

L. Elizabeth L. (Bets) Rasmussen (1938–2006)

It was with great sadness that I received the news of the death of L.E.L. (Bets) Rasmussen on 17 September 2006 in a Seattle Hospital, Washington State, USA, where she was being treated for a bone marrow disorder known as Myelodysplastic Syndrome (MDS), which is a rare cause of progressive and severe anaemia/bone marrow dysfunction. She was 67. Her death came as a shock to many of us, and it has deprived the scientific community of an outstanding and internationally recognized neurochemist who contributed so much to our understanding of chemical communication in elephants. Her research has shown that within the vast communicative interplay within elephant social units or herds, chemical signals are important. They are, as she herself has pointed out, 'the grease, glue and thread to help maintain daily cohesiveness and generational continuity'. Her passing away is both poignant and tragic.

Bets, as she was known to all those who knew her as a colleague, was born on 11 November 1938 in Summit, New Jersey. She graduated in Biology in 1960 from Stanford University – recognized as one of the world's leading teaching and research institutions. This was followed by a stint as a Predoctoral Fellow at the Washington University School of Medicine from 1961 to 1964. Bets carried out research in neurochemistry at Washington University (St. Louis, Missouri), which earned her the Ph D in 1964. She was at the US National Institute for Health (Bethesda, Maryland) in Clinical Neuropathology as a Postdoctoral Fellow from 1964 to 1966; a Research Project Biochemist at the Biomedical Research Laboratory, Dow-Corning Corporation (Midland, Michigan), from 1966 to 1969; Research Associate, Department of Zoology, Washington State University (Pullman, Washington), from 1975 to 1977. She joined the Oregon Graduate Institute (OGI) School of Science and Engineering (in Portland, Oregon) in 1977, where she rose to the rank of Research Professor in the Department of Environmental and Biomolecular Systems. She was also one of the active members of the IUCN Asian Elephant Specialist Group.

It is difficult to write an appreciation of a scientist of the calibre of Bets, for she would have been the first to contend that such posthumous recognition and

praise was totally uncalled for, given that her achievements were due to the collaborative efforts of many of her colleagues. Nevertheless, no one should light a candle, and put it under a bushel. Bets was undoubtedly the most outstanding exponent of chemical communication in elephants. She took to studying some of the complex problems. She had the uncanny knack to look where there was said to be nothing and finding something of value. With Bets, something was either a worthwhile occupation or a total waste of time.



Through patient and painstaking research, she and her colleagues were able to elucidate the chemical structures of compounds that functioned as pheromones in the secretions of the temporal glands in elephants during musth. Her collaborative research, over three decades, with some of the leading veterinarians, chemists, physiologists, ecologists and elephant managers, notably, Iain Douglas-Hamilton, Tom Goodwin, David R. Greenwood, Anthony J. Hall-Martin, David Hess, Mike Keele, V. Krishnamurthy, Scott and Heidi Riddle, Dennis Schmitt, Michael J. Schmidt, Bruce Schulte and Raman Sukumar, was able to expand our knowledge of chemical communication in the life history and social behaviour of elephants, in particular the Asian elephants. Bets became well known following her discovery of the sex pheromone that female elephant secretes in her urine to signal her readiness to mate (*Nature*, 1996).

Through a combination of field observations, behavioural trials of elephants in captivity (much of which was done at the Riddle's Elephant and Wildlife Sanctuary in Greenbrier, Arkansas) coupled with extensive laboratory work at the OGI, Bets together with Heidi Riddle and V. Krishnamurthy revealed in a paper in *Nature* (2002) that during musth, young so-

cially immature Asian bull elephants released honey-like odors to avoid conflict with mature bulls, while older bulls in musth broadcast foul-smelling odors to deter young bulls. This was quite a significant finding that confirmed the reference in the ancient Hindu poetry of the phenomenon of bees being attracted by the secretions of the temporal glands in young elephants in musth.

In recognition of her contribution to the advancement of science she was made a Guggenheim Fellow in 1993–1994. Fame in science is measured in terms of the Nobel Prizes and unfortunately, there is no Nobel Prize for elephant research. But publications (in *Nature*) are good enough. Further results of the research that Bets carried out in collaboration with David R. Greenwood, Dan Comeskey and Martin B. Hunt, published in *Nature* (2005), show that musth among Asian elephants is mediated by the release of a pheromone called frontalin, which exists in two chiral forms or + and – enantiomers. Depending on the ratio of the enantiomers released, other bulls and cows in a population may react and respond in different ways.

Bets was active doing research right to the end of her life. She was supported by her husband, Rei Rasmussen who is Professor of Atmospheric Chemistry at OGI. In a recent study funded by the US National Science Foundation (NSF) with Thomas Goodwin (Hendrix College, Conway, Arkansas) and Bruce Schulte (Georgia Southern University), Bets was studying the development of sexually distinctive chemical signals in captive and wild African elephants. She also received a second NSF grant (with David Greenwood, HortResearch and Auckland University, New Zealand) to continue her pioneering research on olfaction in Asian elephants. Bets was also working with Scott Riddle (Riddle's Elephant and Wildlife Sanctuary) on the development of a promising multisensory approach to reducing Asian elephant crop raiding. Field-testing of this novel approach led Bets, Scott and their associates to do field trials in Southern India, with more trials scheduled in Sri Lanka.

Bets had established a collection of urine samples over the years and a lot of those were urine from elephants in musth. When she travelled to facilities to

get samples, she invariably rented a car. She quickly learned that she always needed to keep a full bottle of essence of orange with her as several times the jars containing musth urine either leaked or spilled in the car – and that smell does not clean up easily! – but the orange extract neutralized the musth smell just long enough for her to return the car without problems. We often wondered how many people were driving around in strong smelling cars!

I remember the day I joined Rohith A. Gunawardena – a chemist and a friend of the Rasmussens – when he came over to Sri Lanka from the US to collect urine from elephants in captivity for Bets. At the research lab in Portland, Bets and her colleagues were able to identify the urinary pheromone released by female Asian elephants prior to ovulation as Z-7-dodecenyl acetate. The research lab at Portland was very much the lengthened shadow of Bets, who spent much of her time doing research and teaching by example and partnership. In the course of her research, Bets managed to collect about 700 gallons of elephant urine! When I visited Bets' lab in Portland and that of Tom Goodwin in Arkansas, I was always nervous to get a drink from their refrigerators having been aware of the advice given to Erma Bombeck by her father: *Never accept a drink from a urologist!*

Bets did not restrict her research to elephants alone. A second and related research area involved reproductive biology of marine vertebrates including carcharhinid sharks, crested auklets and marine mammals, especially as related to social

odors and pheromones. She also analysed the breath volatiles of various cetacean species from a physiological and disease aspect.

Despite her phenomenal research output, Bets still found time to enjoy the sport of water skiing, snorkelling, and scuba diving. She loved the outdoor life.

I first met her in 1998 in the company of Heidi Riddle at the Indian Institute of Science in Bangalore, when both had come to attend a conference on elephants. Bets found humour in simple things, and this is what we will all miss most – a serious scientist who also knew how to enjoy the world around her. One of the stories that we teased her about the most also involves the late Krishnamurthy – the well known and most experienced elephant veterinarian from South India. Bets and Heidi were in Mudumalai Wildlife Reserve, and one night Bets woke up and noticed a blister on her nose and was worried as it had got worse by morning. So she covered it with a band-aid. A little later when they met Krishnamurthy, he asked what had happened and she explained that she had this blister show up overnight and was worried. He immediately exclaimed 'Oh, don't worry, that's just gecko urine', at which Heidi laughed so hard and one is not sure if it was because of the look on her face or the fact that a gecko had peed on her face! After that Heidi made sure that she always gave Bets gecko-themed gifts. To commemorate this event, shortly after when Bets was due to visit Riddle's Sanctuary, Tom Goodwin composed a song entitled, *Billy the Little Gecko* (sung to the tune of *Rudolph the Red-nosed Reindeer*). Scott

and Heidi Riddle's children sang it to Bets and gave her a plastic gecko! It was a big success.

Bets will always be remembered for her invincible and indefatigable spirit, nice touches of humour, total lack of vanity, charming companionship and sheer scientific brilliance. Her public manner concealed a deeply shy and reserved nature, through which those who got to know her well, could sense great warmth and *joie de vivre*. She was always sympathetic to the younger researchers who never failed to be impressed with the clarity of her thought and exposition. She willingly shared her knowledge and experience with the fleetest academic horses as well as the underachievers. She neither flaunted her own achievements nor underrated the accomplishments of others.

Bets touched many lives. She will be long remembered as an extremely talented, versatile and zesty scientist who, despite her strong opinions, wielded great charm and wit, inspiring affection and admiration in equal measures. No one ever doubted the kindness of her heart. She will be sorely missed for her cheerful personality, great enthusiasm and complete integrity.

She is survived by her husband Rei Rasmussen; sons Robin and Erik; two brothers and three sisters.

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