Invasion Biology
001-2-3096

Lecturer: Dr. Monica Mowery
Contact information: monicaan@post.bgu.ac.il

2 Credits

Course description and objectives: Invasive species have strong negative impacts on ecosystems (Ricciardi *et al.* 2013), with an estimated 33% of recent animal extinctions attributed to the effects of alien species (Blackburn et al., 2019). In our changing world, understanding what makes invasive species so successful in their invaded range is essential in mitigating these impacts. In this course, we will learn about the causes and consequences of biological invasions through intersections with ecology, evolution, genomics, and conservation. By the end of the course, students will be able to explain ecological and evolutionary theories of invasive spread, the impact of biological invasions, and discuss recent advances and debates in the field.

Course structure: This course will have 14 classes, composed of lectures, journal article discussions, and student presentations. Each class will begin with a short lecture by the instructor on the topic, then move onto facilitated discussions about specific topics in invasion biology detailed below. Students will choose a topic that interests them and present recent advances in the area. Discussion topics will be subject to change based on students' interests.

Level: The course is open to M.Sc and Ph.D. students. Advanced undergraduates may ask for permission to join the course.

Assessment of students and grading structure:
50% student presentation: Students will choose a journal article about one of the proposed topics below. Students may pick a reading from the list of papers in the syllabus, or choose a paper independently. The presentation will consist of summarizing the article, critically evaluating the methods, results, and discussion, and relating the findings to other research in the field.

50% discussion participation: This grade will be determined by active participation in class discussions. In addition to contributing during classes, participation is also possible by submitting questions about the topic and assigned reading beforehand or writing questions on the class discussion board in Google Classrooms.

Duration and credits: Two hours per week during winter/spring semester of 2022 (two credit points), March 2022 – July 2022 (14 sessions)

Location: Sede Boqer campus, Ben-Gurion University of the Negev. A Zoom option will be available according to student interest.

Detailed description of course topics with background and discussion readings listed below each topic:

1. **History of invasion science: consequences and lessons learned**
    - **Topics:** overview of basic concepts and theory in invasion biology, historical basis of the field, history of notable intentional and unintentional introductions

- **Discussion reading**: Barrett, S.C.H. Foundations of invasion genetics: the Baker and Stebbins legacy (2015). *Molecular Ecology*, 24, 1927-1941.
- Optional: Selections from *The Genetics of Colonizing Species,* Baker and Stebbins 1965.

2. Genetic diversity, bottlenecks, and gene flow

- **Topics:** propagule pressure, transport pathways, vectors, genomic methods, hybridization, epigenetic and transgenerational effects
- **Discussion reading**: Blumenfeld, A. J., Eyer, P. A., Husseneder, C., Mo, J., Johnson, L. N., Wang, C., ... & Vargo, E. L. (2021). Bridgehead effect and multiple introductions shape the global invasion history of a termite. *Nature Communications biology*, *4*(1), 1-12.
- Optional: Colautti, R. I., & Lau, J. A. (2015). Contemporary evolution during invasion: evidence for differentiation, natural selection, and local adaptation. *Molecular ecology*, *24*(9), 1999-2017.
- Optional: Arredondo, T. M., Marchini, G. L., & Cruzan, M. B. (2018). Evidence for human-mediated range expansion and gene flow in an invasive grass. *Proceedings of the Royal Society B: Biological Sciences*, *285*(1882), 20181125.

3. Functional traits related to invasion success

- **Topics:** integrated traits, traits and trade-offs, predicting invasiveness, functional traits, using phylogenetic comparative methods
- **Discussion reading:** Allen, W. L., Street, S. E., & Capellini, I. (2017). Fast life history traits promote invasion success in amphibians and reptiles. *Ecology Letters*, *20*(2), 222-230.
- Optional: Richardson, D. M., Pyšek, P., Rejmánek, M., Barbour, M. G., Panetta, F. D., & West, C. J. (2000). Naturalization and invasion of alien plants: concepts and definitions. *Diversity and distributions*, *6*(2), 93-107.
- Optional: Whitney, K. D., & Gabler, C. A. (2008). Rapid evolution in introduced species, 'invasive traits' and recipient communities: challenges for predicting invasive potential. *Diversity and Distributions*, *14*(4), 569-580.

4. Local adaptation in the novel environment

- **Topics:** how to measure local adaptation, geographic clines, fine-scale vs. broad-scale adaptation, common garden and transplant experiments
- **Discussion reading:** Winwood-Smith, H. S., Alton, L. A., Franklin, C. E., & White, C. R. (2015). Does greater thermal plasticity facilitate range expansion of an invasive terrestrial anuran into higher latitudes?. *Conservation Physiology*, *3*(1), cov010.
- Optional: van Boheemen, L. A., Atwater, D. Z., & Hodgins, K. A. (2019). Rapid and repeated local adaptation to climate in an invasive plant. *New Phytologist*, *222*(1), 614-627.
- Optional: Westley, P. A., Ward, E. J., & Fleming, I. A. (2013). Fine-scale local adaptation in an invasive freshwater fish has evolved in contemporary

time. *Proceedings of the Royal Society B: Biological Sciences*, *280*(1751), 20122327.

5. **Phenotypic plasticity**
    - **Topics:** behavioural plasticity, adaptive plasticity, non-adaptive plasticity, differentiation between plasticity and local adaptation, response to stress, Jack-of-all-trades hypothesis
    - **Discussion reading:** Yeh, P. J., & Price, T. D. (2004). Adaptive phenotypic plasticity and the successful colonization of a novel environment. *The American Naturalist*, *164*(4), 531-542.
    - Optional: Kelly, M. (2019). Adaptation to climate change through genetic accommodation and assimilation of plastic phenotypes. *Philosophical Transactions of the Royal Society B*, *374*(1768), 20180176.
    - Optional: Davidson, A. M., Jennions, M., & Nicotra, A. B. (2011). Do invasive species show higher phenotypic plasticity than native species and, if so, is it adaptive? A meta-analysis. *Ecology letters*, *14*(4), 419-431.

6. **Interspecific interactions: competition, predators, prey, and parasites**
    - **Topics:** competitive exclusion, evolution of increased competitive ability, symbionts, predators, prey, pathogens, parasites, resistance to invasion, facilitation of establishment, microbial mechanisms
    - **Discussion reading:** Broadbent, A., Stevens, C.J., Peltzer, D.A. *et al.* Belowground competition drives invasive plant impact on native species regardless of nitrogen availability. *Oecologia* **186,** 577–587 (2018). https://doi.org/10.1007/s00442-017-4039-5
    - Optional: Colautti, R. I., Ricciardi, A., Grigorovich, I. A., & MacIsaac, H. J. (2004). Is invasion success explained by the enemy release hypothesis?. *Ecology letters*, *7*(8), 721-733.
    - Optional: Beckmann, C., & Shine, R. (2011). Toad's tongue for breakfast: exploitation of a novel prey type, the invasive cane toad, by scavenging raptors in tropical Australia. *Biological Invasions*, *13*(6), 1447-1455.

7. **At the invasion front: shifts during invasive spread**
    - **Topics:** spatial sorting, persistence and spread, iterative dispersal, traits and trade-offs during spread, evolutionary processes, Allee effects, landscape ecology and invasion
    - **Discussion reading:** Ochocki, B. M., & Miller, T. E. (2017). Rapid evolution of dispersal ability makes biological invasions faster and more variable. *Nature communications*, *8*(1), 1-8
    - Optional: Sakai, A. K., Allendorf, F. W., Holt, J. S., Lodge, D. M., Molofsky, J., With, K. A., ... & Weller, S. G. (2001). The population biology of invasive species. *Annual review of ecology and systematics*, *32*(1), 305-332.
    - Optional: Duckworth, R. A., & Badyaev, A. V. (2007). Coupling of dispersal and aggression facilitates the rapid range expansion of a passerine bird. *Proceedings of the National Academy of Sciences*, *104*(38), 15017-15022.

8. **Biogeography of invasions**
    - **Topics:** modelling geographic spread, reaction-diffusion model, dispersal, ecological niche modelling, phylogeny and biogeography, species distribution models, GIS
    - **Discussion reading:** Scott, P., Bader, M. K. F., Burgess, T., Hardy, G., & Williams, N. (2019). Global biogeography and invasion risk of the plant pathogen genus Phytophthora. *Environmental Science & Policy*, *101*, 175-182.
    - Optional: Liu, C., Wolter, C., Xian, W., & Jeschke, J. M. (2020). Most invasive species largely conserve their climatic niche. Proceedings of the National Academy of Sciences, 117(38), 23643-23651.
    - Optional: Schmack, J. M., Schleuning, M., Ward, D. F., & Beggs, J. R. (2020). Biogeography and anthropogenic impact shape the success of invasive wasps on New Zealand's offshore islands. *Diversity and Distributions*, *26*(4), 441-452.

9. Ecosystem and community traits and feedback
    - **Topics:** disturbance, urbanization, agriculture as disturbance, terrestrial and aquatic ecosystems, invasibility, Darwin's naturalization hypothesis, invasional meltdown
    - **Discussion reading:** Santana Marques, P., Resende Manna, L., Clara Frauendorf, T., Zandonà, E., Mazzoni, R., & El-Sabaawi, R. (2020). Urbanization can increase the invasive potential of alien species. *Journal of Animal Ecology*, *89*(10), 2345-2355.
    - Optional: Park, D. S., Feng, X., Maitner, B. S., Ernst, K. C., & Enquist, B. J. (2020). Darwin's naturalization conundrum can be explained by spatial scale. *Proceedings of the National Academy of Sciences*, *117*(20), 10904-10910.

10. Climate change and invasive species
    - **Topics:** climate-driven range shifts, thermal tolerance, ocean warming, future projections, climate resilience
    - **Discussion reading:** Wesselmann, M., Anton, A., Duarte, C. M., Hendriks, I. E., Agustí, S., Savva, I., ... & Marbà, N. (2020). Tropical seagrass *Halophila stipulacea* shifts thermal tolerance during Mediterranean invasion. *Proceedings of the Royal Society B*, *287*(1922), 20193001.
    - Optional: Iwamura, T., Guzman-Holst, A., & Murray, K. A. (2020). Accelerating invasion potential of disease vector *Aedes aegypti* under climate change. *Nature communications*, *11*(1), 1-10.
    - Optional: Stachowicz, J. J., Terwin, J. R., Whitlatch, R. B., & Osman, R. W. (2002). Linking climate change and biological invasions: ocean warming facilitates nonindigenous species invasions. *Proceedings of the National Academy of Sciences*, *99*(24), 15497-15500.

11. Preventing and managing invasive species
    - **Topics:** risk analysis, screening risky species, early detection, eDNA, rapid response, long-term control, biological control methods

- **Discussion reading:** Prior, K. M., Adams, D. C., Klepzig, K. D., & Hulcr, J. (2018). When does invasive species removal lead to ecological recovery? Implications for management success. *Biological Invasions*, *20*(2), 267-283.
- Optional: Beaury, E.M., Fusco, E.J., Jackson, M.R. *et al.* Incorporating climate change into invasive species management: insights from managers. *Biol Invasions* **22,** 233–252 (2020). https://doi.org/10.1007/s10530-019-02087-6

12. Assessing impacts of invasive species

- **Topics:** ecological impacts: biodiversity, communities, food webs, novel ecosystems, modifying physical structure of the environment; economic impact; human health and safety
- **Discussion reading:** Epanchin-Niell, R. S. (2017). Economics of invasive species policy and management. *Biological Invasions*, *19*(11), 3333-3354.
- Optional: Ricciardi, A., Hoopes, M. F., Marchetti, M. P., & Lockwood, J. L. (2013). Progress toward understanding the ecological impacts of nonnative species. *Ecological monographs*, *83*(3), 263-282.
- Optional: Ren, J., Chen, J., Xu, C., van de Koppel, J., Thomsen, M. S., Qiu, S., ... & He, Q. (2021). An invasive species erodes the performance of coastal wetland protected areas. *Science advances*, *7*(42), eabi8943.

13. Criticism of invasion science

- **Topics:** definitions of impact, difficulties of prediction, measuring biodiversity, animal welfare and compassionate conservation, philosophical critiques
- **Discussion reading:** Cassini, M. H. (2020). A review of the critics of invasion biology. *Biological Reviews*, *95*(5), 1467-1478.
- Optional: Russell, J. C., & Blackburn, T. M. (2017). The rise of invasive species denialism. *Trends in Ecology & Evolution*, *32*(1), 3-6.

14. Invasion science: what's next?

- **Discussion reading:** Tebboth, M. G. L., Few, R., Assen, M., & Degefu, M. A. (2020). Valuing local perspectives on invasive species management: Moving beyond the ecosystem service-disservice dichotomy. *Ecosystem Services*, *42*, 101068.
- Optional: Larson, E. R., Graham, B. M., Achury, R., Coon, J. J., Daniels, M. K., Gambrell, D. K., ... & Suarez, A. V. (2020). From eDNA to citizen science: emerging tools for the early detection of invasive species. *Frontiers in Ecology and the Environment*, *18*(4), 194-202.
- Optional: Heger, T., Jeschke, J. M., & Kollmann, J. (2021). Some reflections on current invasion science and perspectives for an exciting future. *NeoBiota*, *68*, 79.

Preliminary knowledge: This course requires previous knowledge of ecology and evolutionary biology. However, the course is open to students from a broad range of backgrounds and diverse perspectives are welcomed.