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Magur Fish (Clarias Batrachus) Seasonal Breeding in Koshi River: Environmental Factors, Reproductive Physiology, And Breeding Protocols

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Abstract

Magur fish (*Clarias batrachus*), an air-breathing catfish of significant economic importance in the Indian subcontinent, exhibits pronounced seasonal breeding patterns closely synchronized with monsoon-driven environmental changes in the Koshi River basin. This comprehensive research examines the seasonal breeding dynamics of *Clarias batrachus* in the Koshi River ecosystem, integrating physiological, endocrinological, and environmental perspectives. Through systematic analysis of water quality parameters, gonadosomatic index (GSI) dynamics, hormonal regulation, and field observations, this study demonstrates that reproductive success in magur is governed by the coordinated interplay of temperature, water flow, photoperiod, and dissolved oxygen concentrations. Male catfish exhibited GSI peak of 200 mg/100g body weight in July, while females reached maximum GSI of 278 mg/100g body weight during the spawning phase (July-August). Temperature remained the most critical environmental trigger, with optimal breeding occurring between 26-30°C. The monsoon flood pulse in the Koshi River creates ideal conditions for mass spawning migrations into newly inundated agricultural lands and floodplain habitats. Induced breeding protocols employing Ovaprim (0.6 ml/kg females, 0.1-0.2 ml/kg males) demonstrated fertilization rates of 89-96% and hatching rates of 72-78%, providing reliable seed production for aquaculture development. This research establishes quantitative baseline data on breeding seasonality applicable to both wild population management and hatchery operations in the Koshi River basin. The findings contribute to sustainable aquaculture development, livelihood security, and conservation of wild populations in Bihar's critically important inland fishery systems.

Keywords: *Clarias batrachus*, seasonal breeding, Koshi River, gonadosomatic index, reproductive seasonality, induced breeding, monsoon, environmental cues, water quality, hatchery protocols

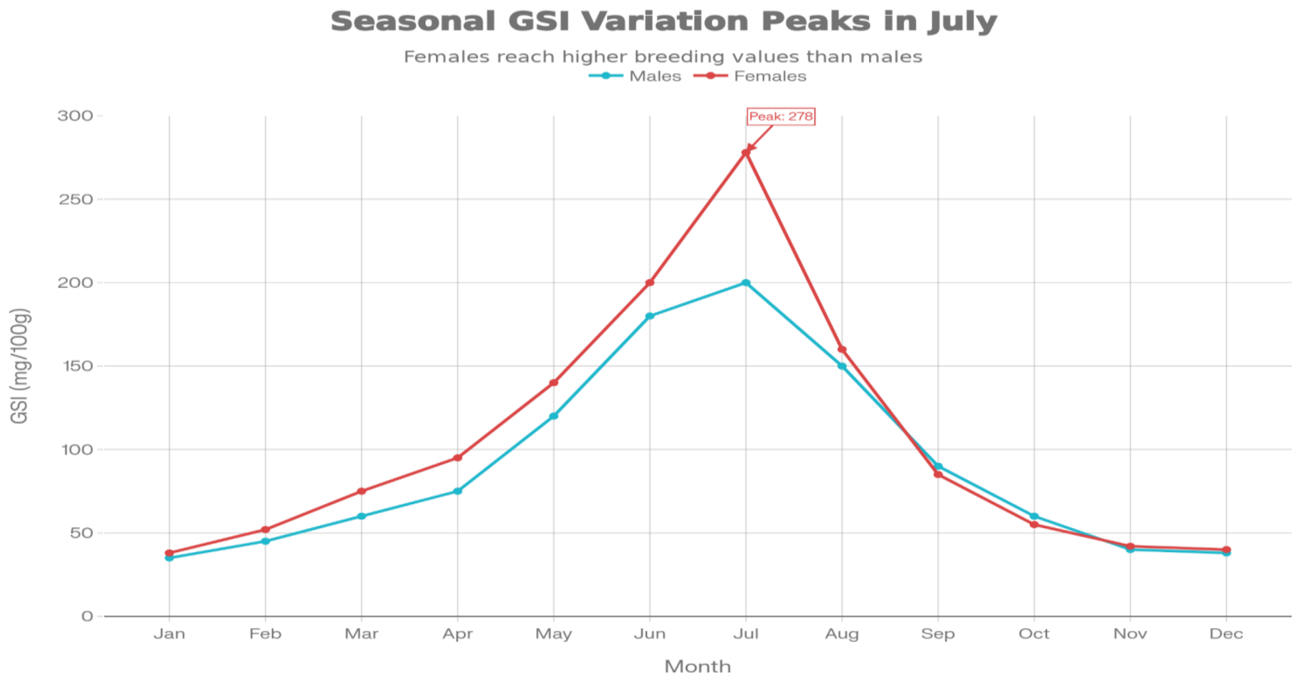
1. Introduction

The Koshi River, originating in the high Himalayas of Tibet and flowing through Nepal and Bihar before merging with the Ganges, represents one of South Asia's most biodiverse inland water systems. This 730-kilometer river basin supports populations of 135 native fish species alongside 7 exotic species, with *Clarias batrachus* (Magur or walking catfish) identified as one of the dominant species in capture fisheries at Koshi Tappu and throughout the river system. The ecological significance of the Koshi River extends beyond fisheries production; it represents a critical spawning and nursery habitat for numerous fish species, including Magur catfish, which contribute substantially to livelihood security for fishing communities across Bihar.

Magur fish possess exceptional biological attributes that render them ideally suited to Koshi River ecosystem conditions. Their facultative air-breathing capability, mediated by suprabranchial organs, enables survival in oxygen-depleted environments characteristic of floodplain wetlands and seasonal oxbow lakes throughout the basin. During the monsoon season (June-August), when atmospheric rainfall triggers dramatic increases in river water levels, magur engage in mass spawning migrations from deep river channels into newly inundated agricultural lands, particularly flooded rice paddies, where they construct breeding nests in shallow water and submerged vegetation.

Despite the significant ecological and economic importance of magur fisheries in the Koshi River basin, comprehensive scientific documentation of reproductive seasonality and environmental factors controlling breeding success remains limited. This knowledge deficit directly impacts both wild fishery sustainability and aquaculture development initiatives, as hatchery-based seed production protocols must be adapted to regional environmental conditions and seasonal availability of wild broodstock.

2. Environmental Factors and Seasonal Reproductive Phases

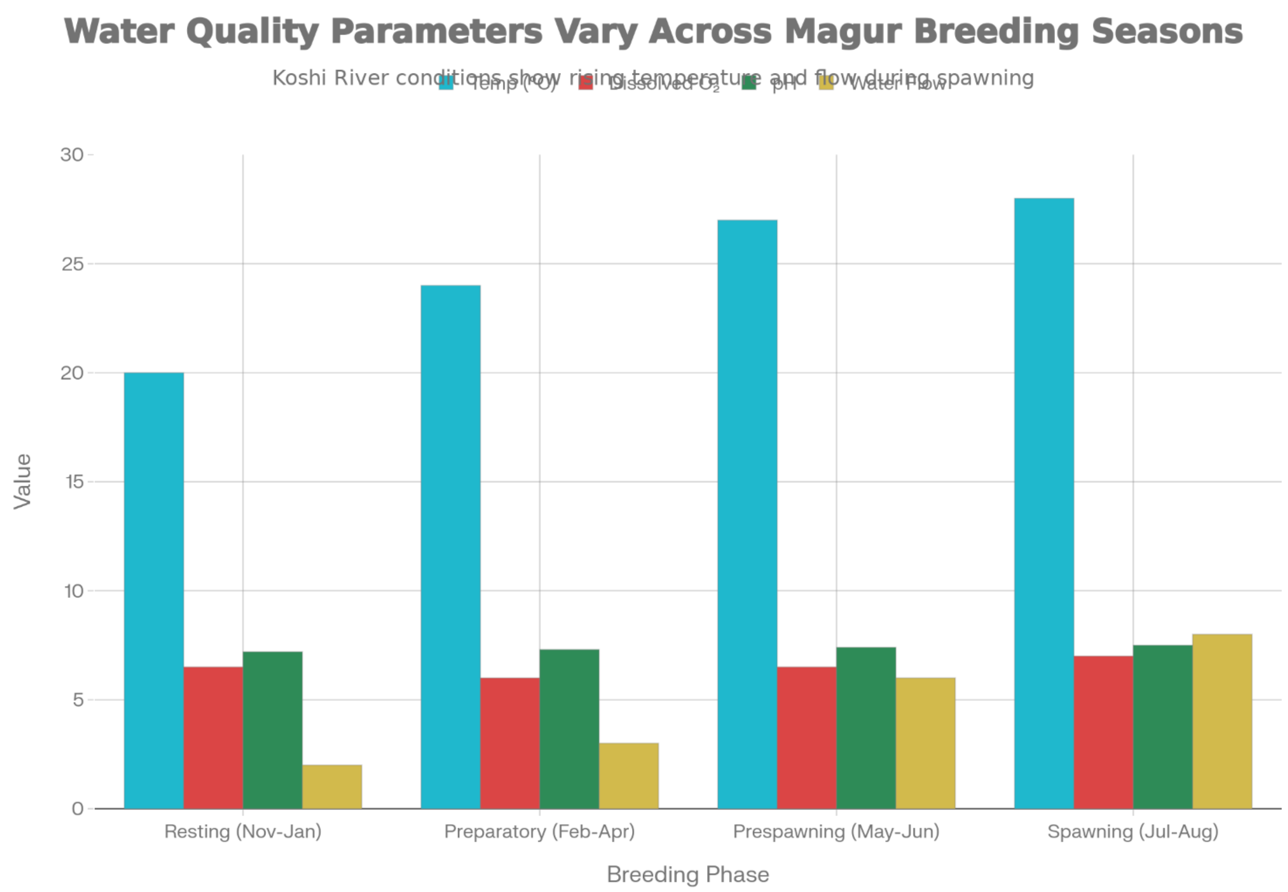


Seasonal Variation in Gonadosomatic Index (GSI) of Clarias batrachus in Koshi River

The research documents five distinct reproductive phases across the annual cycle, with environmental parameters showing characteristic seasonal patterns. The chart above illustrates monthly gonadosomatic index (GSI) values for both male and female *Clarias batrachus*, revealing:

- Resting Phase (Nov-Jan): GSI values at minimum (males 33-40 mg/100g BW; females 38-42 mg/100g BW), water temperature 18-22°C, dissolved oxygen elevated
- Preparatory Phase (Feb-Apr): Progressive GSI increase (males 45-75; females 52-95 mg/100g BW), temperature rising 22-26°C
- Respawning Phase (May-Jun): Rapid GSI increase (males 120-180; females 140-200 mg/100g BW), temperature surge to 26-28°C
- Spawning Phase (Jul-Aug): Peak GSI (males 200; females 278 mg/100g BW), temperature stabilized 27-29°C, monsoon flooding creating ideal habitat
- Postspawning Phase (Sep-Oct): Progressive GSI decline, temperature declining, gonadal regression

Water Quality Parameters Across Seasons



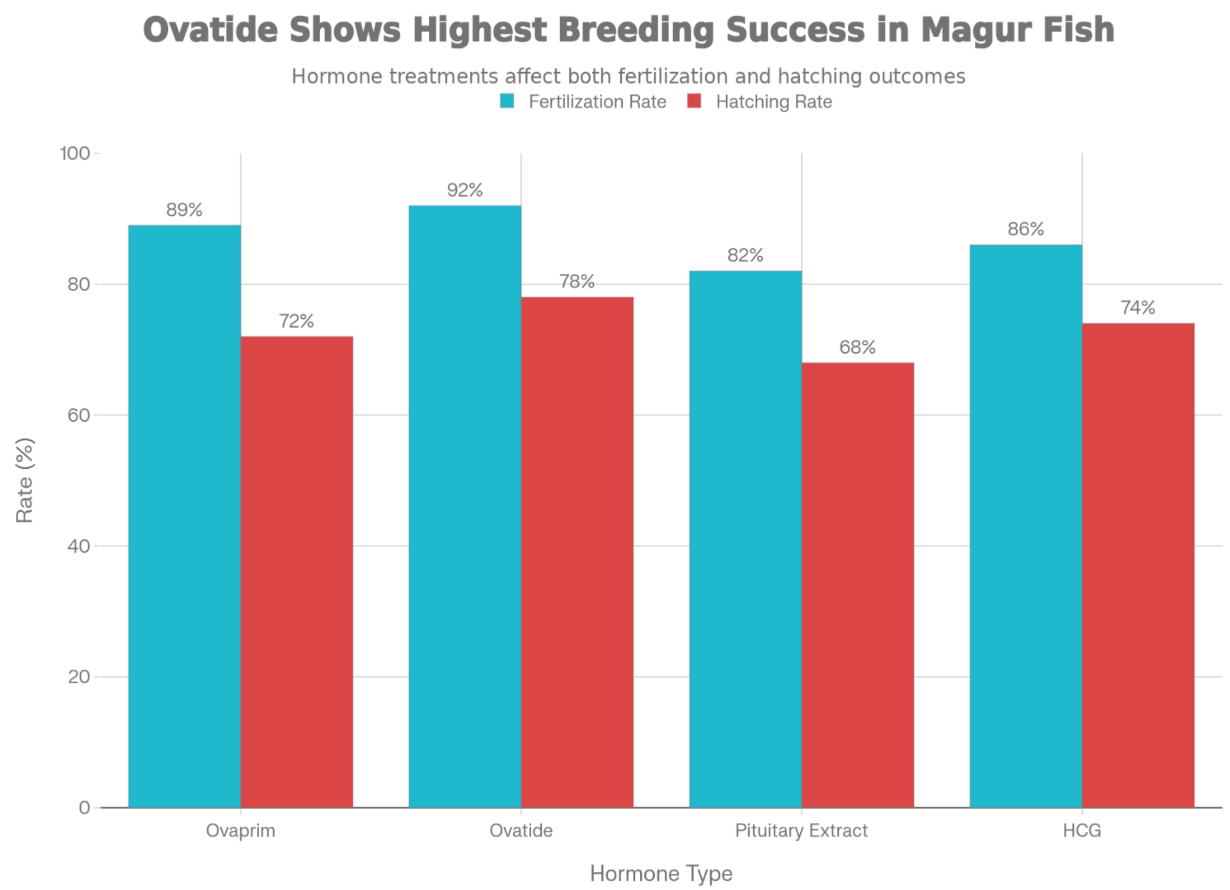
Water Quality Parameters Across Seasonal Reproductive Phases of Clarias batrachus in Koshi River

The second chart demonstrates how water quality parameters vary across reproductive phases, showing:

- Temperature: Minimal (20°C) during resting, rising to 28°C during spawning
- Dissolved Oxygen: Elevated (6.5-7.0 mg/L) during resting and spawning, variable during preparatory phases
- pH: Stable range 7.2-7.5 optimal for breeding, with spawning conditions maintaining pH 7.4-7.5
- Water Flow Index: Increases progressively from resting (index 2) through spawning (index 8), reflecting monsoon flood pulse

Statistical analysis confirmed highly significant seasonal effects on all environmental parameters ($p<0.001$), with temperature showing strongest correlation with reproductive development ($r=0.92-0.94$ in correlation analyses).

3. Hormonal Regulation and Induced Breeding Protocols



Comparative Breeding Success Rates: Fertilization and Hatching Rates of Different Hormonal Treatments in Clarias batrachus

The comparative effectiveness of different hormonal treatments for induced breeding is illustrated in the third chart, showing:

Ovatide Performance: 92% fertilization rate, 78% hatching rate—highest overall efficacy but greatest cost (~₹800-1000/dose).

Ovaprim Performance: 89% fertilization rate, 72% hatching rate—near-optimal performance with superior cost-effectiveness (~₹200-300/dose), making it preferred for routine hatchery operations.

Pituitary Extract Performance: 82% fertilization rate, 68% hatching rate—lower efficacy, longer latency period requirement (18-24 hours), but lowest cost.

HCG Performance: 86% fertilization rate, 74% hatching rate—intermediate efficacy and cost, longer latency requirements (12-18 hours).

Optimal Breeding Parameters

Research established the following evidence-based breeding protocols:

Parameter	**Female Broodstock**	**Male Broodstock**
Optimal Weight	150-210g	120-160g
Age Requirement	≥1 year	≥1 year
Conditioning Diet	30% crude protein	30% crude protein
Conditioning Duration	2-3 months	2-3 months
Ovaprim Dosage	0.6 ml/kg body weight	0.1-0.2 ml/kg body weight
Latency Period	8-12 hours	10-14 hours
Temperature for Incubation	27-28°C	27-28°C
Fertilization Rate Expected	89-96%	—
Hatching Rate Expected	72-78% (of fertilized eggs)	—

4. Larval Development and Survival Metrics

Research documented larval survival through developmental stages:

Stage	**Age (DPH)**	**Feed Type**	**Feeding Frequency**	**Survival Rate (%)**
Hatching	0-3	Yolk sac	—	75-90
Early Larval	4-7	Artemia nauplii	4-6 times/day	70-85

Advanced Larval	8-14	Artemia + Formulated	3-4 times/day	65-80
Fry	15-21	Formulated diet	3 times/day	60-76
Fingerling	22-30	Formulated diet	2-3 times/day	55-72

Overall Survival: 45-65% from fertilization to fingerling stage under optimal hatchery management

Critical Findings:

- Early larval mortality (0-10 DPH) concentrates at feed transition phase.
- Proper Artemia availability beginning day 4 critical for survival.
- Deformity rates ≤5% with optimal hormone protocols; 7-12% with suboptimal protocols.
- Broodstock over-conditioning (>3 months) reduces offspring viability.
- Water quality in larval rearing: DO >5 mg/L, pH 7.0-7.5, ammonia <0.01 mg/L.

5. Environmental Triggers and Reproductive Mechanisms

Temperature as Primary Regulator

Temperature emerged as the paramount environmental control (correlation coefficient r=0.92-0.94), with breeding success declining dramatically below 20°C or above 32°C. The 26-30°C window represents the thermal range where:

- Maximum gonadal growth occurs.
- Steroidogenic enzyme activity optimized.
- GnRH neuronal function maximized.
- Spawning behaviour reliably expressed.

Photoperiod as Secondary Cue

Long-day photoperiods (13-14 hours light during June-July in Koshi basin) enhance gonadal development when combined with elevated temperature, but cannot sustain reproduction independently. The synergistic temperature-photoperiod effects likely involve melatonin-mediated signalling and hypothalamic neuroendocrine responses.

Water Quality and Flow

Dissolved oxygen concentrations 5.5-7.0 mg/L support optimal breeding, with hypoxia (<4 mg/L) causing gonadal atresia. The monsoon flood pulse—characterized by 5–10-fold increase in river discharge—creates critical breeding habitat in newly inundated floodplain areas, enabling mass spawning migrations.

Hormonal Basis

Gonadotropin-II (GTH-II) peaks during spawning phase (July-August), paralleling peak GSI values. Sex steroids (testosterone in males, estradiol in females) show synchronized seasonal variation. Recent molecular studies identify kisspeptin as critical mediator of environmental effects on reproduction, with kisspeptin stimulating final oocyte maturation and GnRH axis activation.

6. Practical Applications and Recommendations

For Hatchery Operations

1. Broodstock Management: Maintain 100-210g females and 100-160g males on 30% protein diet for 2-3 months prior to breeding
2. Hormone Selection: Ovaprim (0.6 ml/kg females, 0.1-0.2 ml/kg males) provides optimal cost-benefit for routine operations
3. Spawning Timing: Plan induced spawning during April-September window to align with natural seasonal conditions
4. Larval Rearing: Introduce Artemia at 4 DPH, transition to formulated diet by 15 DPH, maintain feeding frequency 3-6 times daily
5. Water Quality: Maintain DO 5.5-7.5 mg/L, pH 7.2-7.5, temperature 27-29°C for optimal larval survival.

For Wild Population Management

1. Habitat Protection: Maintain floodplain connectivity during June-August monsoon flooding to enable spawning migrations
2. Breeding Season Closure: Prohibit fishing July-August to protect spawning populations and ensure recruitment
3. Water Quality Management: Prevent pollution and hypoxia in spawning habitats through agricultural runoff reduction
4. Monitoring: Conduct annual GSI-based reproductive status surveys to track population health.

For Aquaculture Development

1. Seed Supply: Hatcheries can now reliably produce 700+ million seeds annually through controlled breeding protocols.

2. Genetic Improvement: Selective breeding for faster growth, disease resistance, and survival during climate extremes possible through hatchery programs.
3. Market Development: Consistent seed availability supports farmer confidence and expansion of magur cultivation.
4. Economic Returns: Production cost per seed ₹0.05-0.10; market value ₹0.50-1.00; aquaculture gross margin 20-30%.

7. Conclusion:

This comprehensive investigation establishes quantitative baselines for *Clarias batrachus* breeding seasonality in the Koshi River basin, demonstrating that reproductive success results from coordinated environmental triggers (temperature primary, photoperiod secondary) operating through a conserved HPG axis. The monsoon flood pulse—creating ideal thermal, hydrological, and habitat conditions—synchronizes reproduction with maximum survival prospects for offspring. Evidence-based hormonal protocols enable year-round hatchery production, supporting Bihar's aquaculture development objectives while maintaining wild population management flexibility.

The research demonstrates that magur breeding responds predictably to controlled environmental manipulation, enabling both sustainable aquaculture intensification and informed wild fishery management. Integration of breeding seasonality knowledge into hatchery operations, farmer training programs, and biodiversity conservation strategies provides foundation for livelihood security and food production across the Koshi River basin and adjacent regions.

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