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Authors: Sarratt, Jacqueline V., Zhao, Shifu, and Ochoa, Ronald

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Biography

Professor Emeritus James W. Amrine Jr.: advancing the study of *Varroa destructor* and eriophyoid mites for over 30 years

JACQUELINE V. SARRATT[1, 4], SHIFU ZHAO[2] & RONALD OCHOA[3]

[1] *San Francisco State University, 1600 Holloway Ave., San Francisco, CA 94132-4033, USA; ORCID: 0000-0002-0664-0565.*

[2] *West Virginia University, 4100 Agricultural Sciences Building, PO Box 6108, Morgantown, WV 26506-6108, USA.*

[3] *United States Department of Agriculture, Systematic Entomology Laboratory, Agricultural Research Service, BARC-West, 10300 Baltimore Ave, Bldg 005, Room 137, Beltsville, MD, 20705-2350, USA; ORCID: 0000-0003-1680-3601.*

[4] *corresponding author: jsarratt1@mail.sfsu.edu*

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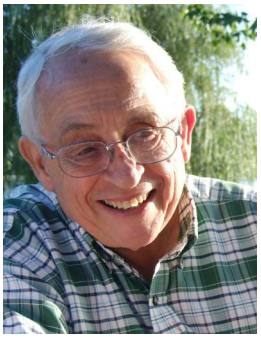


As the world's foremost taxonomist of eriophyoid mites (Eriophyoidea, Acariformes) (Xue *et al.* 2017), Dr. James (Jim) Wesley Amrine Jr.'s name is nearly synonymous with the group. His experiments with *Phyllocoptes fructiphilus* (Eriophyidae) as well as *Varroa destructor* (Varroidae, Mesostigmata, Parasitiformes) (Zhang *et al.* 2011) demonstrate Jim's commitment to developing practical applications of Acari research. In recognition of these and other acarological impacts, we nominate Dr. Amrine for the James A. McMurtry Award. Here we review highlights of his remarkable career, and celebrate his scientific as well as personal contributions.

Early years: pre-Acari

Born on November 17, 1941 in Marion, Ohio, Jim grew up in Columbus and graduated Ohio State University (OSU) with a B.S. in Entomology in 1963.[77] Continuing at OSU in the lab of Dr. Carl Vernard, he reared and described the biology, morphology, and taxonomy of one of the most medically important arthropods in the world in his 1971 thesis, *The black flies (Diptera: Simuliidae) of Ohio.*[1] After obtaining an M.S. degree in Medical Entomology (ME), he completed a Ph.D. in ME with a Botany minor from Iowa State University in 1975. As a postdoctoral student at West Virginia University (WVU), from 1975–1977 Jim worked on photoactive insecticides, and in 1977 was hired Professor of Entomology, Division of Plant and Soil Sciences, WVU. Courses he taught include Insect Physiology, Insect Morphology, ME, Apiculture, Forensic Entomology, Arachnology, as well as a class on writing Environmental Impact Statements and other documents for the U.S. Environmental Protection Agency, retiring from WVU in 2008.[77]

His publications during this time describe cottontail rabbit fleas (*Cediopsylla simplex*) from SEM images;[3] survey the mosquitoes of WV;[4, 5] study the effects of injecting dye into cockroaches;[8] and report pesticide-evading corn caterpillars (*Amphipoea velata*).[9] An early adopter of integrated

pest management (IPM), he was one of the first to investigate *Bacillus thuringiensis* (Bt) as a less-toxic alternative to chemical mosquito and black fly control[7, 10]—a method that is now widespread and continues to be recommended (Gray & Fusco 2017; Lawler 2017).

A pioneer of forensic entomology, between 1978–2013 Dr. Amrine collected data from approximately 75 cases of insects associated with decomposing flesh. Taxon and life stage data were analyzed in collaboration with Dr. Jack Frost, medical pathologist and certified WV State Medical Examiner, and presented with Lee Goff at the First European Forensic Entomology Seminar in Bari, Italy, 1997.[77]

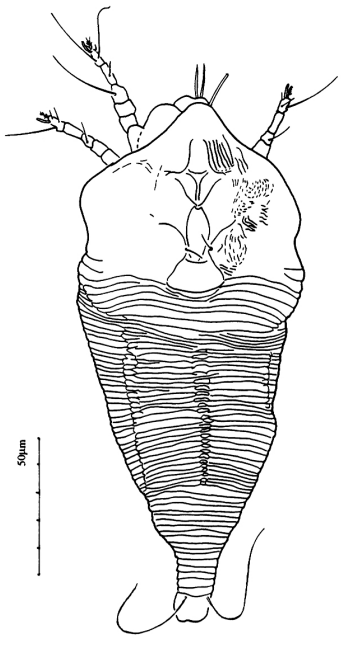
Acari I: Eriophyoidea

In 1985, a conversation with Professor Dale Hindal about multiflora rose, rose rosette disease (RRD), and the eriophyoid mite, *Phyllocoptes fructiphilus* launched a new adventure in Jim's career,[48] and he turned his attention to even smaller and more mysterious creatures.

Rosa multiflora is invasive in the eastern U.S., and can form dense thickets that reduce overall biodiversity. Dr. Amrine asked, could *P. fructiphilus* help manage *R. multiflora* by transmitting RRD and slowing growth? Seeing that greenhouse transmission studies were inconclusive (Doudrick et al. 1986), Jim questioned if mature foliage was less susceptible. He dug up plants, removed all aerial portions, forced new growth to form in a greenhouse, and found infection rate was 100%.[15]

In 1988, both Jim and Dr. Enrico de Lillo independently began developing their own computerized databases of eriophyoid data. A decade later, the pair collaborated to build a combined common resource "*to help researchers easily and quickly find all pertinent information on eriophyoids, especially for identification*".[42] This eventually developed into a cloud-based Dropbox system that continues to evolve and is currently shared with over 60 members worldwide.[112]

As one colleague recalls: "*My first personal interaction with Jim was in 1988, when he attended the last year of my presentation of the agricultural acarology course (of my 18 years' stint) during the Summer Acarology Program of The Ohio State University, Columbus. With him being already well-experienced in taxonomic and applied aspects of eriophyoid mites, I invited him to present much of the information on those mites during three days of that three-week course. Thereafter, he was invited to present that section of the agricultural acarology course for a number of years, until the OSU summer program was ended."* (Lindquist pers. comm. 7/27/21).



In 1991, Jim was in England and Scotland researching the capability of *Cecidophyopsis* (Eriophyidae) to vector blackcurrant reversion virus on *Ribes* spp.[77] By 1994, a new genus was erected "for Dr. James W. Amrine Jr. in honor of his outstanding contributions towards the study of the Eriophyoidea." *Amrineus cocofolius* (right) can be found on coconut palm fronds and may induce chlorotic and necrotic areas (Flechtmann 1994).

The books *Catalog of the Eriophyoidea (Acarina: Prostigmata) of the world*[26, 32] and *Revised keys to world genera of Eriophyoidea (Acari: Prostigmata)*[49] are essential guides for anyone working to understand these enigmatic creatures, and have been called "*indispensable*" (Lindquist pers.

comm. 7/27/21) "*major books*" (Zhang 2017), and it's said that "*everybody in erio-world knows* [Jim's] *Key and database.*" (Chetverikov pers. comm. 6/25/21).

In the 1996 reference work *World Crop Pests Vol. 6*, Jim authored one chapter: "*Phyllocoptes fructiphilus* and biological control of multiflora rose", and coauthored two: "Systematics, diagnoses for major taxa, and keys to families and genera with species on plants of economic importance", and "Preparation, mounting and descriptive study of eriophyoid mites". Jim's methods for preparing and preserving eriophyoids are highly cited, and are the result of countless hours of trial and error to perpetually refine his techniques, as he said, "*My first 6 months back in 1985, all of my slides went into the trash can*." (Amrine pers. comm. 8/3/21). These efforts earned him a reputation as the world expert, as one remarked "*it would be excellent if you make slides* [...] *with* [Jim]. *This is a rare possibility for you to learn his technique. I think this is extremely important for your future erio activity (learning the best technique from the best guru)!*" (Chetverikov, pers. comm. 8/3/21).

Dr. Amrine in Morgantown, WV, August 2021

Jim and his then-Ph.D. student pioneered other methods and greatly expanded our understanding of aerial dispersal behavior of eriophyoids.[40, 41] In Zhao & Amrine 1997a, they show a single pan trap of soapy water on the roof of a tall building could collect hundreds of eriophyoid species. They also found filtration using a vacuum and micro-filter paper collected eriophyoids more efficiently than previous techniques, and resulted in perfect specimens.

Jim's style of field education goes beyond a simple "walk in the park", as topics may range from botany to acarology to behavioral ecology to chemistry and beyond. He finds lessons in any yellow, rusted or deformed leaf, turning a stroll through the garden into a tour of a library of encyclopedias printed on the plants around us. With an eagle eye for detail and a sixth sense for natural curiosities, anything that crosses his path is subject to his integrated approach to careful investigation.

Acari II: *Varroa destructor* and ticks

Honeybees are critical to pollinating our food supply, and parasitic varroa mites are a major pest. With beekeeper Robert Noel, c. 2000 Jim began to test various IPM treatments including formic acid, grease, and oils of lemongrass and spearmint. As Jim said, "*the grease gets on the bees and simply*

makes it harder for the mites to try to hitch a ride", "*it's like trying to ride a greased pig*", and "*African people used lemongrass to manage honey bees for the last several thousand years. They deserve the original credit for that.*" (*WVUToday* 2007, Putney 2007).

For this work, in 2006 Jim was named Researcher of the Year by Florida State Beekeepers, and in 2007 the African Acarological Society and the National Agronomic Institute of Tunisia honored Dr. Amrine with a lifetime recognition award (Schacker 2008; Mancin 2017).

Extending his services beyond agricultural acarology, from 2006–2012, Jim identified tick specimens for Dermpath Diagnostic Labs, Pittsburgh, PA, and estimates he processed ~300 specimens collected from humans in association with suspected Lyme Disease, Rocky Mountain Spotted Fever, etc.[77]

From left: Charnie Craemer (South Africa), Vikram & Indira Prasad (Michigan), Bob Smiley (Maryland (MD)), Ron & Mary Ochoa (MD), Shifu Zhao (WV), Richard Newkirk (MD), James Amrine (WV), at USDA, Beltsville, MD, July 1999.

A search of coauthorships reveals him to be an avid collaborator—far beyond the hills of West Virginia, Dr. Amrine has extensively advanced the study of eriophyoids worldwide. In many eriophyoid papers, when Jim isn't listed on the byline or references, he's often cited as personal communication or thanked in the acknowledgments (de Lillo 2001, Santana 2011, Han *et al*. 2016, Rezende 2016, Gómez-Moya *et al*. 2021, Navia *et al.* 2021, Sullivan & Ozman-Sullivan 2021). When Britto et al. 2007 boldly named a new genus in Brazil from soursop after a fictional ogre (*Shrekin graviolae*, as the long laterodorsal scapular tubercules bore resemblance to the eponymous cartoon character's ears), they made sure to acknowledge "*James W. Amrine Jr.* [...] *for his constructive input regarding the decision of establishing the new genus*."

By 2013 Jim had described several new genera and many new species;[77] over a decade into retirement, Jim still serves as the world's foremost Eriophyoidea expert (Sullivan & Ozman-Sullivan 2021, Navia *et al.* 2021).

Endorsements

In response to an informal survey regarding this nomination, respondents replied: "*I've known Jim for a long time. His enthusiasm, work ethic, mentoring and publication record over many, many*

years make him a worthy nominee for the McMurtry Award. [...] *Jim was* [...] *an invited speaker for the* [XV International Congress of Acarology, 2018, Antalya, Turkey]. *It was wonderful to have the 'father figure' of eriophyoid mites there.*"

"*He makes an impression of a very energetic person, and he is a star in Acarology. The first time I saw him, he walked surrounded by students at a scientific conference in Turkey.*"

"*Given his incredible longevity and productivity in working with mites, Jim would be a very worthy recipient of the McMurtry Award so thank you for nominating him.*"

"*Jim's enthusiasm and knowledge combined to make him an effective teacher of eriophyoidology.*"

"*I can say that he is very optimistic, cheerful, and always smiling. He is very inquisitive, thorough and committed to solving scientific problems. I have only positive impressions from this meeting and from email contacts.*"

"*He is a great scientist, but he is an amazing human* [...] *With a big, big heart. And a love for very little, little creatures.*"

When approached about this biography, Jim's initial response was not to boast about his accomplishments but to immediately give credit to "*Dr. Vik Prasad* […] *Vik made all the difference in helping me get started in my career.*" (Amrine pers. comm. 7/3/21).

Always looking forward, Dr. Amrine wrote: "*Right now,* [USDA-Smithsonian] *wants my collection. But their lab is barely above sea level, and I foresee ocean levels approaching a 100 ft rise in the next 70 years. All of DC will have to be moved, at a horrendously huge expense...The collection needs to be in a safe place.* [...] *I can visualize a small, air conditioned building with great microscopes, cold stage SEM, laser scanning confocal microscopes, DNA lab, about 20 hard-working assistants and about 5 dedicated geneticists and acarologists. It would have vehicles for collecting and a great world-travel fund. It would be great for this vision to come true!*" (Amrine, pers. comm. 5/4/21).

This tribute would be incomplete without also honoring the contributions of Jim's longtime friend, WVU colleague, and "*strong right arm from 1980 to 2009*" (Amrine pers. comm. 7/4/21), Terry Ann Stasny (1929–2020). As Jim said, "*This work could not have been done without the expert assistance of my assistant, Terry Stasny.*"[48] Terry (below, right; photo from Baker *et al.* 1996) is remembered for her joyful charisma and ability to inspire the serenity and energy needed to work with these mites, and is missed by many.

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From left to right- Mercedes Delfinado-Baker, Edward W. Baker, Carl Childers, James W. Amrine Jr., Sueo Nakahara, Charnie Craemer (South Africa), Bob Smiley, Terry A. Stasny (July 1995).

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