



KEMENTERIAN PENGAJIAN TINGGI
JABATAN PENDIDIKAN POLITEKNIK DAN KOLEJ KOMUNITI

BREEDING TECHNOLOGY IN AQUATIC ANIMAL

DR. SITI NOR FATIAH BINTI ZAKARIA
POLITEKNIK JELI KELANTAN

BREEDING TECHNOLOGY IN AQUATIC ANIMAL

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INTRODUCTION FOR BREEDING TECHNOLOGY IN AQUATIC ANIMAL

Breeding technology in aquatic animals represents a cornerstone of modern aquaculture, playing a vital role in enhancing productivity, genetic improvement, and sustainability within the industry. As global demand for aquatic products continues to rise, the development and application of efficient breeding technologies have become increasingly essential. Advances in reproductive biology, genetic selection, hormonal induction, and larval rearing techniques have significantly improved the success of captive breeding programs for both finfish and shellfish species. These innovations not only facilitate year-round seed production but also support the creation of improved strains with desirable traits such as faster growth, higher disease resistance, and better feed utilization. Moreover, the integration of molecular and biotechnological tools has expanded opportunities for selective breeding, conservation, and sustainable aquaculture development.

This book aims to assist students, farmers, and aquaculture practitioners in developing effective management practices for aquatic animal breeding. It provides comprehensive insights into the principles, techniques, and technologies that underpin successful breeding programs, from broodstock selection to fry management. Furthermore, this eBook serves as a valuable reference for students pursuing the *Diploma in Aquaculture Technology*, particularly those enrolled in the course **DYQ30283 – Breeding and Fry Management**, by integrating both theoretical knowledge and practical applications relevant to modern aquaculture systems.

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ACKNOWLEDGEMENT

- First and foremost, I extend my deepest gratitude to Allah SWT, whose guidance, strength, and wisdom have enabled me to complete this eBook entitled “*Breeding Technology in Aquatic Animal.*” I wish to express my sincere appreciation to Politeknik Jeli Kelantan for providing the academic foundation, resources, and conducive environment that made the successful completion of this project possible.
- My heartfelt thanks are also extended to all individuals and parties who have directly or indirectly contributed to this work. In particular, I acknowledge the unwavering support, patience, and motivation of my family and friends, whose presence has been invaluable throughout this endeavor.
- It is my sincere hope that this eBook will serve as a useful reference for students, educators, and professionals in the field, and that it will contribute meaningfully to the advancement and development of the aquaculture industry. This eBook will be used for course; DYQ30283 Breeding and Fry Management.

INTRODUCTION

- The rapid growth of the global aquaculture industry has underscored the importance of advanced breeding technologies in meeting the increasing demand for aquatic animal products. Breeding technology in aquatic animals encompasses a range of scientific methods and practices aimed at improving the genetic quality, health, productivity, and sustainability of farmed species.

INTRODUCTION

- Through the **application of selective breeding, hybridization, genetic engineering, and biotechnology, aquaculture practitioners** can enhance traits such as growth rate, disease resistance, reproductive efficiency, and environmental adaptability.



INTRODUCTION

- With the intensification of aquaculture practices, the need for sustainable and efficient breeding strategies has become more critical than ever. **Traditional breeding methods**, while still valuable, are now complemented by modern biotechnological advancements that enable more precise and predictable outcomes. These innovations not only improve yield and profitability but also contribute to the conservation of aquatic biodiversity and the long-term sustainability of aquatic ecosystems.

TYPES OF BREEDING METHODS

NATURAL BREEDING

- Fish breed in their natural habitat
- Males and females are placed together in a breeding area such as tank, small pond

ARTIFICIAL BREEDING

- Reproductive technique that involves hormonal and genetic manipulation to induce gamete production for artificial fertilization, utilizing methods such as hand-stripping or seminatural breeding.

TYPES OF BREEDING METHODS

SELECTIVE BREEDING

is a genetic improvement programme aimed at enhancing the overall breeding value of a population by identifying and mating only the most desirable individuals—such as those exhibiting superior growth, body weight, or coloration.

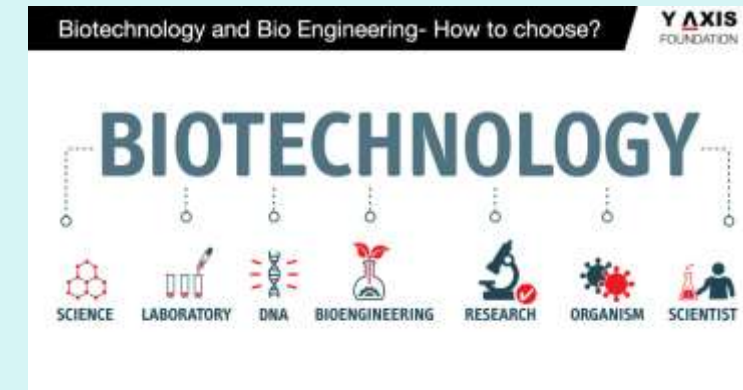
CROSS BREEDING

involves mating different fish to combine desirable traits, leading to offspring with enhanced characteristics like faster growth, disease resistance, and improved environmental tolerance

TUTORIAL 1

- ✓ What role do **sustainable breeding strategies** play in ensuring the long-term productivity and environmental impact of intensified aquaculture practices?
- ✓ What are the **distinguishing** characteristics and applications of natural, artificial, selective, and cross breeding methods in aquaculture?
- ✓ How do **different breeding methods** influence the genetic diversity, productivity, and sustainability of aquatic animal populations?

APPLICATION OF BIOTECHNOLOGY IN AQUACULTURE



Biotechnology plays a major role in fish production through various techniques such as selective breeding, genetic engineering to enhance the growth rate and disease resistance in aquaculture .

Biotechnology, currently, offers many, like, promising opportunities for advancements in aquaculture and related fields. It's, like, essential for scientists to continue exploring new possibilities and methods to further enhance the benefits of biotechnology in sustainable food production and environmental conservation efforts.

Vishwanatham et al., 2024

The potential areas of biotechnology in aquaculture include the use of synthetic hormones in induced breeding, production of monosex, uniparental and polyploid population, molecular biology, transgenic fish, gene banking, improved feeds and health management and development of natural products from marine organisms.

Lakra & Ayyappan, 2003



Recent advances in biotechnology applications to Aquaculture

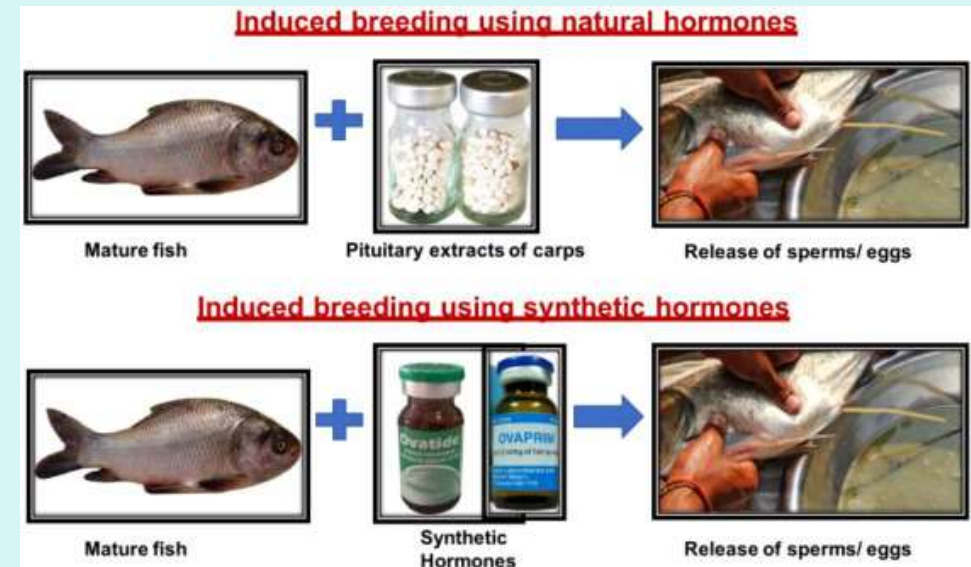
1. Biotechnology technique in fish breeding
2. Chromosomal engineering
3. Transgenic fish production
4. Selective breeding
5. Hybridization and cross-breeding
6. Sex control
7. Aquaculture nutrition
8. Biotechnology and fish health management
9. Molecular biology
10. Cryopreservation of gametes or gene banking
11. Microbial technology for aquaculture
12. Marine natural products

(Vishwanatham et al., 2024) &
(Lakra and Ayyappan, 2003)

1. Biotechnology technique in fish breeding

→ Biotechnology enhances the **hatchability and production rate in fishes**, modern biotechnology has successfully developed breeding hormones such as **gonadotropins releasing hormones (GnRH)**.

→ GnRH is a major regulator and central indicator of reproductive cascade in vertebrates. It is first isolated from pig and sheep hypothalamic with the ability to induce pituitary release of luteinizing hormone (LH) and (FSH) follicle stimulating hormone (Schally et al., 1973).



2. Chromosomal engineering

- **Chromosome set manipulation** technique is to induce the polyploidy and uniparental chromosomes inheritance have been applied extensively in cultured fish (Pandian and koteswaran, 1998; Lakra and Das 1998), these techniques developed in the improvement of hybrid fish as they provide rapid approach in gonadal sterilization , sex control improvement of hybrid varieties in diploid meaning that they possess one or more additional chromosomes set.
- **Androgenesis** is the process by which commercial application done in aquaculture, it can also use in developing homozygous lines in fish and the recovery of lost genotypes from cryopreserved sperms , androgenetic individuals are few developed from cyprinid families and chichilids.

3. Transgenic fish production

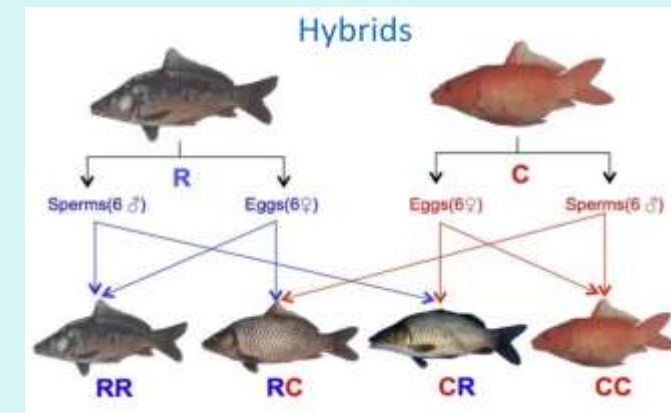
- **Transgenic** is referred as introduction of exogenous gene/DNA in the host genome resulting in its maintenance, transmission and gene expression.
- The technology provides an excellent opportunity for modifying or improving the genetic traits of demandable important fishes, the idea of developing transgenic animals became popular (Palmiter et al.1982) first produced transgenic mouse by introducing metallothionein human growth hormone fusion gene (mT-hGH) into mouse egg.

4. Selective breeding

- The **basis of selective breeding** is to select individuals that possess a high additive genetic value for a desired phenotype (trait) as parents such that they can pass on their superior genes to progeny in following generations.

5. Hybridization and cross-breeding

- **Hybridization** is breeding individuals from two separate species while crossbreeding is the mating of two different varieties/stocks within a species.



8. Biotechnology and fish health management

- **Disease problems** are a major constraint for development of aquaculture.
- Biotechnological tools such as molecular diagnostic methods, use of vaccines and immuno stimulants are gaining popularity for improving the disease resistance in fish and shellfish species world over.

9. Molecular biology

- Recent advances in molecular biology have provided unlimited number of genetic markers which have multiple application in aquaculture and fisheries (Lakra, 2001).
- Molecular genetic approaches began to be used in fisheries in the 1950s. Their use in aquaculture and fisheries has increased dramatically over the past few years.

10. Cryopreservation of gametes or gene banking

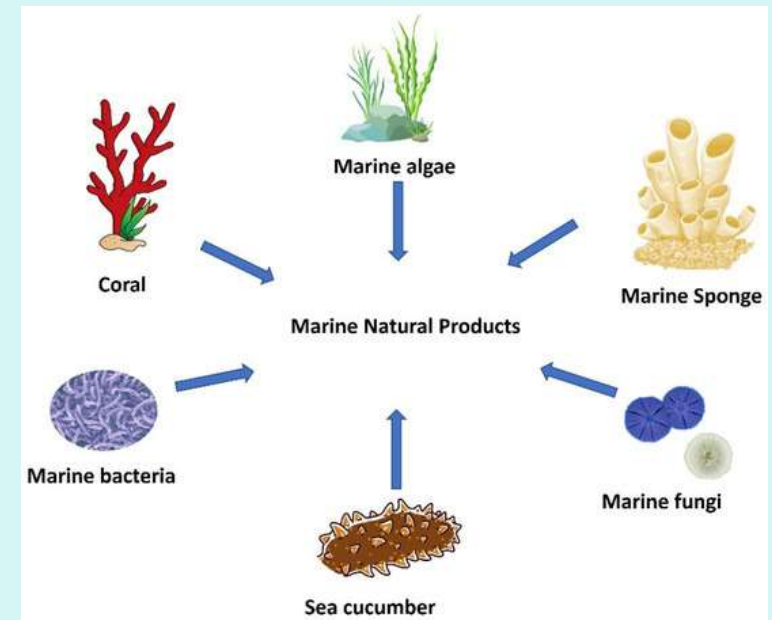
- **Cryopreservation** is a technique, which involve long-term preservation and storage of biological material at a very low temperature usually at -196 0C, the temperature of liquid nitrogen.
- It is based on the principle that very low temperatures tranquilizes or immobilize the physiological and biochemical activities of cell, thereby making it possible to keep them viable for very long period.

11. Microbial technology for aquaculture

- **Microbial technology** for aquaculture comprising aspects of biofertilization, microbial processing of organic matter, use of probiotics and enhancement of feed digestibility, detritus enrichment and shortening of food chains for better energy transfer rates, genetic upgradation of bacterial strains, biofiltration and waste recycling as also techniques pertaining to post-harvest technology hold great promise in improving aquaculture productivity, on a sustainable basis (Ayyappan, 1994).

12. Marine natural products

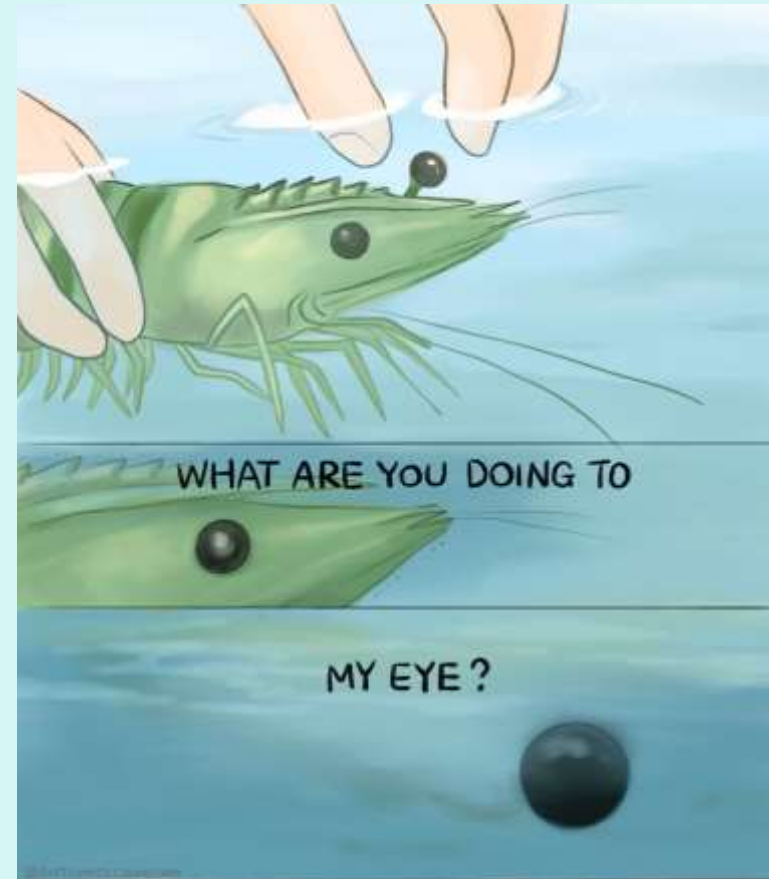
- Commercially valuable products such as pharmaceutical compounds, pigments, oils, sterols, alginates and agarose are being extracted from micro and macro-algae in many parts of the world. Joffe and Thomas (1989) estimated that about 25% of all pharmaceutical sales are drugs derived from plant natural product and an additional 12% are based on microbially produced natural product.



TUTORIAL 2

- ✓ How does **hybridization and cross-breeding** contribute to genetic improvement and adaptability of cultured fish species?
- ✓ How does **aquaculture nutrition**, supported by biotechnology, influence the growth performance and health of farmed fish?
- ✓ What is the **significance of microbial technology** in improving water quality and disease resistance in aquaculture environments?

APPLIED ENDOCRINOLOGY AND ENVIROMENTAL MANIPULATION



The shrimp industry removes the eyes of females to make them breed faster. The industry calls it **eyestalk ablation**.

Applied endocrinology refers to the practical use of hormonal knowledge and treatments to control and enhance biological functions in aquatic organisms, especially in aquaculture. Hormones regulate critical physiological processes such as growth, reproduction, metabolism, and stress responses.

In aquaculture, hormonal manipulation is often used to:

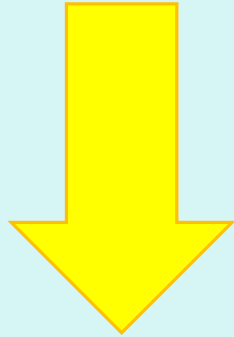
- ❖ Induce spawning out of season
- ❖ Promote sex reversal (e.g., production of monosex populations)
- ❖ Enhance growth rates and feed efficiency
- ❖ Control maturation in broodstock

Environmental manipulation involves the intentional alteration of environmental factors—such as light (photoperiod), temperature, salinity, oxygen levels, and water quality—to influence the behavior and physiology of aquatic animals. This technique helps in:

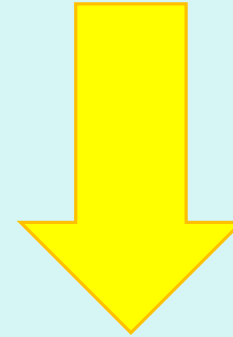
- Synchronizing breeding cycles
- Improving survival and growth conditions
- Reducing disease susceptibility
- Managing stress in cultured species

When **combined**, applied endocrinology and environmental manipulation serve as powerful tools in modern aquaculture to maximize productivity, improve reproductive efficiency, and ensure better health and welfare of farmed aquatic species.

APPLIED ENDOCRINOLOGY AND ENVIROMENTAL MANIPULATION



1. Eye stalk ablation



2. Temperature shock

1. Eye stalk ablation

Eyestalk ablation is the **removal of one (unilateral) or both (bilateral) eyestalks from a crustacean.**

It is routinely practiced on **female shrimps** (or prawns) in almost every marine shrimp maturation or reproduction facility in the world, both research and commercial.

The aim of ablation under these circumstances is to **stimulate the female shrimp to develop mature ovaries and spawn.**



Reasons for eyestalk ablation

Induce maturation:

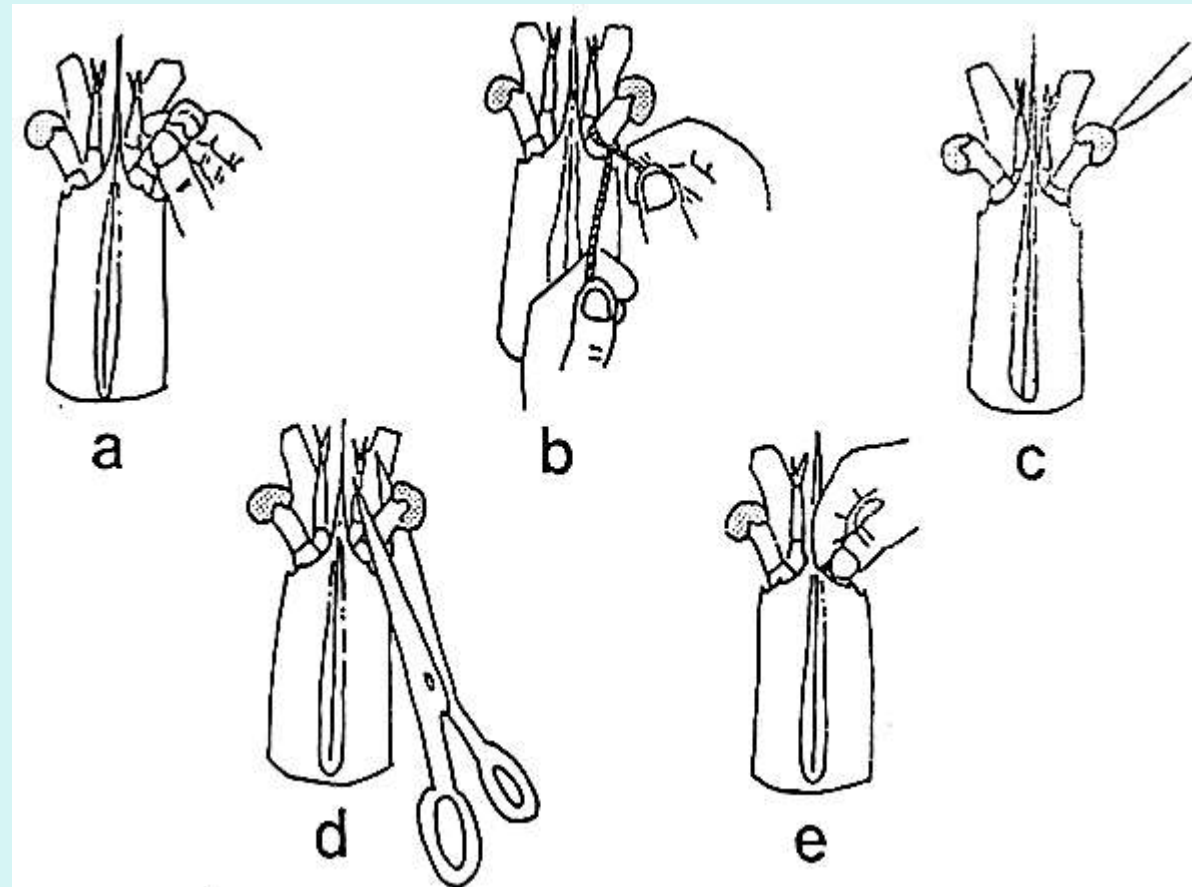
In female shrimp, the eyestalks contain hormones that inhibit ovarian maturation.

Trigger molting:

Removing the eyestalks suppresses the production of moult-inhibiting hormones, which triggers the molting process.

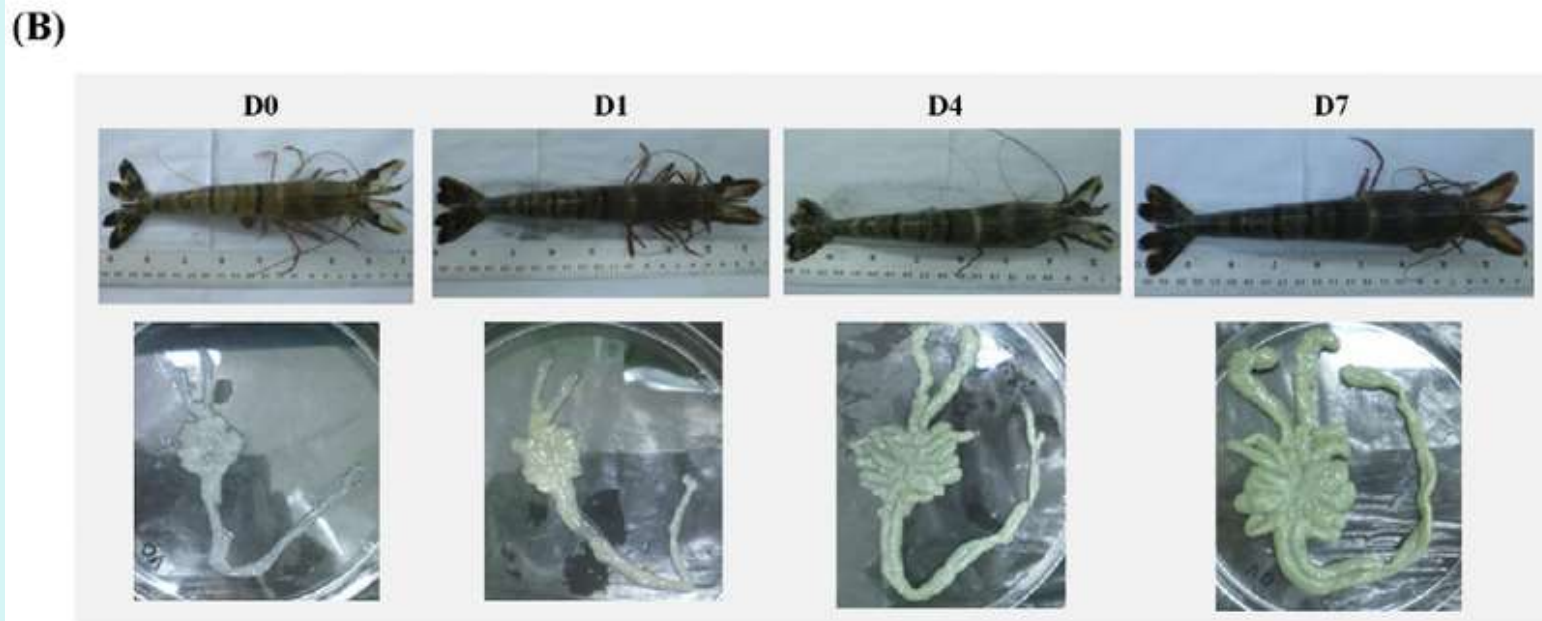
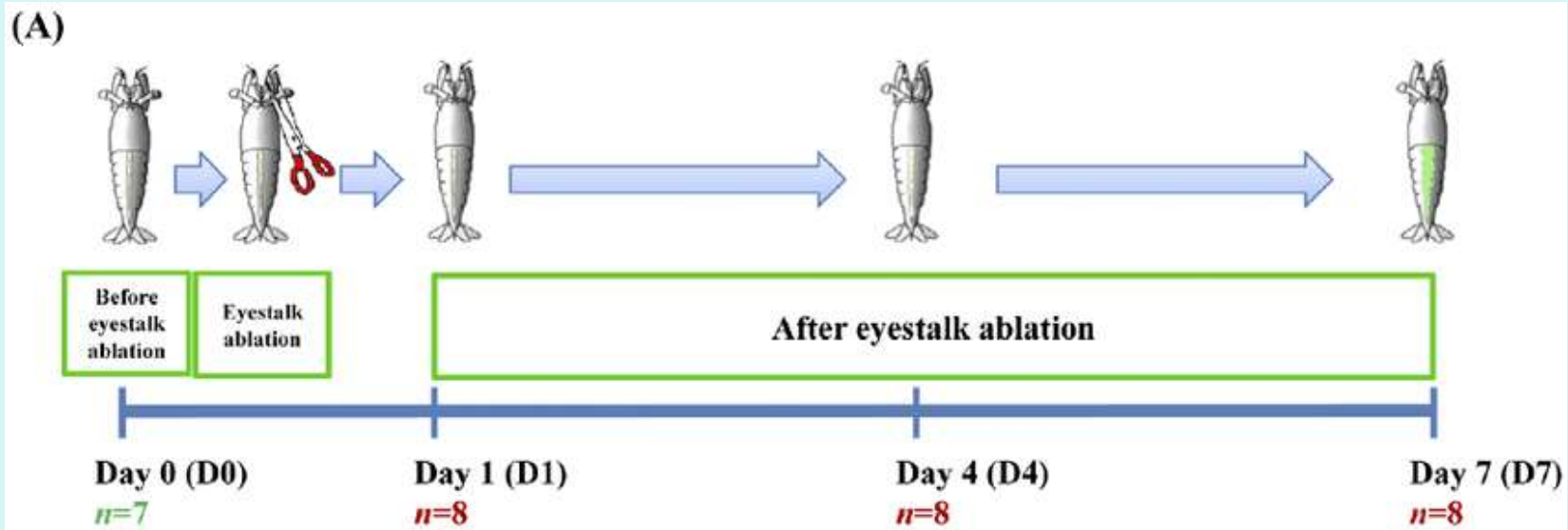
Increase production:

Eyestalk ablation can ensure a consistent, year-round supply of larvae for commercial hatcheries.



Methods of eyestalk removal in Penaeids:

- a) eyeball incision and squeezing
- b) ligation or tying
- c) electrocautery or using a silver nitrate bar
- d) cutting
- e) pinching-crushing



The eyestalk ablation experiment and physiology of shrimp and ovary.

(A) Eyestalk ablation experiment was conducted over 7 days. Ovary samples were collected before eyestalk ablation (D0) and after eyestalk ablation at Days 1, 4 and 7 (D1, D4, and D7, respectively).

(B) Examples of representative shrimp (upper panel) and their ovaries (lower panel) from each time point.

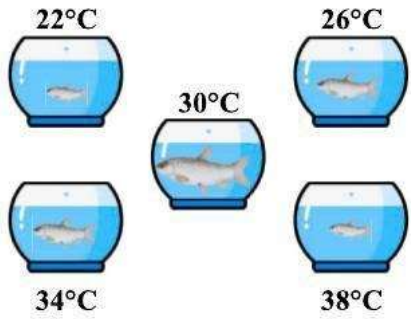
2. Temperature shock

Climate change is leading to an increase in global water temperatures which is having a significant impact on fish populations ([Pörtner and Peck, 2010](#)).

As a result, rising water temperatures are influencing the abundance and distribution of fish species globally, and having a significant impact on the aquaculture industry ([Islam et al., 2022](#); [Stuart-Smith, 2021](#)).

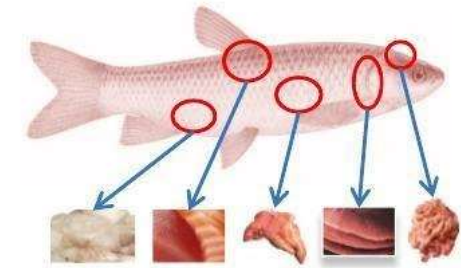
Temperature is essential to the maintenance of optimal physiological functioning in aquatic organisms. Fish can manage natural fluctuations in temperature; however, in freshwater ecosystems acute and rapid temperature changes can originate from sources such as large dams and industrial effluents ([Michie et al., 2020](#)).

Temperature plays an important role in the regulation of physiological, metabolic and behavioural processes of fish, supporting optimal rates of reproduction, growth, metabolism and locomotion ([Beitinger et al., 2000](#), [Brett, 1971](#), [Clarkson and Childs, 2000](#), [Jobling, 1995](#), [Jobling, 1997](#)).



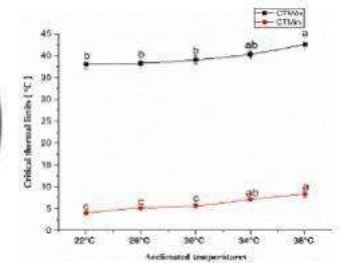
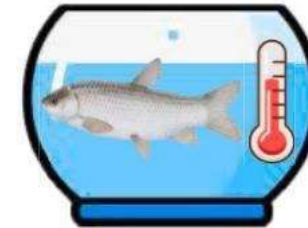
Highest growth rate under 30°C

Why optimum acclimated temperature is necessary during fish culture

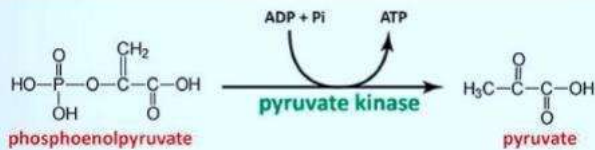


CAT, SOD, POD, LPO, GSH, GSH-Px, GR

Lowest levels recorded in 30°C

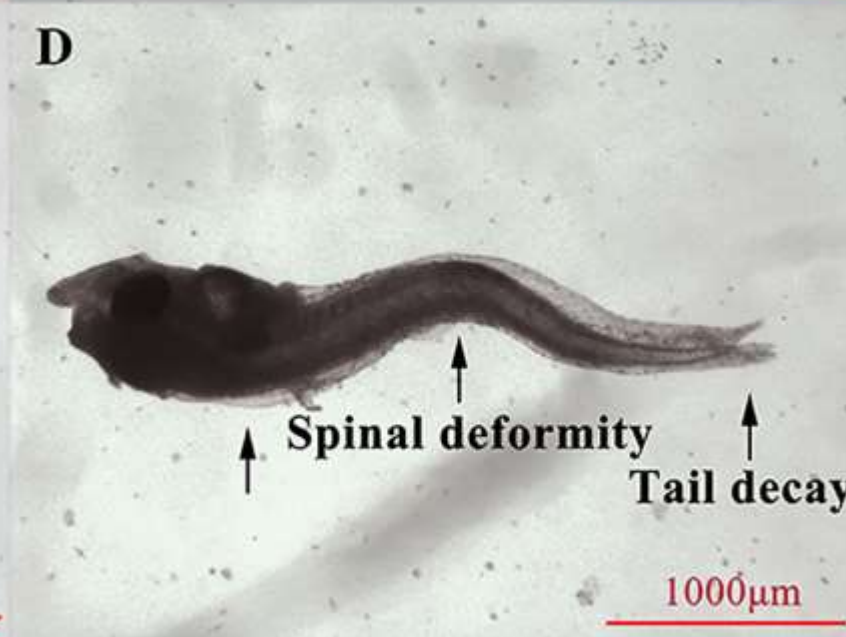
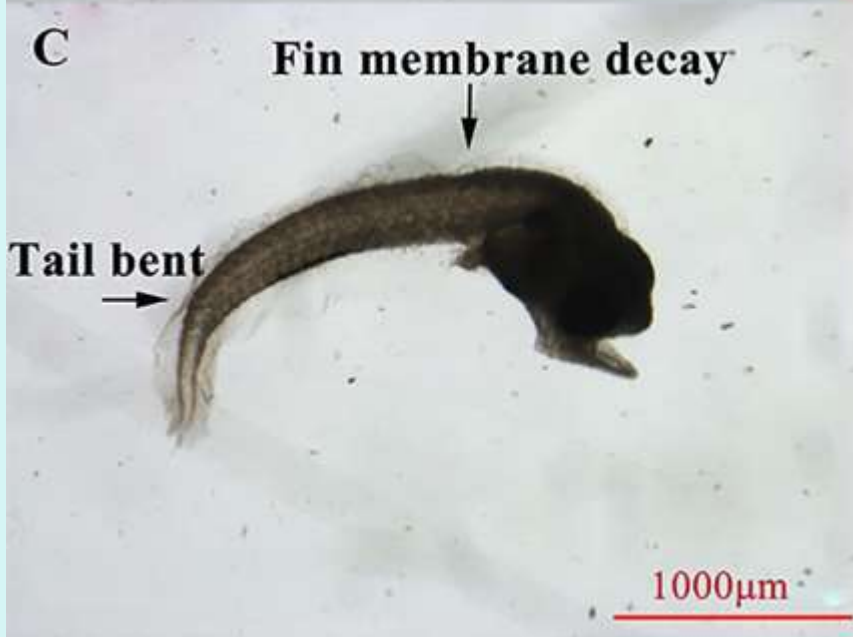
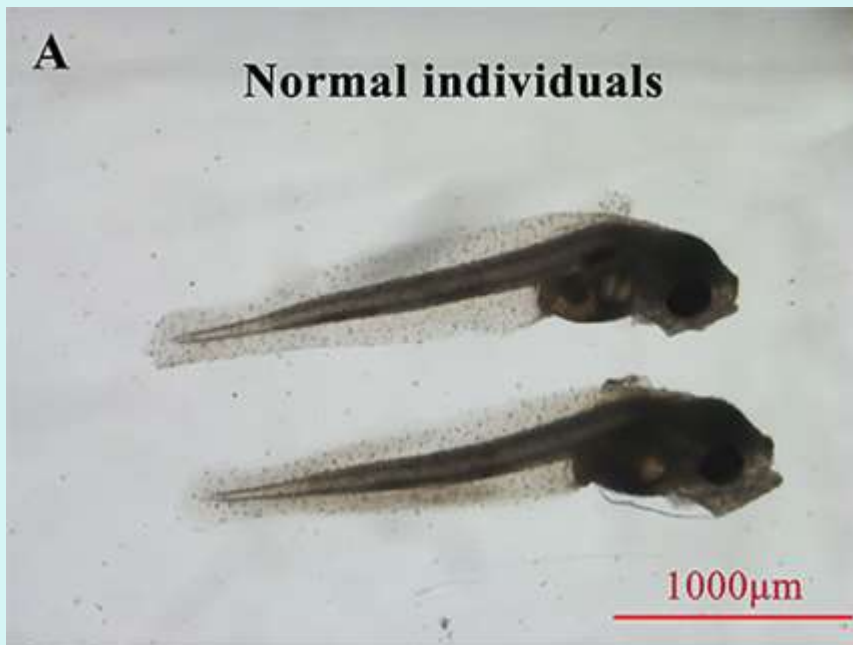


Highest CTMax & CTMin values under 38 °C
Lowest CTMax & CTMin values under 22 °C



Highest PK activity under 30°C

Optimum acclimated temperature is necessary for better and maximum fish performance



Morphology of normal (A) and deformed (B–D) Yellow croaker (*Larimichthys crocea*) larvae taken from Tian et al (2022).

Embryos were exposed to seven different temperatures (15°C, 18°C, 21°C, 24°C, 27°C, 30°C, and 33°C) and observed until hatch.

Embryos incubated at temperatures close to the optimal temperature of 22 °C (21 °C and 24 °C, respectively) had the highest hatching success rate and lowest deformity.

Embryos incubated at 15 °C and 33 °C had the lowest hatching success rate and the highest rate of deformity, demonstrating the impacts of extreme temperatures on development and survival.

TUTORIAL 3

- ✓ **What is the purpose of eyestalk ablation in crustacean aquaculture, and how does it affect the reproductive cycle?**
- ✓ **How does temperature shock influence the physiology and survival of aquatic organisms used in aquaculture?**

THE MOST RECENT RESEARCH CONDUCTED BY THE AUTHOR

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Tahniah

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NUR AINA LYANA BINTI MOHAMAD ALI,
MARINI BINTI NAFI,
NURUL HANA BINTI MOHD BAKRI,
ERLIANA BINTI MOHAMAD

Di atas kejayaan mendapat
**TVET APPLIED RESEARCH GRANT SCHEME
(T-ARGS) 2025**

Tajuk Penyelidikan:
**Enhancing Redclaw, *Cherax quadricarinatus* Growth
Through Pineapple Waste and IoT Applications**

Ikhlas daripada:
PENGARAH
DAN SELURUH WARGA
POLITEKNIK JELI KELANTAN

MALAYSIA MADANI | MQA | MEOT | SMART GREEN | Politeknik Jeli Kelantan | www.pjk.edu.my | PROFESIONALISME JAJA KEGEMILANGAN

Title for research:

Enhancing redclaw, *Cherax quadricarinatus* growth through pineapple waste and IoT applications

Total of grant: RM79,680.00

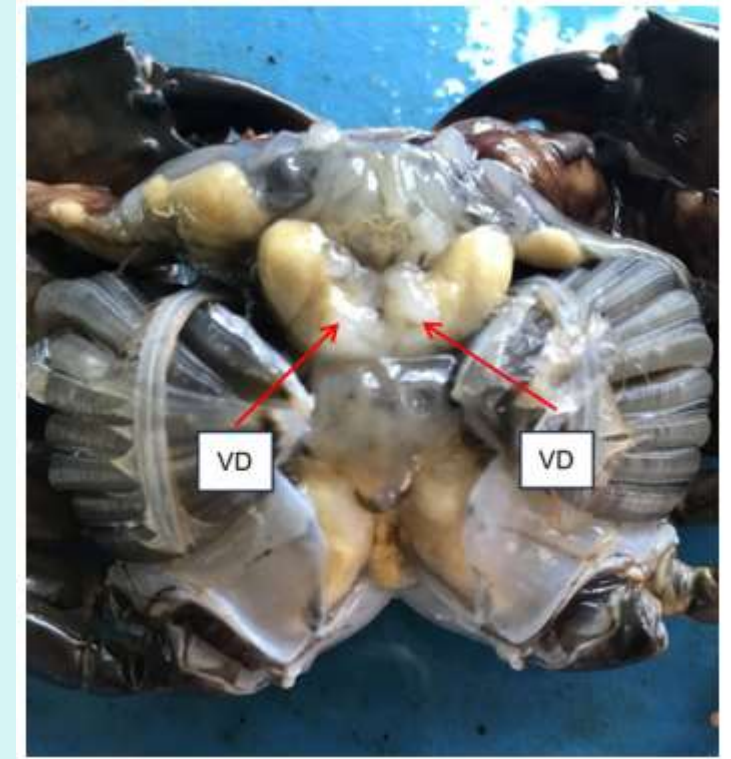
Objectives

1. To **evaluate the effectiveness of pineapple waste** as a sustainable feed source for enhancing growth performance in redclaw, *Cherax quadricarinatus*.
2. To **develop the role of IoT technology** in monitoring and optimizing gonad development and environmental conditions in redclaw, *Cherax quadricarinatus*.

Effect of different extenders and cryoprotectants on sperm viability of mud crab *Scylla tranquebarica* for short-term storage

The aim of the present study was to determine the extenders such as calcium-free saline, Ringer's solution and phosphate buffer and to determine the effect of different concentrations of cryoprotectants with different duration of exposure for short-term storage of mud crab, *Scylla tranquebarica* sperm cells.

In a nutshell, the phosphate buffer and 5% glycine proved to be the most effective extender and cryoprotectant in this study.



Reproductive system of mature male in mud crab, *Scylla tranquebarica*, VD: Vas deferens

Gonad maturation of giant freshwater prawn, *Macrobrachium rosenbergii* at the bay of Padas River, Beaufort, Sabah, Malaysia

This study provides new information on the gonad maturation of *M. rosenbergii* especially in Padas River Bay, Beaufort, Sabah, Malaysia. A total of 40 tails in *M. rosenbergii* (20 tails of male and 20 tails of female) were obtained from Kampung Inuman, Beaufort, Sabah.

Stage	Number		Mean (cm)		Gonad maturity (%)	
	Male	Female	Male	Female	Male	Female
I	2	2	16.43 ± 3.13	12.06 ± 1.82	Immature (40)	Immature (30)
II	6	4				
III	5	2				
IV	6	3	16.43 ± 3.44	14.87 ± 4.27	Mature (60)	Mature (70)
V	1	9				

Gonad maturity (%) and body length (mean ± standard deviation) for males and females of *M. rosenbergii*

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ABOUT THE AUTHOR

Personal Statement

I specialize in animal science, specifically in aquatic animal reproductive biology and breeding technologies. During my tenure as a Senior Lecturer (DS51) at Universiti Malaysia Sabah from October 2015 to February 2020. My research focused on **sperm cryopreservation in lobsters, reproductive biology of crustaceans such as mud crabs, and breeding techniques for freshwater crayfish, *Cherax quadricarinatus***. Additionally, I conducted studies on the growth performance and gonad development of the giant freshwater prawn, *Macrobrachium rosenbergii*, in aquaponics and Integrated Multi-Trophic Aquaculture (IMTA) systems. Since February 2020 until now, as a Lecturer at Politeknik Jeli Kelantan, I continue to contribute to animal science through research and teaching in aquatic animal (fish, shrimp and crayfish).

Academic Qualifications

- ✓ **PhD, Universiti Malaysia Terengganu, 2015 (Aquaculture-Breeding Technology and Cryopreservation in Mud Spiny Lobster)**
- ✓ **MSc, Universiti Malaysia Terengganu, 2010 (Aquaculture)**
- ✓ **BSc in Agrotechnology (Aquaculture), Universiti Malaysia Terengganu, 2009**



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