Aquaculture Genetics Research

JAMES COOK UNIVERSITY
AUSTRALIA

Driving sustainable, high-performing aquaculture solutions through advanced genetics, digital innovation, and integrated breeding solutions that deliver real-world impact for producers and the global seafood sector.

Aquaculture
Genetics
James Cook University

Selective Breeding Program Development

Our work in selective breeding follows a clearly defined and sequential approach to deliver robust genetic improvement programs tailored to a wide range of aquaculture species

Focal Species:

- Fin fish (e.g. Barramundi, Grouper, Tilapia, Snapper, Flounder)
- Crustaceans (e.g. Shrimp, Lobster, Crayfish)
- Molluscs (e.g. Abalone, Pearl Oyster)
- Novel species (e.g. Seaweeds, Insects - for aquafeeds)

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1. Genomic Resources Development

We establish foundational tools that underpin farm management and selective breeding programs.

Key Activities

- Development of on-farm DNA extraction and genotyping workflows, including implementation of rapid, low-cost protocols suitable for farm environments
- Design and validation of genetic evaluation platforms for parentage and on-farm management
- Development of genome-wide genetic markers for selective breeding applications
- Generation of novel species genetic maps and gene expression data

2. Genetic Evaluation of Captive and Wild Populations

We evaluate the genetic composition of populations to inform sustainable broodstock management.

Key Activities

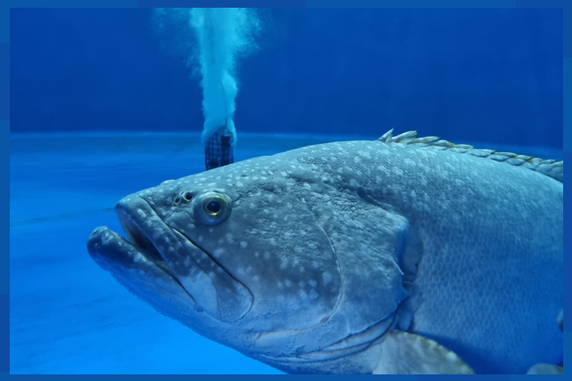
- Genetic relationship analyses and genetic diversity audits
- Population structure assessments
- Determining inter-generational levels of genetic diversity and inbreeding

3. Production Trait Genetic Evaluations

We focus on comprehensively understanding and enhancing traits that drive aquaculture productivity.

Key Activities

- Refinement of trait breeding objectives for improved farm productivity
- Understanding the genetic architecture of production traits (i.e. heritability) for enhanced breeding applications
- Integration of production trait data into composite breeding indexes or genomic models



4. Whole-of-Farm Breeding Strategies

We deliver next-generation breeding program designs using both on-farm and simulation technologies.

Key Activities

- Advanced genomic selection programs for disease resistance, growth, and product quality traits
- Design of digital twin platforms to simulate optimal selective breeding outcomes
- Optimisation of alternate breeding

Novel Technologies for Improved Farm Productivity

We apply AI, genomics, and molecular tools to boost aquaculture productivity - advancing disease detection, breeding, and strain selection for more sustainable, high-performing production.

Data-Driven Aquaculture Management

Focus Areas

Machine learning and AI for predictive farm analytics

Digital capture to obtain industrial-scale phenotypic or difficult-to-measure data

Key Activities

- Develop AI predictive models to predict growth metrics, disease outbreaks, and optimize farm operations.
- Implement real-time decision support using AI- driven algorithms.
- Apply near-infrared spectroscopy for accurate product quality prediction.
- Capture and analyse images to assess key quality metrics such as size, shape, and color.

Cryopreservation of Gametes & Advanced Reproductive Approaches

Focus Areas

Reproductive biotechnology for aquaculture species

Hormonal control of sex-change

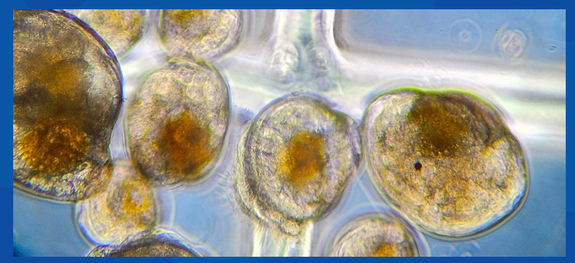
Development of spawning practices to optimize breeding outcomes

Gamete preservation and artificial fertilization

Biomarkers to determine sex and sex change

Key Activities

- Enhance cryopreservation techniques
- Improve reproductive control and genetic resource banking.
- Hormonal regulation of sex-change and maturation in species such as barramundi, pearl oysters, groupers, and crustaceans
- Development of non-invasive molecular tools to establish sex of barramundi and other species



Pathogen Detection, Survelliance & Disease Resistance

Focus Areas

Advanced pathogen detection, biosecurity, and breeding for resistance

Key Activities

- Use eDNA, eRNA, and metabarcoding to detect aquaculture pathogens from water samples.
- Development of molecular-based pathogen diagnostics
- Investigate genetic pathogen resistance mechanisms in barramundi, shrimp, and prawns.
- Understand capability to select for genetic-determined resistance
- Identification of genetic markers

Proteomics & Biomarker Studies in Aquaculture Species

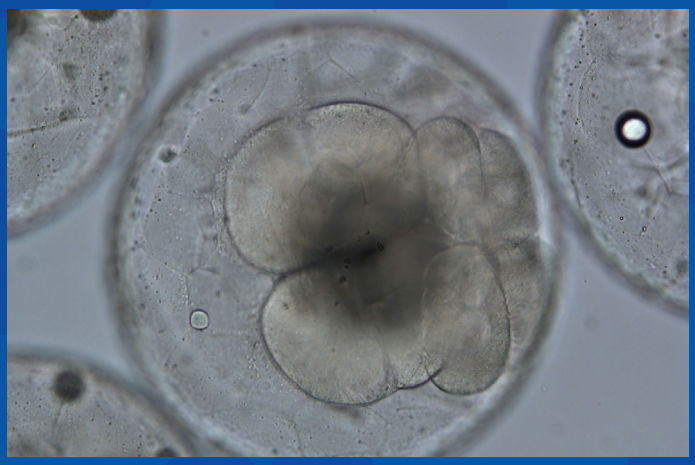
Focus Areas

Stress response and disease resistance

Reproductive status and sex identification

Key Activities

- Evaluation of heat shock proteins and disease-related biomarkers
- Development of non-invasive methods for assessing reproductive status
- Application in species including barramundi, pearl oysters, and groupers



Gene Editing to Understand the Genetic Basis and Improve Commercial Traits

Focus Areas

Premium aquaculture product development

Key Activities

- Identify genetic drivers of golden colouration in barramundi.
- Surrogate germ-line transplantation to rapidly transfer genetic potential of superior breeders
- CRISPR-CAS9 gene editing capabilities

Propagation and Strain Selection for Seaweed Aquaculture

Focus Areas

Seaweed strain selection and enhancement

Genetic tools for high-performance algae

Key Activities

- Assess population structure and clonality in Asparagopsis taxiformis
- Develop markers for strain selection and performance traits
- Estimate genetic parameters for key outputs like bromoform production
- Lay the groundwork for broader application across algal aquaculture

Key Personnel

Distinguished Professor Dean Jerry
Professor Kyall Zenger

For information, please contact:
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