

**MORPHOLOGICAL ABERRATION AND GROWTH INHIBITION OF  
CYPERMETHRIN ON THE DEVELOPMENT OF  
GOSNER STAGE 25 TO 42**

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## ACCEPTANCE SHEET

This undergraduate thesis entitled “**MORPHOLOGICAL ABERRATION AND GROWTH INHIBITION OF CYPERMETHRIN ON THE DEVELOPMENT OF GOSNER STAGE 25 TO 42**” prepared and submitted by **ALIZZA YVETTE BALDADO MEMITA**, in partial fulfillment of the requirements for the degree of **BACHELOR OF SCIENCE IN BIOLOGY (ZOOLOGY)**, is hereby accepted.



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## ABSTRACT

**MEMITA, ALIZZA YVETTE B.**, Department of Biological Sciences, College of Arts and Sciences, Central Luzon State University, Science City of Munoz, Nueva Ecija, Philippines, **FEBRUARY 2020, MORPHOLOGICAL ABERRATION AND GROWTH INHIBITION OF CYPERMETHRIN ON THE DEVELOPMENT OF GOSNER STAGE 25 TO 42**

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Cypermethrin is a synthetic pyrethroid a highly used pesticide in agriculture household for insect control. This pesticide is toxic not only for insects but also in mammals. Cypermethrin can be used against pest in the household, in agriculture, and in other animals. In order to establish morphological abnormalities and growth inhibition caused by cypermethrin to the development of Gosner stage 25 to Gosner stage 42 *Rhinella marina* tadpoles, toxicity experiment and observation of the development of tadpoles from gosner stage 25 to were assessed. The acute toxicity experiment revealed that Cypermethrin has an  $LC_{50}$  value of 0.50 ppm which is considered as highly toxic. The observed morphological aberrations caused by Cypermethrin are; bent-tail and discoloration of tail and fore-limb of gosner stage 42 tadpoles. Growth retardation was also observed. Thus, the *R. marina* tadpoles at Gosner stage 25 to 42 are significantly affected by the presence of Cypermethrin in terms of morphological aberration with the varying concentrations.

## LITERATURE CITED

- Adams, E., Jones, A., & Arnold, S. (2005). Multiple paternity in a natural population of a salamander with long-term sperm storage. *Molecular Ecology*, 14(6), 1803-1810.
- Agostini, M., Natale, G., & Ronco, A. (2010). Lethal and sublethal effects of Cypermethrin to *Hypsiboas pulchellus* tadpoles. *Ecotoxicology*, 19, 1545-1550.
- Ahmed, M., & Lahkar, B. (1999). Observation on the reproduction of *Polypedates leucomystax* (Gravenhorst 1829). *Journal of the Bombay Natural History Society*, 96(3), 478.
- Altig, R., & McDiarmid, R. (1999). Body plan: development and morphology. In tadpoles: the biology of anuran larvae. *Chicago and London: The University of Chicago Press*, 24-51.
- AmphibiaWeb. (2018). University of California, Berkeley, CA, USA, Available online: <https://amphibiaweb.org>. Retrived on September 22, 2019, 9:00 pm.
- ASTM, American Scosociety for Testing and Materials (1991). Standard guide for conducting the Frog Embryo Teratogenesis Assa- *Xenopus*. *American Scosociety for Testing and Materials*, 1-11.
- Alcala, A., & Brown, W. (1998). Philippine Amphibians: An Illustrated Field Guide. Bookmark, Makati City, Philippiness.
- Balsinky, J. (1981). Adaptation of nitrogen metabolism to hyperosmotic environment in Amphibia. *Journal of Experimental Zoology*, 215, 335-350.
- Barlow, S., Sullivan, F., & Lines, J. (2001). Risk assessment of the use of deltamethrin on bed nets for the prevention of malaria. *Food Chemical Toxicology*, 39(5), 407-422
- Beasley, M., & Temple, W. (2009). Pyrethroid toxicity and its management. *Hazardous Substances Series*, 41-43.
- Beebee, T., & Griffiths, R. (2005). The amphibian decline crisis: a watershed for conservation biology. *Biology Conservation*, 125, 271-285.
- Brown, R., Diesmos, A., & Alcala, A. (2008). Philippine amphibian biodiversity is increasing in leaps and bounds. In: Threatened amphibians of the World. *IUCN - The World Conservation Union, Gland, Switzerland; and Conservation International, Arlington Virginia, USA*, 82-83.

- Brown, R., McGuire, J., Ferrer, J., Icarangal, N., & Kennedy, R. (2000). Amphibians and reptiles of Luzon Island, II: Preliminary report on the herpetofauna of Aurora Memorial National Park, Philippines. *Hamadryad*, 2(25), 175-195.
- Carey, C., & Bryant, C. (1995). Possible interrelations among environmental toxicants, amphibian development, and decline of amphibian populations. *Environmental Health Perspectives*, 103, 13-17.
- Carvajal, A., Ponce, N., Ferrin, M., Reinoso, D., Lee, C., Bond, J. (2009). Embryogenesis and laboratory maintenance of the foam-nesting Tu'ngara frogs, *Engystomops Physalaemus*. *Developmental Dynamics*, 238, 1444-1454.
- Chakravarty, P., Bordoloi, S., Grosjean, S., Ohler, A., & Borkotoki, A. (2011). Tadpole morphology and table of developmental stages of *Polypedates teraiensis*. *Alytes*, 27(3), 85-115.
- Courchesne, C., & Bantle, J. (1985). Analysis of the activity of DNA, RNA, and Protein Synthesis inhibitors on *Xenopus* embryo development. *Teratogenesis Carcinogenesis and Mutagenesis*, 5, 177-193.
- Cox, C. (1996). Insecticide factsheet: Cypermethrin. *Journal of Pesticide Reform*, 16(2), 15-21.
- Dawson, D., & Bantle, J. (1987). Development of a Reconstituted Water Medium and Preliminary Validation of the Frog Embryo Teratogenesis Assay-Xenopus (FETAX). *Journal of Applied Toxicology*, 7, 237-244.
- Diesmos, A., & Brown, R. (2011). Diversity, biogeography and conservation of Philippine amphibians. In: Biology and conservation of tropical Asian amphibians, Proceedings of the Conference "Biology of the Amphibians in the Sunda Region, Southeast Asia." *Institute of Biodiversity and Environmental Conservation, Universiti Malaysia Sarawak, Kota Samarahan*, 6-49.
- Diesmos, A., Brown, R., & Alcala, A. (2002). New species of narrow-mouthed frog (Amphibia: Anura: Microhylidae; Genus *Kaloula*) from the mountains of Southern Luzon and Polillo Islands, Philippines. *Copeia*, 4, 1037-1051.
- Dumont, J., Schultz, T., Buchana, M., & Kao, G. (1983). "Frog Embryo Teratogenesis Assay-Xenopus (FETAX)—A Short-term Assay Applicable to Complex Environmental Mixtures. *Shortterm Bioassays in the Analysis of Complex Environmental Mixtures III*, 394-405.
- FAO, Food and Agriculture. (2007). State of the World's Forests. *Food and Agriculture Organization of the United Nations, Rome*.

- Figueiredo, J., & Rodrigues, D. (2014). Effects of four types of pesticides on survival, time and size to metamorphosis of two species of tadpoles (*Rhinella marina* and *Physalaemus centralis*) from the Southern Amazon, Brazil . *Herpetological Journal*, 24, 7-15.
- Fort, D., Stover, E., & Farmer, D. (2000). Assessing the predictive validity of Frog Embryo Teratogenesis Assay-Xenopus (FETAX). *Teratogenesis Carcinogen Mutagen* , 20, 87-98.
- Gray, H., & MacKenzie, T. (2016). Tactics used by cane toads, *Rhinella marina* (Linnaeus 1758) (Anura: *Bufo*idae), to disrupt amplexant pairs and to avoid persistent satellite males. *Herpetology Notes*, 9, 233-235 .
- Hayes, T., Case, P., Chui, S., & Chung, D. (2006). Pesticide mixtures, endocrine disruption, and amphibian declines: are we underestimating the impact? *Environmental Health Perspectives*, 114,40-50.
- He, F. (2000). Neurotoxic effects of insecticides-current and future research: a review. *Neurotoxicology*, 21(5), 829-83.
- Heaney, L., & Regalado, J. (1998). Vanishing Treasures of the Philippine Rain Forest. The Field Museum, Chicago, Illinois, USA, 238-240.
- Hillman, S., Withers, P., Drewes, R., & Hillyard, S. (2009). Ecological and environmental physiology of Amphibians. Oxford University Press: New York, NY, USA.
- Hobbes, M., & Groot, W. (2003). Corn and beyond: an exploration of sustainability, indebtedness, and future land use of the Sierra Madre forest fringe, The Sierra Madre Mountain Range: Global Relevance, Local Realities. *Jan Douwe Van der Ploeg*, 161-173.
- Hoffmann, M., Hilton-Taylor, C., Angulo, A., Böhm, M., Brooks, T., & Butchart, S. (2010). The impact of conservation on the status of the world's vertebrates. *Science*, 330,1503–1509.
- Johnstone, K., Capra, M., & Newman, B. (2007). Organophosphate pesticide exposure in agricultural workers. *Australian Government: Rural industries Research and Development Corporation*, 1-103.
- Kazemi, M., Tahmasbi, A., Valizadeh, R., Naserian, A., & Soni, A. (2012). Organophosphate pesticides: a general review. *Agricultural Science Research Journals* , 2(9), 512-522.

- Kiesecker, J. M., Blaustein, A. R., & Belden, L. K. (2005). Complex causes of amphibian population declines. *Nature*, 410, 681-684.
- Kummer, D. (1992). *Deforestation in the Postwar Philippines*. Chicago University Press, Chicago, USA.
- Lawrence, J., & Casida, J. (1982). Two classes of pyrethroid in the cockroach. *Pesticide Biochem and Physiology*, 18, 914.
- Leaflet, F. (1956). Commercial possibilities and limitations in frog raising. *United States Department of Interior, Fish and Wildlife Service Washington 25, D.C, Frog Culture and the Frog Industry*, 1-4.
- Lever, C. (2001). *The Cane Toad: The History and Ecology of a Successful Colonist*. Oatley, UK, Westbury Academic and Scientific Publishing.
- Li, Y., Cohen, J., & Rohr, J. (2013). Review and synthesis of the effects of climate change on amphibians. *Integrative Zoology*, 8, 145-161.
- Lips, K., Burrowes, P., Mendelson, J., & Parra-Olea, G. (2005). Amphibian declines in Latin America: widespread population declines, extinctions, and impacts. *Biotropica*, 37, 163-165.
- MacKinnon, J. (2002). *A Preliminary Analysis of the Philippine Protected Areas System: Gaps and Recommendations: Philippine Biodiversity Conservation Priorities: A Second Iteration of the National Biodiversity and Action Plan*. DENR-PAWB, CI Philippines, UP CIDS, and FPE, Quezon City, Philippines, 56-63.
- Mallari, N., Tabaranza Jr, B., & Crosby, M. (2001). *Key Conservation Sites in the Philippines*. A Haribon Foundation and BirdLife International Directory of Important Bird Areas. Bookmark, Inc., Makati City, Philippines.
- Mann, R., & Bidwell, R. (2000). Application of the FETAX protocol to assess the developmental toxicity of nonyphenol ethoxylate to *Xenopus laevis* and two Australian frogs. *Aquatic Toxicology*, 5, 19-29.
- Meister, R. (1992). *Farm Chemicals Handbook*. Willoughby, USA. : Meister Publishing Company.
- Myers, N. (1988). Environmental degradation and some economic consequences in the Philippines. *Environmental Conservation*, 15, 205-214.
- Myers, N., Mittermeller, R., Mittermeller, C., da Fonseca, G., & Kent, J. (2000). Biodiversity hotspots for conservation priorities. *Nature*, 403, 853-858.

- Nace, G., Culley, D., Emmons, M., Gibbs, E., Hutchison, V., & McKinnell, R. (1974). *Amphibians: Guidelines for the breeding, care and management of laboratory animals*. Washington DC: National Academy Press.
- National Pesticide Information Center, NPTC. (1998). Cypermethrin. The National Pesticide Information Center (NPIC) is a cooperative effort between Oregon State University and the United States Environmental Protection Agency, Fax: 1-541-737-0761.
- Navas, C., & Otani, L. (2010). Physiology, environmental change, and anuran conservation. *Science*, 330,83-103.
- O' Rourke, D. (2002). Reptiles and amphibians as laboratory animals. *Laboratory Animal*, 31, 43-47.
- Ong, P., Afuang, L., & Rosell-Amball, R. (2002). Philippine Biodiversity Conservation Priorities, a 2nd iteration of the national biodiversity strategy and action plan: final report. Quezon City: Department of Environment and Natural Resources, Conservation International Philippines, Biodiversity Conser. *Center for Integrative and Development Studies*, 1-113.
- Palmquist, K., Salatas, J., & Fairbrother, A. (2012). Pyrethroid insecticides: use, environmental fate, and ecotoxicology . *Insecticides – Advances in Integrated Pest Managemen*, 11, 251-280.
- Pap, L., Bajomi, D., & Szekely, I. (1969). The pyrethroids, an overview. *International Pest Council*, 38(1), 15-19.
- Perkins, A., Walters, F., Sievert, J., Rhodes, B., Morrisey, B., & Karr, C. (2016). Home use of a pyrethroid-containing pesticide and facial paresthesia in a toddler: a case report. *International Journal of Environmental Research and Public Health*, 1-7.
- Pingali, P., & Roger, P. (1995). Impacts of pesticides on farmer health and rice environment: An overview of results from a multidisciplinary study in the philippines. *International Rice Research Institute*, 1-678.
- Posa, G., Diesmos, A., Sodhi, N., & Brooks, T. (2008). Hope for threatened tropical biodiversity: lessons from the Philippines. *BioScience*, 58, 231-240.
- Pough, F. (2007). Amphibian biology and husbandry. *ILAR Journal*, 48,3,203-213.
- Pounds, J. (2001). Climate and amphibian declines. *Nature*, 410, 639-640.
- Reina, J., Duarte, J., Cerrillos, L., Bautista, J., & Moreno, I. (2017). Insecticide reproductive toxicity profile: organophosphate, carbamate and pyrethroids. *Journal of Toxins*, 4(1), 1-7.

- Republic of the Philippines. (2009). Assessing progress towards the 2010 Biodiversity target: The 4th national report to the convention on biological diversity . *Republic of the Philippines*, 1-108.
- Roque, C., Zamora, P., Alonzo, R., Padilla, S., Ferrer, M., Cacha, M. (2000). The root causes of biodiversity loss: Philippines: Cebu, Negros, and Palawan. *Earthscan Publications*, 282-308.
- Sabourin, T., Faulk, R., & Goss, L. (1985). The Efficacy of three non-mammalian test systems in the identification of chemical teratogens. *Journal of Applied Toxicology*, 5, 225-233.
- Sandhu, H., & Brar, R. (2000). Textbook of Veterinary Toxicology. 1st Ed. New Dehli, India: Kalyani Publ, 225-235.
- Siler, C., Diesmos, A., Linkem, C., Diesmos, M., & Brown, R. (2010). A new species of limestone-forest frog, genus *Platymantis* (Amphibia: Anura: Ceratobatrachidae) from Central Luzon Island, Philippines. *Zootaxa*, 2482, 49-63.
- Sharma, A., Yadav, B., Rohatgi, S., & Yadav, B. (2018). Cypemethrin toxicity: a review. *Journal of Forensic Sciences*, 9(4), 1-3.
- Sodhi, N., Bickford, D., Diesmos, A., Lee, T., Koh, L., Brook, B. (2008). Measuring the Meltdown: Drivers of Global Amphibian Extinction and Decline. *Plos One*, 3(2), 1-8.
- Stuart, S., Chanson, J., Cox, N., Young, B., & Rodrigues, A. (2004). Status and trends of amphibian declines and extinctions worldwide. *Science*, 306, 1783-1786.
- Stuart, S., Hoffman, M., Chanson, J., Cox, N., Berridge, R., Ramani, P. (2008). Threatened Amphibians of the World. Lynx Edicions: Barcelona, Spain; IUCN: Gland, Switzerland; Conservation International: Arlington, VA, USA, ISBN 978-84-96553-41-5.
- Tan, J. (2000). The Last Great Forest: Luzon's Northern Sierra Madre Natural Park. Bookmark, Makati City, Philippines.
- Tirado, R., & Bedoya, D. (2008). Agrochemical use in the Philippines and its consequences to the environment . *Greenpeace Southeast Asia*, 1-14.
- Tyler, M. (2009). Frogs and toads as experimental animals. *ANZCCART Humane Science*, 1-7.
- Vences, M., & Kohler, J. (2008). Global diversity of amphibians (Amphibia) in freshwater. *Hydrobiologia*, 595, 569-580.

- Ullah, M., Ahmad, M., Khan, M., & Ahmad, I. (2006). Toxic effect of cypermethine in female rabbits. *Pakistan Veterinary Journal*, 26(4), 193-196.
- Verdade, V., Dixo, M., & Curcio, F. (2010). Risks of extinction of frogs and toads as a result of environmental Changes. *Estudos Avançados*, 24(68), 161-172.
- Wahbe, T., & Bunnell, F. (2003). Relations among larval tailed frogs, forest harvesting, stream microhabitat, and the site parameters in southwestern British Columbia. *Canadian Journal for Research*, 33(7), 1256-1266.
- WHO, World Health Organization. (1989). International programme on chemical safety, World Health Organization: Geneva, Switzerland. *Environmental Health Criteria* 82 – *Cypermethrin*, 1-88.
- Wilson, A., & Johnson, S. (2017). The cane or "bufo" toad (*Rhinella marina*) in Florida. *Department of Wildlife Ecology and Conservation, UF/IFAS Extension*, 387, 1-6.
- Wilson, E. (1992). *The Diversity of Life*. The Belknap Press of Harvard University Press, Cambridge, 424 p.