arts and Sciences at Mayagüez for his contributions to entomology for Puerto Rico and the Caribbean.

*Dr. Jenaro Maldonado-Capriles*

Prolific author Jenaro Maldonado-Capriles published more than 150 articles on Neotropical insects, including those of medical-veterinary and agricultural importance. According to Santiago-Blay (1997), he worked as an entomologist for the Bureau of Malaria Control for the State Health Department, which led him to write his first publication: "The fleas of Puerto Rico" (1945). After completing his doctorate he focused on the hemipteran families Cicadellidae, Miridae, and Reduviidae. His major contribution to insect taxonomy was his 694-page "Systematic Catalogue of the Reduviidae of the World" (1990). Another important work is "The Miridae of Puerto Rico", published in 1969 and supplemented by additions and corrections in 1991. His last contribution (Maldonado, 1996) was a brief but incomplete summary of all the taxonomic contributions for 25 orders of insects until 1993. He wrote this article intending to show that intensive collecting remains to be done in the Caribbean region (Maldonado, 1996).

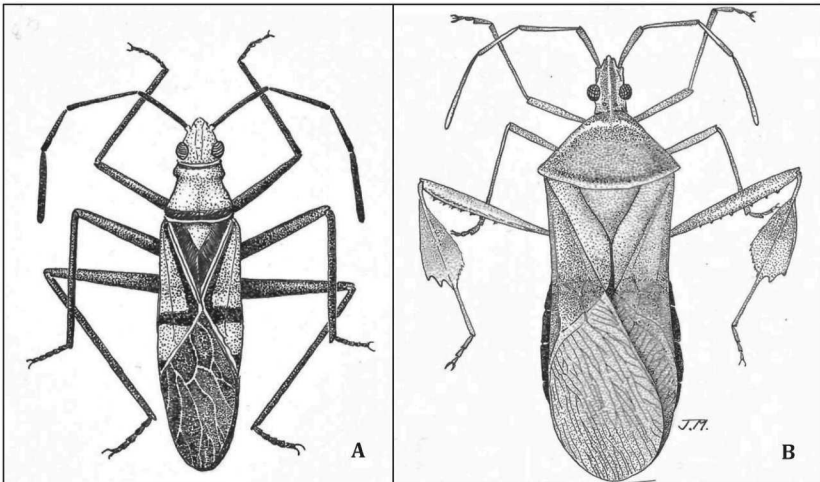
Maldonado's private insect collection involved more than 18,000 specimens. Most of the primary types are deposited in the National Mu-

seum of Natural History of the Smithsonian Institution in Washington, D.C. (Santiago-Blay, 1997). He received the maximum recognition given a taxonomist, with one genus and 22 species named in his honor.

*Dr. Silverio Medina-Gaud*

Silverio Medina-Gaud produced more than 80 publications, each considered a great contribution to the field of entomology in Puerto Rico, especially in taxonomy. His first publication in taxonomy was his master's degree research, "The Thysanoptera of Puerto Rico" (1961), in which he described seven new species. In 1978, his doctoral dissertation titled "The Muscidae of Puerto Rico" was published, and in 2006, a revised version was published. This revision includes information and descriptions of 52 species of muscids recognized from Puerto Rico, with seven of the species described as new to science (Medina-Gaud, 2006). As a result, he achieved the most complete and representative collection of thrips and muscids of Puerto Rico, which is deposited in MEBT.

In 1977, he published the first Spanish-language guide to collecting, preserving and mounting insects and other arthropods, a useful guide for professors, students and others with an interest in this discipline. In collaboration with Maldonado-Capriles, he produced several publications, among those worth mentioning, the first illustrated (Figure 3) laboratory manual of harmful and beneficial insects of Puerto Rico (Maldonado-Capriles and Medina-Gaud, 1985).



**FIGURE 3.** Original drawings of the first illustrated manual of the harmful and beneficial insects of Puerto Rico (Maldonado and Medina, 1985). (A) *Dysdercus andreae* (L.) (Hemiptera: Pyrrhocoridae) and (B) *Leptoglossus gonara* (L.) (Hemiptera: Coreidae).

In collaboration with other members of the Crop Protection Department, UPRM, he maintained and increased the AES-IRC to more than 200,000 specimens. His contributions include descriptions of more than 15 new species and more than 200 new reports of species not previously reported on the island. Five new species have been named in his honor. For his contributions to entomological knowledge, in 2005 the Board of Trustees of the University of Puerto Rico granted him the distinction of Emeritus Professor of the College of Agricultural Sciences at UPR's Mayagüez Campus.

*Dr. Juan A. Torres*

Juan A. Torres was a professor in the Biology Department of the University of Puerto Rico at Bayamón specializing in entomology and ecology. The focus of his research was taxonomy and ecology of ants, but he also worked with wasps, termites and other groups of insects. According to Lugo (2016), Torres used empirical fieldwork, sagacious observations and experimentation to advance the taxonomy and ecology of ants in Puerto Rico. The result was new species and genus descriptions, taxonomical revisions, new synonyms and new reports of species, as well as documentation of new ecological aspects and the behavior of various taxonomic groups (Lugo, 2016).

Of the 34 publications by Torres, "Insects of the Luquillo Mountains, Puerto Rico", published in 1994, is noteworthy. This report is a revision of the literature of forest entomology with information on basic insect ecology, forest and wood insects, taxonomy and systematics.

In memory of Juan Torres, Julio A. Genaro and Nico M. Franz published the paper "The bees of Greater Puerto Rico (Hymenoptera: Apoidea: Anthophila)" in 2008. Juan Torres, along with Roy Snelling, collaborated on the initial version of the manuscript (Genaro and Franz, 2008). They revised previous relevant studies and provided an annotated catalog with information about the origin and distributional patterns of 39 species of bees that occur in Puerto Rico and adjacent islands, including new reports and nomenclature corrections.

*Dr. José A. Mari-Mutt*

Professor of the Department of Biology at UPRM, José A. Mari-Mutt wrote two books, 11 general interest articles and more than 70 peer-reviewed articles in entomology. His legacy includes 65 papers on the taxonomy of springtails, a collection of nearly 3,500 slides of primarily Neotropical Collembola (Franz and Yussef-Vanegas, 2009); and as coauthor, "A Catalog of the Neotropical Collembola" (1990), which lists 959 species in 158 genera with synonyms.

Prof. Julio A. Micheli

Julio A. Micheli, avid beetle collector and art professor at the Pontifical Catholic University of Puerto Rico in Ponce, has built a collection exceeding 2,000 specimens of Puerto Rican cerambycids within a span of over 30 years (Micheli, 2010). Other contributions include peer-reviewed articles with descriptions of new species, taxonomical keys, remarkable drawings of each species described, and morphological structures. His biggest legacy is the book "Longicornios de Puerto Rico" (2010) where he drew in pencil 72 cerambycids from his collection. His daughter, Dr. Charyn Micheli, a Coleoptera taxonomist working at the Smithsonian Institution, coauthored an article with Dr. Steven Lingafelter where they described one new genus and four new species of Cerambycidae. One species described in the paper was named in honor of her father, *Elateropsis julio* Lingafelter and Micheli (Lingafelter and Micheli, 2004).

#### BIBLIOGRAPHY OF PUERTO RICAN INSECT TAXONOMY

All taxonomical references published over 98 years -from 1917 to 2015- are listed in the Bibliography to provide an insight into the taxonomical work published by entomologists who have conducted research in Puerto Rico. A total of 349 articles with taxonomic information are listed, including circulars, bulletins, peer-reviewed articles and books. Of the 26 orders of insects known to occur in Puerto Rico, the following 17 orders have been found to be related to taxonomy (number of published papers in parentheses): Protura (1), Collembola (43) Thysanura (1), Ephemeroptera (1), Odonata (1), Orthoptera (1), Isoptera (4), Blattodea (1), Hemiptera (113), Thysanoptera (13), Phthiraptera (2), Coleoptera (33), Neuroptera (1), Hymenoptera (13), Lepidoptera (21), Siphonaptera (1), Diptera (29). In addition to the aforementioned orders of insects, 19 articles related to arthropods such as Acarina and Arachnida have been published. Another 57 articles have included taxonomy-related information about multiple orders of insects. In general, the best and most widely studied orders are Collembola and Hemiptera, based on publications by Mari-Mutt (Collembola) and Maldonado-Capriles (Hemiptera). The following references are those related to insect taxonomy in Puerto Rico.

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### *Further Research*

This work provides a compilation of the taxonomic contributions by the scientists who played a leading role in expanding knowledge of the insect fauna of Puerto Rico, and it presents a bibliography of their research papers. These are our legacies, available today through the publications in this paper describing the Puerto Rican insect fauna and serving as reference to numerous scientists and students doing research. Despite these contributions, much taxonomic research remains to be done in order to properly document the entomofauna of Puerto Rico (Franz and Yusseff-Vanegas, 2009; Maldonado-Capriles, 1996). Some groups are in great need of revision. After Wolcott's 1948 "The Insects of Puerto Rico", no publication treating the orders Diplura, Phasmatodea, Dermaptera, Embiidina, Zoraptera, Mantodea, Psocoptera, Trichoptera, and Strepsiptera was found.

Thanks to the pioneering work of Wolcott, Martorell, Maldonado-Capriles, Medina-Gaud, Mari-Mutt and many other entomologists we have a better understanding of the insect fauna of the island. A comprehensive faunistic study of the insects of Puerto Rico needs to be undertaken. As Maldonado-Capriles (1996) recommended, the first step should be to provide keys to the families and genera of the insect orders in Puerto Rico.

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