

Jackson Champer

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<https://jchamper.github.io>

SIGNIFICANT ACADEMIC POSITIONS

Assistant Professor, Peking University 2021.5-Present

- School of Life Sciences, Center for Bioinformatics, Center for Life Sciences.
- Experimental gene drive research with flies, mosquitoes, and others.
- Computational modeling of gene drives.
- Visiting Professor at Fujian Agriculture and Forestry University.

Postdoctoral Fellow, Cornell University 2016.5-2021.3

- Labs of Philipp Messer and Andrew Clark in the Department of Molecular Biology and Genetics and the Department of Computational Biology.
- Improved gene drive systems, designs and experiments.
- Computational modeling and genetic analysis of gene drives in realistic environments.

Graduate Researcher, City of Hope Beckman Research Institute 2010.9-2015.6

- Lab of Markus Kalkum in the Department of Immunology.
- Mass spectrometry and proteomics for antifungal vaccine development.
- Rotation on the immunological and proteomic analysis of breast cancer extracellular matrix with S. Emily Wang.

Researcher, University of California, Los Angeles 2008.6-2009.7, 2013.8-2014.9

- Lab of Jenny Kim in the Department of Dermatology.
- Immunological and proteomic analysis of *Propionibacterium acnes* phylotypes.
- Analysis of antimicrobial treatments for acne and *Staphylococcus aureus* infection.

Graduate Researcher, University of California, Los Angeles 2004.6-2004.9

- Lab of David Cline in the Department of Physics and Astronomy.
- Simulations, design, and construction of a dark matter detector.

Undergraduate Researcher, University of Oregon 2003.8-2004.6

- Lab of Russell Donnelly in the Department of Physics.
- Propagation of vortex rings in fluid and diffusion of a marker dye.

EDUCATION

Ph.D. in Biology, City of Hope Beckman Research Institute 2015.6

M.S. in Physics, University of California, Los Angeles 2006.12

B.S. in Physics and Mathematics, University of Oregon 2004.6

PUBLICATIONS

#Equal contribution

*Corresponding Author

Italics indicate mentored lab member for the project

Preprints

61. Yang X, Xu X, Chen Y, Wei J, Huang W, Wu S*, **Champer J***, Wang J*. Assessment of drive efficiency and resistance allele formation of a homing gene drive in the mosquito *Aedes aegypti*. *bioRxiv*, September 2024.

60. Han Y, **Champer J***. A comparative assessment of self-limiting genetic control strategies for population suppression. *bioRxiv*, September 2024.

59. Zhang X, Sun W, Kim IK, Messer, PW, **Champer J***. Population dynamics in spatial suppression gene drive models and the effect of resistance, density dependence, and life history. *bioRxiv*, August 2024.

58. Xu X*, Chen J, Wang Y, Liu Y, Zhang Y, Yang J, Yang X, He Z*, **Champer J***. Gene drive-based population suppression in the malaria vector *Anopheles stephensi*. *bioRxiv*, May 2024.

Publications

57. Faber N#*, Xu X#, Chen J, Hou S, Du J, Pannebakker BA, Zwaan BJ, van den Heuvel J, **Champer J***. Improving the suppressive power of homing gene drive by co-targeting a distant-site female fertility gene. *Nature Communications*, 2024.

56. Champer SE*, Chae B, Haller BC, **Champer J**, Messer PW*. Resource-explicit interactions in spatial population models. *Methods in Ecology and Evolution*, 2024.

55. Wang GH*, Hoffman A*, **Champer J***. Gene drive and symbiont technologies for control of mosquito-borne diseases. *Annual Review of Entomology*, 2024.

54. Feng R, **Champer J***. Deployment of tethered gene drive for confined suppression in continuous space requires avoiding drive wave interference. *Molecular Ecology*, 2024.

53. Chen W, Guo J, Liu Y, **Champer J***. Population suppression by release of insects carrying a dominant sterile homing gene drive targeting *doublesex* in *Drosophila*. *Nature Communications*, 2024.

52. Zhu J#, Chen J#, Liu Y#, Xu X, **Champer J***. A Population suppression with dominant female-lethal alleles is boosted by homing gene drive. *BMC Biology*, 2024.

51. **Champer J***, Schlenoff D*. Battles between ants (Hymenoptera: Formicidae): a review. *Journal of Insect Science*, 2024.

50. Zhang S, **Champer J***. Performance characteristics allow for confinement of a CRISPR toxin-antidote gene drive for population suppression in a reaction-diffusion model. *Proceedings: Biological Sciences*, 2024.
49. Liu Y, Jiao B, **Champer J**, Qian W*. Overriding Mendelian inheritance in *Arabidopsis* with a CRISPR toxin-antidote gene drive that impairs pollen germination. *Nature Plants*, 2024.
48. Du J*, Chen W, Jia X, Xu X, Yang E, Zhou R, Zhang Y, Metzloff M, Messer PW, **Champer J***. Germline Cas9 promoters with improved performance for homing gene drive. *Nature Communications*, 2024.
47. Hou S#, Chen J#, Feng R, Xu X, Liang N, **Champer J***. A homing rescue gene drive with multiplexed gRNAs reaches high frequency in cage populations but generates functional resistance. *Journal of Genetics and Genomics*, 2024.
46. Ma S#, Ni X#, Chen S, Qiao X, Xu X, Chen W, **Champer J**, Huang J*. A small-molecule approach to restore female sterility phenotype targeted by a homing suppression gene drive in the fruit pest *Drosophila suzukii*. *PLoS Genetics*, 2024.
45. Yang J, Xu X, Wu J, **Champer J**, Xie M*. Involvement of miR-8510a-3p in response to Cry1Ac protoxin by regulating *PxABCG3* in *Plutella xylostella*. *International Journal of Biological Macromolecules*, 2024.
44. Clark AC*, Alexander A, Edison R, Esvelt K, Kamau S, Dutoit L, **Champer J**, Champer S, Messer PW, Gemmell N. A framework for identifying fertility gene targets for mammalian pest control. *Molecular Ecology Resources*, 2023.
43. Pan M, **Champer J***. Making waves: Comparative analysis of gene drive spread characteristics in a continuous space model. *Molecular Ecology*, 2023.
42. Liu Y, Teo W, Yang H, **Champer J***. Adversarial interspecies relationships facilitate population suppression by gene drive in spatially explicit models. *Ecology Letters*, 2023.
41. Zhu Y, **Champer J***. Simulations reveal high efficiency and confinement of a population suppression CRISPR toxin-antidote gene drive. *ACS Synthetic Biology*, 2023.
40. Chen J, Xu X, **Champer J***. Assessment of distant-site rescue elements for CRISPR toxin-antidote gene drives. *Front Bioeng Biotechnol*, 2023.
39. Li J, **Champer J***. Harnessing *Wolbachia* cytoplasmic incompatibility alleles for confined gene drive: a modeling study. *PLoS Genetics*, 2023.
38. Champer SE#, Kim IK#, Clark AG, Messer PW, **Champer J***. *Anopheles* homing suppression drive candidates exhibit unexpected performance differences in simulations with spatial structure. *eLife*, 2022.

37. Langmüller AM[#], **Champer J^{#*}**, Lapinska S, Xie L, Metzloff M, Champer SE, Liu J, Xu Y, Du J, Clark AG, Messer PW*. Fitness effects of CRISPR endonucleases in *Drosophila melanogaster* populations. *eLife*, 2022.
36. Metzloff M, Wang E, Dhole, S, Clark AG, Messer PW, **Champer J^{*}**. Experimental demonstration of tethered gene drive systems for confined population modification or suppression. *BMC Biology*, 2022.
35. Liu Y, **Champer J^{*}**. Modeling homing suppression gene drive in haplodiploid organisms. *Proceedings: Biological Sciences*, 2022.
34. Yang E, Metzloff M, Langmüller AM, Xu X, Clark AG, Messer PW, **Champer J^{*}**. A homing suppression gene drive with multiplexed gRNAs maintains high drive conversion efficiency and avoids functional resistance alleles. *G3: Genes, Genomes, Genetics*, 2022.
33. Wang GH*, Du J, Chu CY, Madhav M, Hughes GL, **Champer J^{*}**. Symbionts and gene drive: two strategies to combat vector-borne disease. *Trends in Genetics*, 2022.
32. Champer SE, Oakes N, Sharma R, Garcia-Diaz P, **Champer J**, Messer PW*. Modeling CRISPR gene drives for suppression of invasive rodents. *PLoS Comput Biol*, 17(12), e1009660 2021.
31. Ferreira-Martins D^{#*}, **Champer J^{#*}**, McCauley DW, Zhang Z, Docker MF. Genetic control of invasive sea lamprey in the Great Lakes. *J Great Lakes Res*, 47(S1), S764-S775, 2021.
30. **Champer J^{#*}**, Kim IK[#], Champer SE, Clark AG, Messer PW*. Suppression gene drive in continuous space can result in unstable persistence of both drive and wild-type alleles. *Mol Ecol*, 30(4), 1086-1101, 2021.
29. Long KC, Alphey L, Annas GJ, Bloss CS, Campbell KJ, **Champer J**, et al. Core commitments for field trials of gene drive organisms. *Science*, 370(6523), 1417-1419, 2020.
28. **Champer J^{#*}**, Champer SE[#], Kim IK, Clark AG, Messer PW. Design and analysis of CRISPR-based underdominance toxin-antidote gene drives. *Evol Appl*, 14(4), 1052-1069, 2020.
27. **Champer J^{#*}**, Yang E[#], Lee E, Liu J, Clark AG, Messer PW*. A CRISPR homing gene drive targeting a haplolethal gene removes resistance alleles and successfully spreads through a cage population. *Proc Natl Acad Sci U S A*, 117(39), 24377-24383, 2020.
26. **Champer J^{*}**, Kim IK, Champer SE, Clark AG, Messer PW. Performance analysis of novel toxin-antidote CRISPR gene drive systems. *BMC Biol*, 8(1), 27, 2020.
25. **Champer J^{*}**, Zhao J, Champer SE, Liu J, Messer PW*. Population dynamics of underdominance gene drive systems in continuous space. *ACS Synth Biol*, 9(4), 779-792, 2020.

24. *Champer SE, Liu C, Oh SY, Wen Z, Clark AG, Messer PW, Champer J**. Computational and experimental performance of CRISPR homing gene drive strategies with multiplexed gRNAs. *Sci Adv*, 6(10), eaaz0525, 2020.
23. *Champer J**, *Lee E, Yang E, Liu C, Clark AG, Messer PW**. A toxin-antidote CRISPR gene drive system for regional population modification. *Nat Commu*, 11(1), 1082, 2020.
22. *Champer J***, *Wen Z#, Luthra A, Reeves R, Chung J, Liu C, Lee YL, Liu J, Yang E, Messer PW, Clark AG**. CRISPR Gene drive efficiency and resistance rate is highly heritable with no common genetic loci of large effect. *Genetics*, 212(1), 334-341, 2019.
21. *Champer J**, *Chung J, Lee YL, Liu C, Yang E, Wen Z, Clark AG, Messer PW**. Molecular safeguarding of CRISPR gene drive experiments. *Elife*, 8, e41439, 2019.
20. *Liu J#, Champer J***, *Langmüller AM, Liu C, Chung J, Reeves R, Lee YL, Luthra L, Clark AG, Messer PW**. Maximum likelihood estimation of fitness components in experimental evolution. *Genetics*, 211(3), 1005-1017, 2019.
19. *Yu Y**, *Dunway S, Champer J, Kim J, Alikhan A**. Changing our microbiome: Probiotics in dermatology. *Br J Dermatol*, 182(1), 39-46, 2019.
18. *Champer J***, *Liu J#, Oh SY, Reeves R, Luthra L, Oakes N, Clark AG, Messer PW**. Reducing resistance allele formation in CRISPR/Cas9 gene drive. *Proc Natl Acad Sci U S A*, 115(21), 5522-5527, 2018.
17. *Champer M**, *Wong AM, Champer J, Brito IL, Messer PW, Hou JY, Wright JD*. The role of the vaginal microbiome in gynaecological cancer. *BJOG*, 125(3), 309-315, 2018.
16. *Champer J**, *Reeves R, Oh SY, Liu C, Liu J, Clark AG, Messer PW**. Novel CRISPR/Cas9 gene drive constructs reveal insights into mechanisms of resistance allele formation and drive efficiency in genetically diverse populations. *PLoS Genetics*, 13(7), e1006796, 2017.
15. *Champer J#*, *Buchman A#, Akbari OS**. Cheating evolution: Engineering gene drives to manipulate the fate of wild populations. *Nat Rev Genet*, 17, 146-159, 2016.
14. *Champer J*, *Ito JI, Clemons KV, Stevens DA, Kalkum M**. Proteomic analysis of pathogenic fungi reveals highly expressed conserved cell wall proteins. *J. Fungi*, 2(1), 6, 2016.
13. *Yu Y#, Champer J#*, *Agak GW, Kao S, Modlin RL, Kim J**. Different *Propionibacterium acnes* phylotypes induce distinct immune responses and express unique surface and secreted proteomes. *J Invest Dermatol*, 136(11), 2221-2228, 2016.
12. *Yu Y, Champer J, Kim J**. Analysis of the surface, secreted, and intracellular proteome of *Propionibacterium acnes*. *EuPA Open Proteom*, 9, 1-7, 2015.

11. Yu Y, **Champer J**, Beynet DP, Kim J, Friedman AJ*. The role of the cutaneous microbiome in skin cancer: Lessons learned from the gut. *J Drugs Dermatol*, 14(5), 461-465, 2015.
10. Yu Y, **Champer J**, Garbán H, Kim J*. Typing of *Propionibacterium acnes*: A review of methods and comparative analysis. *Br J Dermatol*, 172(5), 1204-1209, 2015.
9. Schmidt NW, Agak GW, Deshayes S, Yu Y, Blacker A, **Champer J**, Xian W, Kasko AM, Kim J, Wong GC*. PenTobra: An aminoglycoside with robust antimicrobial & membrane activity against *Propionibacterium acnes*. *J Invest Dermatol*, 135(6), 1581-1589, 2015.
8. Chow A, Zhou W, Liu L, Fong MY, **Champer J**, Van Haute D, Chin AR, Ren X, Gugiu BG, Meng Z, Huang W, Ngo V, Kortylewski M, Wang SE*. Macrophage immunomodulation by breast cancer-derived exosomes requires Toll-like receptor 2-mediated activation of NF- κ B. *Sci Rep*, 4, 5750, 2014.
7. Taylor EJM*, Yu Y, **Champer J**, Kim J. Resveratrol demonstrates antimicrobial effects against *Propionibacterium acnes*. *Dermatol Ther*, 4, 249-257, 2014.
6. Lehrnbecher T*, Kalkum M, **Champer J**, Tramsen L, Schmidt S, Klingebiel T. Immunotherapy in invasive fungal infection-focus on invasive aspergillosis. *Curr Pharm Des*, 19(20), 3689-3712, 2013.
5. **Champer J***, Patel J, Fernando N, Salehi E, Wong V, Kim J. Chitosan against cutaneous pathogens. *AMB Express*, 3(1), 37, 2013.
4. Friedman AJ, Phan J, Schairer DO, **Champer J**, Qin M, Pirouz A, Blecher-Paz K, Oren A, Liu PT, Modlin RL, Kim J*. Antimicrobial and anti-inflammatory activity of chitosan-alginate nanoparticles: a targeted therapy for cutaneous pathogens. *J Invest Dermatol*, 133(5), 1231-1239, 2013.
3. **Champer J**, Diaz-Arevalo D, *Champer M*, Hong TB, *Wong M*, *Shannahoff M*, Ito JI, Clemons KV, Stevens DA, Kalkum M*. Protein targets for broad-spectrum mycosis vaccines: quantitative proteomic analysis of *Aspergillus* and *Coccidioides* and comparisons with other fungal pathogens. *Ann N Y Acad Sci*, 1273, 44-51, 2012.
2. Chandra M, Zang S, Li H, Zimmerman L, **Champer J**, Chow A, Zhou W, Tsuyada A, Yu Y, Gao H, Ren X, Lin RJ, Wang SE*. Nuclear translocation of type I TGF- β receptor confers a novel function in RNA splicing. *Mol Cell Biol*, 32(12), 2183-2195, 2012.
1. Bungau C, Camanzi B, **Champer J**, Chen Y, Cline DB, Luscher R, Lewin JD, Smith PF*, Smith NJT, Wang H. Monte Carlo studies of combined shielding and veto techniques for neutron background reduction in underground dark matter experiments based on liquid noble gas targets. *Astroparticle Physics*, 23, 97-115, 2005.

Book Chapters

Clark AC, Alexander A, **Champer J**, Edison R, Katuwal M, Gemmell NJ. Management of vertebrate pests using genetic control techniques. Published in: “Applied Environmental Genomics.” *CSIRO Publishing*, 2023.

Champer J. Gene Drives for *Anopheles* Mosquitoes. Published in: “Mosquito Gene Drives and the Malaria Eradication Agenda.” *Jenny Stanford Publishing*, 2023.

Champer J. *Drosophila melanogaster* as a Model for Gene Drive Systems. Published in: “Transgenic Insects: Techniques and Applications.” *CABI*, 2022.

Patents

Yu Y, **Champer J**, Kim J. Compositions and Methods for Treating Skin and Mucus Membrane Diseases. US 20170065647. Published November 2015.

Taylor E, **Champer J**, Kim J. Treatment of inflammatory and infectious skin disorders. US 20140018437 A1. Published January 2014.

RESEARCH SUPPORT

NSFC RFIS II	Champer	2024.10 - 2026.9
Beijing City Project	Champer	2024.7 - 2026.6
Beijing Foreign Talents Program	Champer	2023.11 - 2024.10
李革赵宁 Life Science Youth Research Fund	Champer	2023.3 - 2025.2
NSFC General Project	Champer	2022.11 - 2026.10
NSFC Overseas Youth Program	Champer	2022.9 - 2025.8
SLS-Qidong Innovation Fund	Champer	2021.10 - 2023.9
Peking University Initial Funding School of Life Sciences and Center for Life Sciences laboratory startup funding	Champer	2021.5 - 2026.5
NIH/NIAID K22AI146276 Engineering and modeling improved CRISPR gene drive systems *award only available for new faculty at domestic institutions	Champer	award declined*
NIH/NIAID F32AI138476 Dynamics of gene drives in natural populations	Champer	2018.4 - 2021.3
NIH/NIAID R21AI130635	Messer, Clark, Champer*	2017.9 - 2020.9

Improved CRISPR gene drive systems with reduced resistance allele formation

*key personnel

CLASSROOM TEACHING

Session Host/Coordinator , Frontiers Literature Review, Peking University	2023.3 - Present
Lecturer , Population Genetic Engineering, Peking University	2022.9 - Present
Co-Lecturer , Mathematical Modeling in the Life Sciences, Peking University	2022.3 - Present
Co-Lecturer , Various Short Classes, Peking University	2021.10 - Present
Visiting Lecturer , General Academics, Peking Union Medical College	2022.10
Guest Lecturer , Population Genetics and CRISPR classes, Cornell University	2017.9 - 2020.3
Teaching Fellow , Current Topics in Biology, City of Hope	2014.3 - 2014.4
Physics Teaching Assistant , University of California, Los Angeles	2004.9 - 2006.12

RESEARCHERS MENTORED

Current Lab Members at Peking University

Postdocs: Jie Du, Jie Yang, Xuejiao Xu, Christopher Krueger (co-mentored with Bo Zhang)

Graduate Students: Jialiang Guo, Jinyu Zhu, Nicky Faber (co-mentored, Wageningen University), Ruobing Feng, Weizhe Chen, Xiaozhen Yang (visiting, M.S.), Xinyue Zhang, Yingke Wu, Yiran Liu, Yue Han

Staff Members: Xihua Jia, Yang Zhang

Undergraduates and Volunteers: Chengwei Shi, Jiahe (Carol) Li, Peixin Wu, Siyan Wu, Weitang Sun, Xiaokuan Wang, Yuna Cho, Yuqi Zhang, Ziye Wang

Former Lab Members

Peking University Postdocs: Yuan Hu Allegretti

Peking University Graduate Students: Haonan Yang (M.S.), Mollyann Qi (visiting)

Peking University Staff Members: Chenyi Chu, Jingheng Chen, Li Yang, Ning Xia, Ruizhi (Rachel) Zhou, Shibao Hou, Weiwei Chen

Peking University Undergraduates and Volunteers: Haochen Yang, Jialing Fang, Mingzuyu Pan, Shijie Zhang, Theodore Jeliazkov, WeiJian Teo, Yutong Zhu, Ziqian Xu, Ziyin Yao

Peking University Rotating Graduate Students: Biao Zhang, Cao Yu, Hongjun Long, Kunyu Wang, Moming Guo, Siyang Zhou, Weiwen Yang, Wenqing Tian, Xuqing Feng, Yukun Shen

Cornell University Undergraduates: Anisha Luthra, Chen Liu, Emily Yang, Isabel Kim, Jingxian (Clara) Liu, Joan Chung, Joanna Zhao, Lin Xie, Matt Metzloff, Phoebe Conley, Riona Reeves, Sandra Lapinska, Suh Yeon (Sunny) Oh, Esther (formerly Yoo Lim) Lee, Zhaoxin (Cindy) Wen

Cornell University Other Students: Anna Langmuller (visiting graduate student), Nathan Oakes (graduate student for one project), Sam Champer (volunteer, brother), Yineng Xu (rotating graduate student)

University of California, Riverside Students: Jennifer Shyong, Kenneth Truong

City of Hope Students: Jason Yu, Mayyen Wong, Miriam Champer, Molly Shannahoff

University of California, Los Angeles Students: Elaheh Salehi, Julie Patel, Nathalie Fernando, Sam Ngo, Victoria Wong, Yang Yu

OTHER EXPERIENCE

Conference Sessions Organized

International Congress of Entomology, 2024 (main session and satellite session)

International Conference on Insect Science, 2023

International Congress of Genetics, 2023 (main session and satellite session)

Conference Talks

Entomological Society of China, 2021

Society for Mathematical Biology Conference, 2024 (invited)

Malaria Vector Control Technologies Conference, 2024 (invited)

Gene Drive Research Forum Meeting, 2024 (invited)

BRIN Mathematics of Malaria Transmission Dynamics, 2023 (invited)

International Conference on Insect Pest Management, 2023 (invited)

Entomological Society of China, 2021 (two talks, one invited)

Interdisciplinary Workshop on Synthetic Gene Drives, 2021 (invited)

Canadian Conference For Fisheries Research, 2021 (invited)

Entomological Society of America, Conference, 2019

Sea Lamprey International Symposium, 2019 (invited)

EMBO Vector Conference, 2019

Society for the Study of Evolution Annual Meeting, 2019 (invited)

Entomological Society of America, Joint Annual Meeting, 2018 (invited)

Genetics Society of America, *Drosophila* Research Conference, 2018

Cold Spring Harbor, Genome Engineering: The CRISPR-Cas Revolution, 2017

Invited Seminars

Chongqing Normal University (2024)

Chinese Academy of Sciences Institute of Genetics and Developmental Biology (2023)

Nanjing Agricultural University (2023)

Fujian Agriculture and Forestry University (2023)
 France National Research Institute for Agriculture, Food and Environment (2022)
 Chinese Academy of Sciences Institute of Zoology (2021)

Workshops

Gene Drive Research Forum - Bridging gaps in Stakeholder Engagement, 2021
 Target Malaria - Plausible Pathways to Potential Harm Workshop, 2021
 FNIH - Data Needs and Assay Design for Decision Making on Gene Drive Mosquitoes, 2019
 ILSI - Gene Drive Modeling Conference, 2019

Journal Editor: PLOS Genetics (2021-Present), BMC Biology (2022-Present)

Journal Referee: American Naturalist, Applied Biosciences, BioDesign Research, Bioscience, BMC Biology, Chromosome Research, Ecological Modelling, Ecological Psychology, eLife, European Journal of Dermatology, Ecological Psychology, Evolutionary Applications, Frontiers in Agronomy, Frontiers in Bioengineering and Biotechnology, Frontiers in Insect Science, Frontiers in Microbiology, G3, Genes, Genetics, Infection Genetics and Evolution, Insect Biochemistry and Molecular Biology, Insect Science, iScience, Journal of Applied Ecology, Journal of Evolutionary Biology, Journal of Functional Foods, Journal of Fungi, Journal of Great Lakes Research, Journal of Medical Entomology, Journal of Theoretical Biology, Malaria Journal, Mathematical Biosciences and Engineering, Molecular Ecology, NAR Genomics and Bioinformatics, Nature Communications, Nature Protocols, PeerJ, PLOS Genetics, PNAS, Proceedings of the Royal Society B, Research Ideas and Outcomes, Review Commons, Science Bulletin, Scientific Reports, STAR Protocols, Transgenic Research

Other Referee

National Carp Control Plan for Australia “Synergistic genetic biocontrol options for common carp (*Cyprinus carpio*)”
 United Nations Environment Programme: Frontiers, Emerging Issues of Environmental Concern, Synthetic Biology