

# Jacob M. Graving

Max Planck Institute of Animal Behavior  
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**Research Interests** Computational models for animal behavior, Bayesian statistical inference, machine/deep learning, probabilistic programming, nonlinear dynamics

## Education

2020 (expected) **Ph.D., Biology**  
Department of Collective Behaviour, Max Planck Institute of Animal Behavior  
Chair of Biodiversity and Collective Behaviour, University of Konstanz  
Centre for the Advanced Study Collective Behaviour, University of Konstanz  
International Max Planck Research School (IMPRS) for Organismal Biology

2015 **M.S., Biology**  
Department of Biological Sciences, Bowling Green State University

2013 **B.S., Biology**  
Department of Biological Sciences, Bowling Green State University

## Publications

In Preparation **Graving, J.M.**, Couzin, I.D. A deep generative model for dimensionality reduction.

In Review Li, L., Nagy, M., **Graving, J.M.**, Bak-Coleman, J., Guangming X., Couzin, I.D. Schooling fish save energy by vortex-phase matching. In review

2019 **Graving, J.M.**, Chae, D., Naik, H., Li, L., Koger, B., Costelloe, B.R., Couzin, I.D. (2019). DeepPoseKit, a software toolkit for fast and robust animal pose estimation using deep learning. *eLife*, 8. <https://doi.org/10.7554/elife.47994>  
bioRxiv: <https://doi.org/10.1101/620245> Code: <https://github.com/jgraving/deepposekit>  
Press: Quanta Magazine, Nature Methods, Nature News & Views, *eLife Science Digests*

2018 Alarcón-Nieto, G.\*, **Graving, J.M.\***, Klarevas-Irby, J.A.\*, Maldonado-Chaparro, A.A., Mueller, I., and Farine, D.R. (2018) An automated barcode tracking system for behavioural studies in birds. *Methods in Ecology and Evolution* 9 (6), 1536-1547. <https://doi.org/10.1111/2041-210X.13005> bioRxiv: <https://doi.org/10.1101/201590> \*contributed equally

2017 **Graving, J.M.**, Bingman, V.P., Hebets, E.A., and Wiegmann, D.D. (2017). Development of site fidelity in the nocturnal amblypygid *Phrynus marginemaculatus*. *Journal of Comparative Physiology A*, 203(5), 313-328. <https://doi.org/10.1007/s00359-017-1169-5>  
Bingman, V.P., **Graving, J.M.**, Hebets, E.A., and Wiegmann, D.D. (2017). Importance of the antenniform legs, but not vision, for homing by the neotropical whip spider *Paraphrynus laevifrons*. *Journal of Experimental Biology*, 220(5), 885-890. <https://doi.org/10.1242/jeb.149823>  
Press: Discover Magazine, National Geographic

2016 Wiegmann, D.D., Hebets, E.A., Gronenberg, W., **Graving, J.M.**, and Bingman, V.P. (2016). Amblypygids: model organisms for the study of arthropod navigation mechanisms in complex environments. *Frontiers in Behavioral Neuroscience*, 10, 47. <https://doi.org/10.3389/fnbeh.2016.00047>

## Research

2015–present **Max Planck Institute of Animal Behavior,**  
**Department of Collective Behaviour**  
Iain D. Couzin

“Revealing the Behavioral Algorithms of Social Animals”  
Studying how sensory information and internal state drive the collective dynamics of animal groups. Developing machine learning methods to collect and analyze behavioral data.

2011–2015 **Bowling Green State University, Department of Biological Sciences**  
Daniel D. Wiegmann, Verner P. Bingman  
“Navigation and Sensory Discrimination in Amblypygids”  
Studied how amblypygids, a group of nocturnal arachnids, navigate home in the dark

2013 **Bowling Green State University, Department of Biological Sciences**  
Sheryl L. Coombs  
“The Sensory Basis of Rheotaxis in Fish”  
Studied how fish use multimodal sensory information to orient to flow.

2009 **SETGO Summer Research Scholar, Bowling Green State University**  
Matthew L. Partin  
“Phenotypic Plasticity in Photosynthetic Stony Corals”  
Studied how genetically identical coral propagules adapt their morphology and physiology to changing environments.

## Teaching

2019 **ASAB 2019 Summer Conference, University of Konstanz**  
Workshop Organizer and Lecturer  
– Seminar on “Machine Learning in the Behavioral Sciences”  
– Practical Workshop on “Quantifying Behavior with Machine Learning”

2016–now **University of Konstanz, Chair of Biodiversity and Collective Behaviour**  
Lecturer and Project Advisor, Intensive Research Course for Master’s Students  
– Measuring Animal Behavior with Computer Vision  
– Analyzing Behavioral Data  
– Introduction to Programming

2013–2015 **Department of Biological Sciences, Bowling Green State University**  
Graduate Assistant  
– Advanced Biostatistics (for Graduate Students)  
– Introduction to Biostatistics  
– Population and Community Ecology  
– Introductory Biology for Non-Science Majors  
– Guest Lecture on “Arthropod Navigation”, Animal Behavior

2009–2012 **Bowling Green State University, Department of Biological Sciences**  
Student Coordinator and Teaching Assistant, Marine Biology Laboratory  
– Introduction to Inland Marine Research  
– Aquarium Husbandry  
– Reef Aquarium Husbandry I and II

2009 **Bowling Green State University, Department of Environmental Science**  
Student Teaching Assistant, Introduction to Environmental Science

## Funding

2013–2015 **Graduate Research Fellowship**  
100% Tuition Waiver and \$45,000 Stipend  
Bowling Green State University

2013 **Undergraduate Research Fellowship**  
\$5000 Stipend, \$800 Research Funds  
Bowling Green State University, Center for Undergraduate Research and Scholarship

- 2009–2011 **T. Richard Fisher Biology Scholarship**  
\$8000/year Tuition Scholarship  
Bowling Green State University, Department of Biological Sciences
- 2009 **Summer Research Fellowship**  
\$5000 Stipend, \$1000 Research Funds  
Science, Engineering, Technology Gateway Ohio (SETGO), National Science Foundation
- 2009–2013 **Award of Scholars**  
Merit-based 75% Tuition Scholarship  
Bowling Green State University, College of Arts and Sciences

## Invited Talks

- 2019 **Revealing the Behavioral Algorithms of Social Animals Using Deep Learning**  
Princeton Neuroscience Institute (PNI)  
Princeton University, Princeton, New Jersey, USA  
July 2, 2019
- 2018 **Perception and Motion in Locust Swarms**  
Integrated Behavioral Research Group (IBRG)  
Princeton University, Princeton, New Jersey, USA  
March 16, 2018
- Perception and Motion in Locust Swarms**  
Department of Biological Sciences Seminar Series  
Bowling Green State University, Bowling Green, Ohio, USA  
February 28, 2018

## Outreach

- 2017 **Konstanzer Lange Nacht Der Wissenschaft**  
“Long Night of Science” Public Outreach Event  
Volunteer  
Konstanz, Germany
- 2016 **Das Schwarmverhalten der Fische**  
Public Seminar by Prof. Jens Krause  
Volunteer Co-organizer  
Konstanz, Germany
- 2013–2014 **Kid’s Tech University, Bowling Green State University**  
Public Outreach Event for Schoolchildren Grades K–8  
Volunteer  
Bowling Green, Ohio, USA
- 2008–2010 **The Toledo Zoo Aquarium**  
Volunteer and Intern  
Toledo, Ohio, USA

## Advisees

- Graduate  
Simon Gommel, M.S. Biology, University of Konstanz  
Taylor Carter, M.S. Biology, University of Konstanz  
Ingabritta Hormann, M.S. Biology, University of Konstanz
- Undergraduate  
Nicole Meister, B.S. Computer Science, Princeton University  
Chiara Hirschhorn, B.S. Biology, University of Konstanz  
Daniel Chae, B.S. Computer Science, Princeton University  
Connie Santangelo, B.S. Biology, Bowling Green State University

Lindsey Cunningham, B.S. Biology, Bowling Green State University  
Tracy Togba, B.S. Biology, Bowling Green State University

## Peer Review

*Journals:* eLife, Science Advances, PNAS  
*Grants:* IMPRS Project Grant, IMPRS Travel Grant

## Skills

### Computational

*Languages:* Python (Expert), R (Intermediate), MATLAB (Intermediate)  
*Applications:* Bayesian inference, statistical analysis, data visualization,  
machine learning, deep learning, computer vision, and image processing  
*Libraries:* Stan, TensorFlow, PyTorch, scikit-learn, OpenCV

### Biological

*Physiology:* electrophysiology, histology, ophthalmoscopy, fish lateral line disruption and visualization  
*Microscopy:* scanning and transmission electron microscopy, confocal, fluorescence, and general light microscopy

## References

**Iain D. Couzin**

Director, Max Planck Institute of Animal Behavior  
Professor, University of Konstanz  
Department of Collective Behaviour  
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**Daniel D. Wiegmann**

Associate Professor  
Bowling Green State University  
Department of Biological Sciences  
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**Verner P. Bingman**

Distinguished Research Professor  
Bowling Green State University  
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**Sheryl L. Coombs**

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