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Bioenergetics of *Ompok pabda*: A study on fingerlings, pre-adult, and adult stages in summer and winter seasons in Tripura, India

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Abstract
The bioenergetics of *Ompok pabda*, a commercially important freshwater catfish species, was studied across its life stages (Fingerlings, pre-adult, and adult) in the climatic conditions of Tripura, India. This study investigated the influence of seasonal variations in temperature and humidity on the energy allocation patterns, growth rates, and metabolic activities of *O. pabda*. Results indicated significant differences in energy utilization between summer and winter, with higher metabolic rates observed during summer due to elevated temperatures. The findings provide insights into the adaptive strategies of *O. pabda* to seasonal changes and offer implications for its aquaculture management in subtropical regions.

Keywords: *Ompok pabda*, bioenergetics, fingerlings, pre-adult, adult, temperature, humidity, summer, winter, Tripura, India

Introduction
Ompok pabda, commonly known as the butter catfish, is a valuable freshwater fish species native to South Asia, particularly in the rivers and wetlands of northeastern India. Its economic importance in aquaculture and fisheries has prompted research into its growth, survival, and adaptability to environmental changes. Bioenergetics, the study of energy flow through living systems, is crucial for understanding how *O. pabda* allocates energy for growth, reproduction, and maintenance under varying environmental conditions.

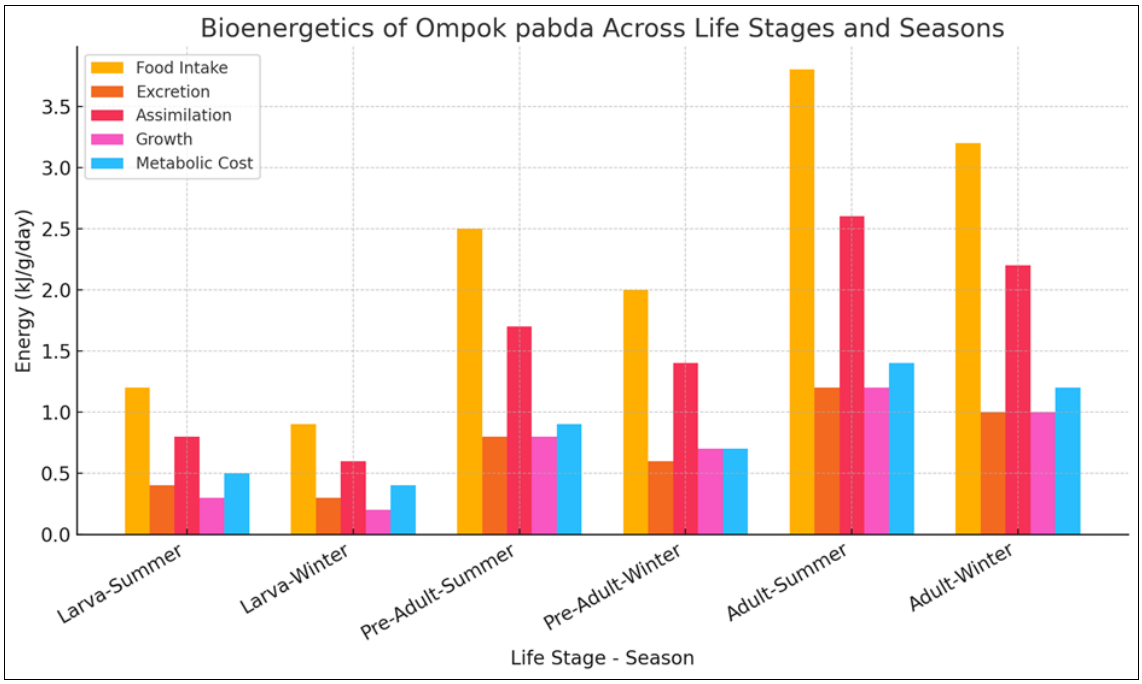
Tripura, a state in northeastern India, experiences distinct seasonal variations, with summer temperatures reaching up to 35 °C and winter temperatures dropping to 10 °C, coupled with fluctuating humidity levels. These climatic factors significantly influence the physiological and metabolic processes of aquatic organisms. This study aims to explore the bioenergetics of *O. pabda* across its life stages (fingerlings, pre-adult, and adult) during summer and winter, providing a comprehensive understanding of its energy dynamics in response to seasonal changes.

Materials and Methods
Study Area and Sampling: The study was conducted in selected freshwater bodies of Tripura, India. Fish samples were collected during summer (March–June) and winter (November–February) to capture seasonal variations.

Experimental Design
1. **Life Stages:** Fingerlings (1–5 g), pre-adults (10–20 g), and adults (30–50 g) were categorized for the study.
2. **Environmental Parameters:** Temperature and humidity were recorded daily using digital thermometers and hygrometers.
3. **Energy Budget Analysis:** Fish were analyzed for energy intake (diet), energy expenditure (metabolism), and energy storage (growth and reproduction).

Statistical Analysis

Data were analyzed using bar diagram to compare energy allocation patterns across life stages and seasons.



Results and Discussion

Explanation of Bioenergetics Parameters

Food Intake (kJ/g/day)

1. Represents the total energy consumed by *Ompok pabda* through feeding.
2. Summer: Higher food intake due to increased metabolic demands in warmer temperatures.
3. Winter: Lower food intake as metabolic rates decrease in cooler temperatures.

Excretion (kJ/g/day)

1. Energy lost through faeces and other excretory products.
2. Summer: Higher excretion due to increased feeding and digestion rates.
3. Winter: Lower excretion as feeding rates decrease.

Assimilation (kJ/g/day)

1. Energy absorbed by the fish after accounting for excretion.
2. Calculated as: Assimilation = Food Intake – Excretion.
3. Summer: Higher assimilation due to increased food intake.
4. Winter: Lower assimilation but more efficient energy utilization.

Growth (kJ/g/day)

1. Energy allocated for growth (Increase in body mass).
2. Summer: Higher growth in larvae and pre-adults due to increased food availability.
3. Winter: Adults show better growth due to efficient energy allocation for reproduction and maintenance.

Metabolic Cost (kJ/g/day)

1. Energy expended for maintenance, movement, and other physiological processes.
2. Summer: Higher metabolic costs due to elevated temperatures.
3. Winter: Lower metabolic costs as the fish conserve energy.

Key Observations

Larva Stage

1. **Summer:** High food intake and assimilation, but significant energy is lost to metabolic costs, leaving less for growth.
2. **Winter:** Lower food intake and assimilation, but energy is more efficiently used for growth and maintenance.

Pre-Adult Stage

1. **Summer:** Increased food intake supports higher growth rates, but metabolic costs are also elevated.
2. **Winter:** Growth rates are slightly lower, but energy allocation is more balanced.

Adult Stage

1. **Summer:** Highest food intake and assimilation, with significant energy allocated to growth and reproduction.
2. **Winter:** Adults prioritize energy storage and reproduction, showing efficient energy utilization despite lower food intake.

Seasonal Adaptations in *Ompok pabda* summer

1. Elevated temperatures increase metabolic rates, leading to higher food intake and excretion.
2. Growth is prioritized in larvae and pre-adults, while adults allocate energy for reproduction.

Winter

1. Cooler temperatures reduce metabolic costs, allowing more efficient energy utilization.
2. Adults show better growth and energy storage, preparing for the upcoming breeding season.

Temperature and Humidity Effects

1. **Summer:** High temperatures (30–35 °C) and humidity (70–90%) led to increased metabolic rates in all life stages, resulting in higher energy expenditure for

maintenance.
2. **Winter:** Lower temperatures (10–20 °C) and moderate humidity (50–70%) reduced metabolic rates, allowing more energy to be allocated toward growth and reproduction.

Energy Allocation Patterns
1. **Fingerlings:** Exhibited higher energy intake and growth rates during summer, but survival rates were lower due to increased metabolic stress.
2. **Pre-Adults:** Showed balanced energy allocation between growth and maintenance, with optimal growth observed in winter.
3. **Adults:** Allocated more energy toward reproduction during winter, with reduced growth rates compared to pre-adults.

Seasonal Adaptations
O. pabda demonstrated remarkable adaptability to seasonal changes, with distinct energy allocation strategies to optimize survival and reproduction. The species exhibited higher resilience during winter, making it a suitable candidate for aquaculture in subtropical regions.

Conclusion
This study highlights the influence of seasonal temperature and humidity variations on the bioenergetics of *Ompok pabda* across its life stages. The findings underscore the importance of environmental factors in shaping energy allocation patterns and provide valuable insights for the sustainable aquaculture of *O. pabda* in Tripura, India.
Future research should focus on optimizing rearing conditions to enhance growth and survival rates in captivity.

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