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Seasonal variation in species composition and abundance of freshwater prawns (*Macrobrachium* spp.) across different hydrological regimes in Bangladesh

Rakhi Das[1*], Shahin Alam[1], Nazia Naheen Nisheeth[1], Sharmin Sultana[1], Md. Mohammad Ashraful Alam[2], Harunor Rashid[1], Anuradha Bhadra[2]
[1] Bangladesh Fisheries Research Institute, Freshwater Station, Mymensingh, Bangladesh
[2] Bangladesh Fisheries Research Institute, Headquarters, Mymensingh, Bangladesh
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Abstract

Seasonal hydrological changes have a significant impact on the population dynamics of freshwater prawns of the genus Macrobrachium, which are an essential ecological and economic component of Bangladesh's inland fisheries. In three different freshwater habitats the lentic Chaira Beel floodplain, the lotic Brahmaputra River, and the vast Mithamoin Haor wetland this study assessed the seasonal fluctuations in species composition and abundance of Macrobrachium prawns. To determine the Catch Per Unit Effort (CPUE) of dominat species, monthly sampling was carried out using frame nets during a one-year cycle, divided into pre-monsoon, monsoon, and post-monsoon seasons. Results revealed clear successional patterns that were influenced by hydrological regimes. During the monsoon season, *M. lamarrei* remained the most productive, reaching a peak of 0.710 kg/gear/hour in September at Mithamoin Haor. The pre-monsoon phase, on the other hand, had the largest total community biomass, with *M. villosimanus* reached a maximum CPUE of 0.66 kg/gear/hour in Mithamoin during March and *M. malcolmsoni* peaking at 0.54 kg/gear/hour in the Brahmaputra River in April. During October, a specific peak of *M. acanthurus* (0.78 kg/gear/hour) happened in Chaira Beel, signaling the end of the monsoon. These findings indicate various *Macrobrachium* species occupy specific seasonal hydrological niches, with maximal biomass occurring when water quantities decline during the pre-monsoon period. These observations are crucial for establishing habitat-specific management strategies to ensure Bangladesh's prawn resource exploitation is sustainable.

Keywords: Macrobrachium, hydrological cycle, seasonal abundance, wetland ecology, inland fisheries

Introduction

Freshwater prawns from the Macrobrachium genus are one of Bangladesh's most commercially and ecological significant aquaculture industries (Ahamed *et al*., 2014) [1]. These decapod crustaceans, which are frequently referred to as "white gold" because of their enormous export worth and economic impact, are essential to the local population's access to high-quality animal protein and to the livelihoods of millions of people nationally (Ahmed & Diana, 2015) [3].With its extensive network of rivers, canals, floodplains, and haors, Bangladesh is endowed with a special set of hydrological conditions that sustain a wide variety of *Macrobrachium* species (Nahar *et al*., 2025) [22]. These species are closely related to the seasonal hydrological cycle and the unique ecological features of their habitats, yet their distribution and abundance are not consistent (Mejia-Ortiz & Alvarez, 2010) [20].

Macrobrachium is a genus distinguished by its exceptional capacity to adapt to a variety of freshwater and estuary habitats (Makombu *et al*., 2019) [17]. Although species like *M. malcolmsoni*, *M. villosimanus*, and *M. lamarrei* are extensively distributed in Bangladesh, the seasonal variations of the tropical climate have a significant impact on their population dynamics (Rahman *et al*., 2022) [7]. The hydrological regime of Bangladesh is broadly categorized into three distinct phases: the pre-monsoon (March–May), the monsoon (June–October), and the post-monsoon (November–February) (Azad *et al*., 2022) [7]. Each season brings major changes in water level, flow velocity, dissolved oxygen, and nutrient availability that influence freshwater prawn breeding patterns, recruitment, and catchability (Duggan *et al*., 2019a).

To manage fishery resources sustainably, it is crucial to comprehend the prawns' temporal and spatial distribution (Ahmed *et al*., 2010) [5]. This study focuses on three distinct ecological habitats that represent the diversity of Bangladesh's inland waters. The Brahmaputra River provides a lotic environment with strong currents and high productivity. Chaira Beel represents a seasonal floodplain wetland dominated by dense aquatic vegetation. Mithamoin Haor serves as a vast, inundated breeding ground during the monsoon. Previous research has indicated that prawn abundance, often measured as Catch Per Unit Effort (CPUE) varies significantly between such lotic and lentic systems, yet comparative data encompassing multiple species across these specific hydrological regimes remains limited (O'Neill *et al*., 2005) [23].

Current environmental pressures, including habitat degradation, over-exploitation, and climate change-induced alterations in water flow, threaten the stability of these prawn populations (Arthington *et al*., 2016) [6]. To ensure long-term sustainability, it is crucial to establish baseline data regarding how different species respond to seasonal shifts in their respective habitats. For instance, the dominance of *M. lamarrei* during high-water periods compared to the pre-monsoon peak of *M. villosimanus* suggests that different species utilize environmental niches differently throughout the year (Bhattacharjya *et al*., 2021) [8]. The primary objective of this research is to evaluate the seasonal variations in species composition and abundance of *Macrobrachium* prawns by quantifying the average catch per unit effort (CPUE) across diverse hydrological regimes, specifically representing lotic and lentic freshwater systems in Bangladesh. Additionally, the study aims to characterize the specific temporal distribution and successional patterns of various prawn species to identify peak productivity periods and ecological niches within distinct riverine, beel, and haor habitats.

Method and Materials

Study Area and Habitat Characteristics

The study was carried out in three specifically selected freshwater habitats in Bangladesh that represented distinct hydrological regimes and ecological conditions. A variety of freshwater prawn species found a healthy home at Site 1 (S1), which was situated at the Brahmaputra River Point in Mymensingh. This important lotic system is distinguished by strong water currents, high ecological productivity, and major seasonal flooding. A seasonal floodplain wetland habitat with shallow water depths and extensive aquatic vegetation was represented by Site 2 (S2), Chaira Beel in Tarakanda, which experiences significant hydrological changes all year round. Site 3 (S3) was in Kishoreganj's Mithamoin Haor, a large floodplain wetland that is frequently flooded during the monsoon. Freshwater prawns and a variety of fish species use this location as a vital biological nursery and breeding area.

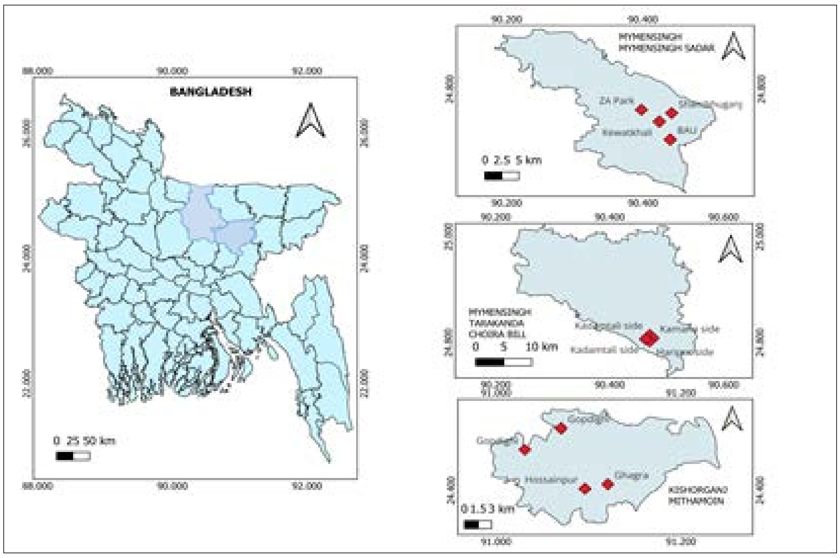

Fig 1: Geographical location of the study site depicting habitat characteristics and collection points for *Macrobrachium spp.* in Bangladesh.

Sampling Period

Sampling was conducted monthly and divided into three distinct seasons: the pre-monsoon (March–May), the monsoon (June–October), and the post-monsoon (November–February) to assess the impact of the regional hydrological cycle on aquatic biodiversity. This temporal stratification ensures that the data accurately reflect the seasonal dynamics of the prawn populations and the inherent hydrological variations of the Bangladesh climate.

Sampling Methods

Specimens were gathered utilizing a frame net that had stretched mesh measuring 3 mm. The net was run through both shallow and somewhat deep zones at each location to provide a representative sampling of the prawn population structure. Collections were conducted at several sub-locations within each major site to reduce spatial bias. After being collected, the specimens were kept in suitable containers and brought to the lab for a thorough examination of their morphology and taxonomy.

Species Identification

Different physical traits, such as rostrum shape and dentition, body colors, chela structure, and particular carapace features, were used to identify the species. These diagnostic characteristics were confirmed using traditional taxonomic keys and regional sources. This precise method ensured that all collected specimens were taxonomically correct.

Data Collection and Analysis

Primary data from the Bangladesh Fisheries Research Institute (BFRI) and relevant scientific literature were combined with secondary data from the same sources. The primary data included species composition, seasonal occurrence, relative abundance, and site-wise variance. Seasonal differences in species composition and temporal dispersion patterns were identified by analyzing the generated dataset. To show the ecological relationships within the study area, all of the results were combined and presented using detailed tables and graphical visuals.

Result and Discussion:

Seasonal Species Composition

The seasonal distribution and abundance of *Macrobrachium* species, quantified via Average Catch Per Unit Effort (CPUE), revealed distinct successional patterns across the three study locations. During the Monsoon season (June–September), *M. lamarrei* distributed across Chaira Beel, Mithamoin, and Brahmapura maintained the highest overall productivity, peaking at 0.457 kg/gear/hour in August (Table 1). It shows that *M. lamarrei* is adaptable to higher turbidity and wider foraging areas based on its lead during high water seasons (Hossain *et al*.,2021) [14]. Larger species, such as *M. malcolmsoni* and *M. villosimanus*, showed more moderate yields, most likely due to the dispersion of individuals across wide submerged floodplains, which limits catchability (Hossain *et al*., 2011, Siriwut *et al*., 2021) [15, 25].

The post-monsoon transition (October–January) marked a significant shift in community structure as water levels receded. While most taxa declined in CPUE, *M. acanthurus* (exclusive to Chaira Beel) reached an exceptional peak of 0.78 kg/gear/hour in October, the highest CPUE recorded in the study. This localized surge may reflect the concentration of the population in dwindling water bodies, which increases gear efficiency (Siriwut *et al.*, 2021) [25]. Conversely, *M. kistnensei* (exclusive to the Brahmapura River) recorded its lowest productivity, dropping to 0.04 kg/gear/hour by January, indicating sensitivity to cooling water temperatures and reduced flow characteristic of winter in lotic systems (Nagabhushanam *et al*., 1979) [21].

The pre-monsoon phase (February–May) was characterized by a broad resurgence in biomass across nearly all taxa. *M. villosimanus* and *M. malcolmsoni* reached their maximum annual abundance during this time, peaking in April at 0.575 kg/gear/hour and 0.523 kg/gear/hour, respectively. Similarly, Mithamoin-specific species *M. mirabilis* and *M. dayanum* achieved their highest yields in April, recording 0.42 kg/gear/hour and 0.36 kg/gear/hour. This consistent peak across species suggests that the pre-monsoon environment defined by rising temperatures and stable, concentrated water volumes provides optimal biological and physical conditions for the catchability and population density of diverse *Macrobrachium* assemblages (Ahmed *et al*.,2013) [4].

Table 1: Seasonal variation in the average Catch per Unit Effort (CPUE) of Macrobrachium species across different sampling locations.

Season	Month	Avg. CPUE (Kg/gear/ hour)						
		M. villosimanus	*M. lamarrei*	*M. mirabilis*	*M. malcolmsoni*	*M. dayanum*	*M. acanthurus*	*M. kistnensei*
Monsoon	June	0.23	0.387	0.21	0.237	0.14	0.182	0.21
	July	0.22	0.430	0.19	0.290	0.16	0.19	0.22
	August	0.255	0.457	0.18	0.250	0.12	0.174	0.15
	September	0.17	0.410	0.25	0.108	0.15	0.57	0.15
Post-monsoon	October	0.195	0.170	0.23	0.124	0.18	0.78	0.13
	November	0.175	0.170	0.22	0.159	0.22	0.027	0.12
	December	0.225	0.163	0.3	0.223	0.3	0.107	0.06
	January	0.295	0.333	0.33	0.403	0.33	0.25	0.04
Pre-monsoon	February	0.315	0.313	0.28	0.382	0.28	0.189	0.08
	March	0.565	0.467	0.4	0.487	0.3	0.0276	0.13
	April	0.575	0.453	0.42	0.523	0.36	0.365	0.16
	May	0.53	0.380	0.33	0.390	0.29	0.391	0.19

Temporal Distribution at Mithamoin Haor

The temporal distribution of *Macrobrachium* species at Mithamoin Haor exhibited distinct seasonal fluctuations in Catch per Unit Effort (CPUE) reflecting the biological response of the prawn community to the haor's unique hydrological cycle. During the Monsoon season (June–September), *M. lamarrei* emerged as the dominant species, attaining its annual maximum CPUE of 0.71 kg/gear/hour in September (Figure 2). This peak suggests that *M. lamarrei* effectively utilizes the extensive inundation of the haor ecosystem, potentially benefiting from the increased nutrient availability and expanded foraging grounds provided by the floodwaters (Islam & Hossain, 2019) [16].

The post-monsoon period (October–January) was characterized by a steady presence and gradual increase in the abundance of *M. villosimanus*, which rose from 0.34 kg/gear/hour in October to 0.38 kg/gear/hour by January. Concurrently, *M. malcolmsoni* reached a significant seasonal peak of 0.53 kg/gear/hour in January. These trends indicate that as water levels begin to recede and stabilize, certain species experience a concentration in biomass, leading to increased catchability within the remaining water bodies (Cott *et al*.,2008) [9].

The pre-monsoon season (February–May) represented the peak period of productivity for the majority of the *Macrobrachium* assemblage. Both *M. villosimanus* and *M. malcolmsoni* attained their highest recorded annual values during this phase, reaching 0.66 kg/gear/hour and 0.64 kg/gear/hour in March, respectively. Similarly, the localized species *M. mirabilis* and *M. dayanum* reached their seasonal maxima in April, with CPUE values of 0.42 kg/gear/hour and 0.36 kg/gear/hour.

Scientifically, these findings suggest a clear successional pattern: while *M. lamarrei* thrives during the high-water monsoon months, the broader *Macrobrachium* community at Mithamoin Haor achieves its peak biomass and catchability during the pre-monsoon stage. This surge is likely driven by rising water temperatures and the concentration of prawns in smaller water volumes, which optimizes harvest efficiency before the onset of the next flooding cycle (Ahmed *et al*.,2014) [1].

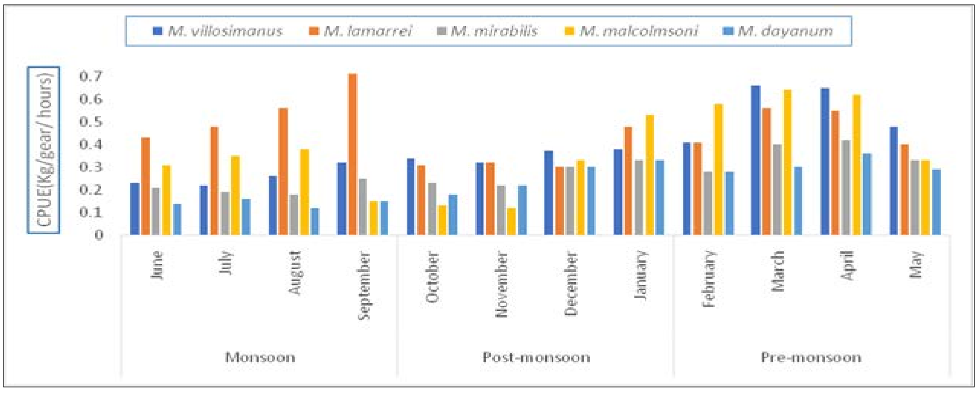

Fig 2: Temporal distribution of Catch Per Unit Effort (CPUE) of different Macrobrachium species at Mithamoin Haor.

Temporal Distribution at Brahmaputra River

The temporal distribution of *Macrobrachium* species within the Brahmaputra River demonstrated significant seasonal variability in abundance, reflecting the complex ecological interactions within this high-energy lotic system. During the Monsoon season (June–September), *M. kistnensei* reached its peak productivity of 0.22 kg/gear/hour in July, whereas *M. malcolmsoni* declined to a seasonal low of 0.10 kg/gear/hour by September (Figure 3). This differential response likely stems from *M. kistnensei*'s specialized adaptation to utilize riverine margins and flooded vegetation as refuge during peak flows, while larger species like *M. malcolmsoni* may migrate to deeper waters or more stable habitats to avoid high current velocities (Hongjamrassilp *et al*.,2021) [13].

The Post-monsoon period (October–January) was marked by an initial sharp decrease in *M. lamarrei* catch rates to 0.06 kg/gear/hour, though levels recovered significantly by January to 0.28 kg/gear/hour. This pattern suggests that receding water levels and decreasing temperatures in the early post-monsoon initially disperse *M. lamarrei* populations or reduce their metabolic activity, while the subsequent stabilization allows for a re-aggregation and recovery in population density within the river channel (Wen *et al*., 2024) [26].

The Pre-monsoon phase (February–May) emerged as the most productive interval for the dominant species, driven by rising temperatures and reduced water volume which concentrates prawn density. *M. malcolmsoni* attained its annual maximum CPUE of 0.54 kg/gear/hour in April, while *M. lamarrei* peaked at 0.46 kg/gear/hour in March. Notably, *M. kistnensei* was absent from the catch records starting from November through the end of the study period, indicating a potential migration to deeper water or a highly specialized life cycle restricted to high-flow periods. These trends suggest that while small-sized species like *M. kistnensei* are more prevalent during high-water months, the overall biomass of the *Macrobrachium* community in the Brahmaputra River is highest during the pre-monsoon season, likely due to increased metabolic rates and efficient harvesting opportunities as water volumes decline (Mamun 2016) [18].

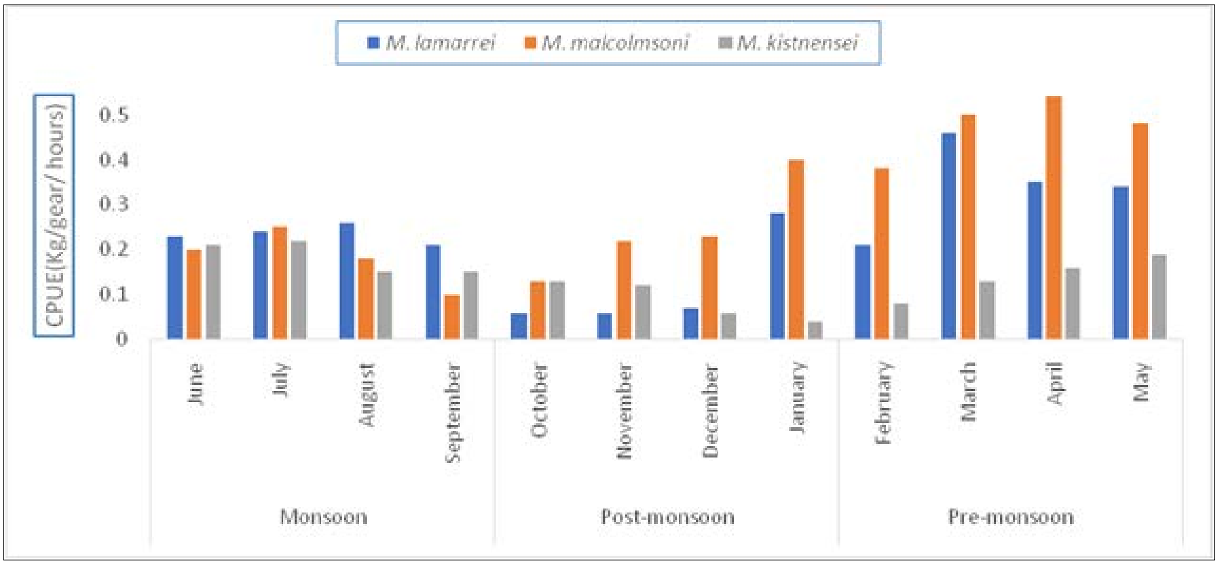

Fig 3: Temporal distribution of Catch per Unit Effort (CPUE) of different Macrobrachium species at Brahmaputra River.

Temporal Distribution at Chaira Beel

The temporal distribution of *Macrobrachium* species at Chaira Beel demonstrated significant seasonal variability in abundance, highlighting the rapid ecological successions characteristic of floodplain wetland ecosystems. During the Monsoon season, *M. lamarrei* emerged as the dominant taxon, achieving its maximum catch rate of 0.57 kg/gear/hour in July (Figure 4). This monsoon peak likely corresponds to the inundation of the *beel* (wetland), which provides expansive foraging grounds and allows *M. lamarrei* to thrive in the high-water conditions (Covich *et al*., 2015) [10].

The Post-monsoon period was characterized by a distinct and singular peak of *M. acanthurus*, which reached its highest annual CPUE of 0.78 kg/gear/hour in Octoberthe highest individual value recorded at this location. This localized surge suggests that as water levels begin to recede, *M. acanthurus* populations become highly concentrated in dwindling water volumes, significantly increasing their catchability. In contrast, *M. villosimanus* experienced a sharp decline during the transition from monsoon to post-monsoon, falling to its lowest point of 0.02 kg/gear/hour in September, indicating a sensitivity to the rapidly changing hydrological conditions at the onset of the dry season (Duggan *et al*., 2019b).

The Pre-monsoon phase (February–May) showed a broad resurgence in community productivity as water temperatures rose and volumes remained low. *M. villosimanus* attained its annual peak of 0.58 kg/gear/hour in May, while *M. malcolmsoni* reached its maximum of 0.41 kg/gear/hour in April. These results indicate a clear successional pattern in species dominance, shifting from the monsoon-favored *M. lamarrei* to the pre-monsoon abundance of *M. villosimanus* and the specialized post-monsoon peak of *M. acanthurus*. Scientifically, this succession demonstrates how different *Macrobrachium* species utilize specific hydrological windows to maximize population density and catch efficiency in fluctuating lentic environments (Marques *et al*., 2016) [19].

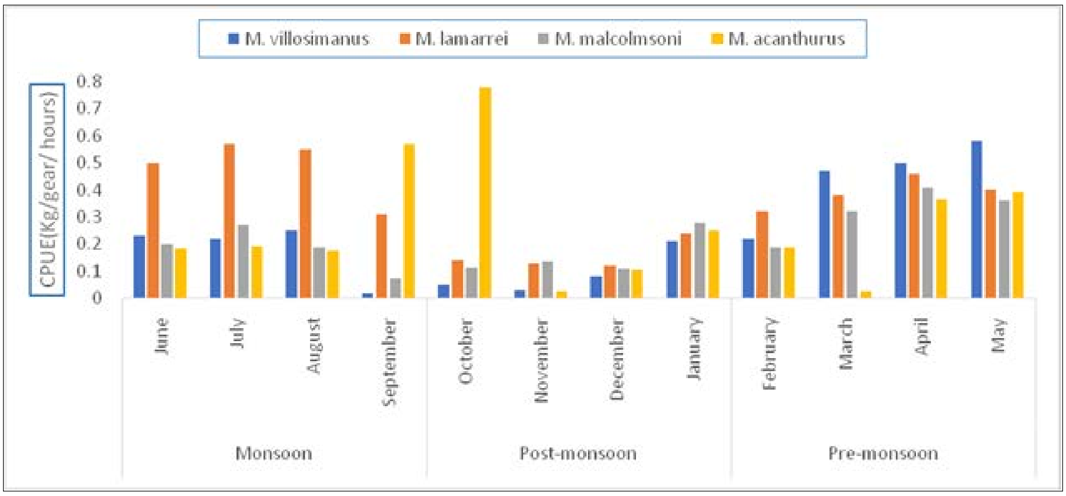

Fig 4: Temporal distribution of Catch Per Unit Effort (CPUE) of different Macrobrachium species at Chaira Beel.

Conclusion

This study demonstrates that the seasonal hydrological cycle is the primary driver of *Macrobrachium* species composition and abundance in Bangladesh's freshwater ecosystems. While *M. lamarrei* thrives during the monsoon, peak biomass and catchability for dominant species like *M. villosimanus* and *M. malcolmsoni* occur during the pre-monsoon due to concentrated water volumes. Furthermore, specific habitats support unique population spikes, such as *M. acanthurus* in floodplain wetlands during the post-monsoon. These findings emphasize that sustainable management strategies must be site-specific and seasonal, accounting for the unique ecological niches of individual *Macrobrachium* species rather than applying a uniform approach.

Disclaimer (Artificial intelligence)

The author(s) hereby declare that no generative artificial intelligence (AI) technologies, including large language models such as ChatGPT, Copilot, or similar tools, were used in the preparation, writing, analysis, or revision of this manuscript.

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