CHAPTER SEVEN

DISCUSSION

CHAPTER -VII

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The studies on total body sizes of various species of prawns are very important from taxonomic point of view. Many workers stidued the total body size of various species of prawns from tip of rostrum to tip of telsion. Maximum body size as 200 mm in length in *M. birmanicum choprae* reported by Sinha *et al.*, (1996) - 188.5 mm in male and 130.5mm in female *M. birmanicum choprae* (Joychandran and Joseph, 1990). Joychandran and Joseph further reported that both *M. birmanicum choprae* and *M. malcolmsonni* grow to fairly large size for culture. In case of *M. lamarrie* – 80mm in female and 69mm in male was reported by Joychandran & Joseph (1990). Sinha *et al.*, (1996) reported 5 – 6 mm in *M. lamarrie*. In case of *M. malcolmsonii* 230mm in male and 200mm in female was reported by Kalita and Bhagwati (2002). Again 97 to 150mm in female *M. malcolmsonii* was reported by Kalita(2002) and 51 – 233mm by Rao(1990). Kalita and Bhagwati (2002) reported 32 – 67mm in *M. menoni* and 30–58mm in *M. tiwari* and in case of *M. assamensis*, Kalita (2002) reported a size of 57– 65 mm.

Dutta(2001) reported the maximum total body length of some species of freshwater prawn from few district Assam, as 65– 167mm (*M. birmanicum choprae*), 35 – 60 mm (*M. malcolmsonii*), 32 – 67 mm (*M. menoni*), 26 – 92

FIG. 4 – SHOWING MORPHOMETRY PARAMETERS OF *MACROBRACHIUM SPP.*

Fig. 4.1 – Eye stalk

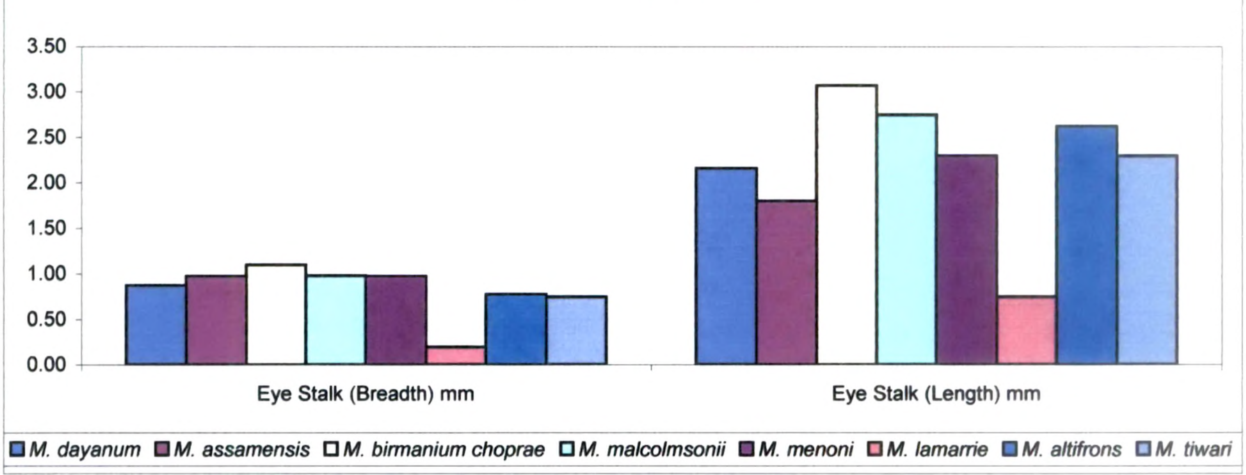


Fig. 4.2 – Fecundity

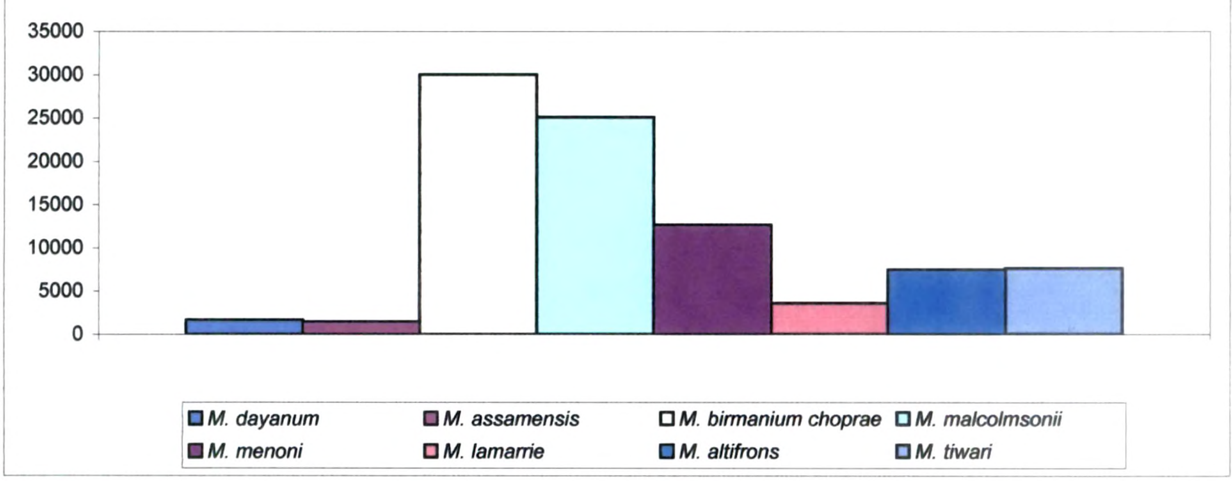
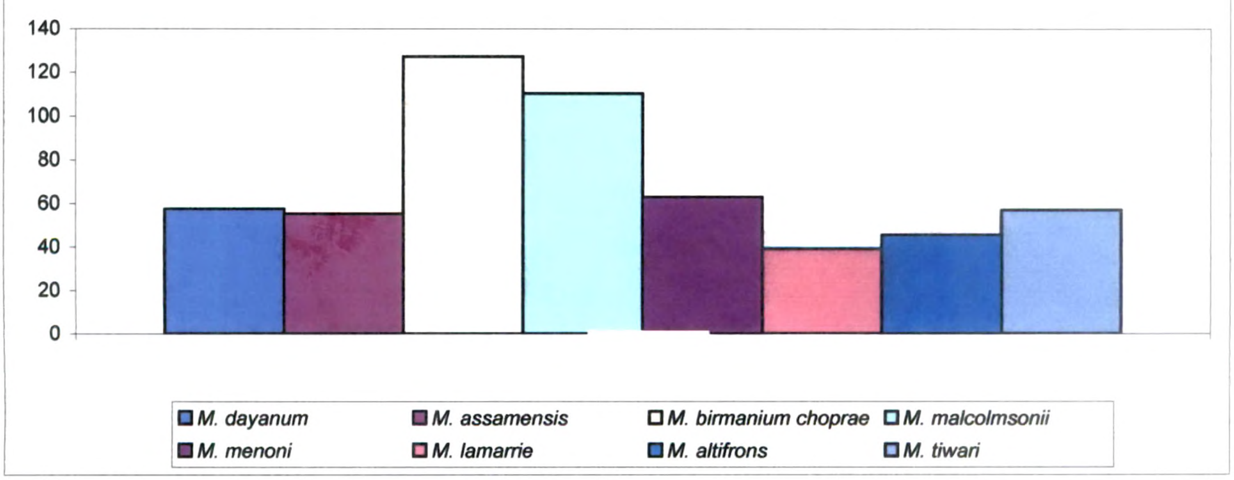


Fig. 4.3 – Body size



mm (*M. dayanum*), 31 – 76.2 mm (*M. assamensis*), 17 – 65 mm (*M. lamarrie*), 43 – 47 mm (*M. altifrons*) and 30 – 58 mm (*M. tiwari*).

Joychandran & Joseph (1990) and Sinha (1996) found the lowest minimum body size 5mm and maximum 80mm in *M. lamarrie*. The other above mentioned authors never critically studied the total body length in other species. In the present investigations, the following ranges of body sizes obtained in the various collected species of the fresh water – *Macrobrachium* of Assam viz. 68 – 180mm (*M. birmanicum choprae*), 48 – 162 mm (*M. malcolmsonii*), 32 – 95 mm (*M. menoni*), 25 – 93 mm (*M. dayanum*), 30 – 78.6 mm (*M. assamensis*), 20 – 55 mm (*M. lamarrei*), 41 – 48 mm (*M. altifrons*) and 54 – 60 mm (*M. tiwari*).

Out of all the above mentioned species the smallest size was recorded in *M. lamarrei* by Sinha *et al.* (1996) and the biggest size is *M. malcolmsonii* by Joychandran and Joseph (1990). In the present investigation almost in support of Sinha's observation, the smallest body size was also recorded in *M. lamarrei* among all the collected freshwater water species of *Macrobrachium*. But it was in disagreement with the previous author that largest body size was only recorded in *M. birmanicum choprae* instead of *M. malcolmsonii*. It has been reported that mean size of prawn increases substantially at reduced stocking density. But the total yield in such cases is reduced to un-economic level (Smith *et al.* 1978 and Brody *et al.* 1980) (Table-1).

Sex Ratio: - Malecha *et al.* (1981) and Varghese *et al.* (1990) found the best sex ratio as 4– 5 female per male for the production of barried giant prawn and 7 female with a male by a smallest sized Caridean species (Balasundaram, *et al,* 1982). But in the present work, the different sex ratio was observed in various species in natural condition - as 2 to 3 (♂) to 1(♀) in *M. birmanicum choprae*, 3 to 4 (♂) : 1 (♀) in *M. malcolmsoni,* 2 to 3 (♂) : 1 (♀) in *M. menoni*); 4 to 6 (♂) to 1 (♀) in case of *M. dayanum* and *M. assamensis*, 8 - 10 (♂) to 1 (♀) in *M. lemarrie*; 2 to 3 (♂) : 1 (♀) in *M. altifrons* and *M. tiwari*. Significantly the best sex ratio was recorded only in of *M. birmanicum choprae, M. malcolmsonii, M. menoni, M. altifrons* and *M. tiwari*. It was in disagreement with the previous authors in case of *Marcobachium* of Assam, naturally the number of male is more than that of female which is reversed in case of observation made by other authors in different places. In support of the previous observation by Sagi and his co-worker (1986) the present work also reported that the performance of female prawns are strongly influenced by the presence of males resulting in growth inhibition, suggestive of evolving a mono sex for farming system. Balasundaran (1982) reported the sex ratio as 7(♂) : 1 (♀) in certain freshwater prawn as highest number of abnormal sex ratio value. In support of his observation it was observed that rerversed abnormal sex ratio value as 6 to 7 (♂) : 1 (♀) in *M. lamarrie*. This was a significant observation of our present work.

Body Colouration :

Taxonomically the Assam's prawns are very significant in their body colouration due to the presence of the different types of colour pigments in different parts of the body. These types of observations were never found among the members of Indian prawns found in different part of India. Regarding body colouration very limited information are available. Fujimora and Okamoto (1972) and Fujimora (1974) observed the colouration as blue in the claw portion of the body. But he never clearly described the colouration of the body. But in the present investigation it was found that taxonomically body colouration among the various collected species of *Macrobrachium* are different because all the collected *Macrobrachium* species from Assam show their own identity due to the possession of a particular body colour during the different stages of growth. In both *M. dayanum* and *M. assamensis*, it was observed that in young condition light greenish colour is more towards dorsal part of the body. Adult shows light to dark ash colour. In adult, the body shows heavy deposition of green, pink to light black coloured pigments. In *M. birmanicum choprae* – in young condition where body is white. In adult red coloured pigments are found. *M. malcolmsonii* – in young white colour but in adult due to pigmentation turn to grey, *M. menoni* – body without pigment. Very few light yellow pigments are found towards rostrum. *M. lamarrei* – Body colour white and transluscent. *M. altifrons* – body colour white but very light yellowish coloured pigments found in carapace and *M. tiwari* – Body colour is mainly white, pigmentation found on the base of carapace. Individually from *M. menoni* to *M. tiwari*, the body colouration is almost same throughout the various stages of growth.

Rostrum : Rajyalakshmi (1974) described about the rostrum of various prawns but failed to give a clear picture about it. Kotpal (1975) and Kurian & Sebastian (1993) studied the morphology of rostrum of a typical prawn. In the present investigation, the rostrum of the various collected species of *Macrobrachium* is found to be one of the most important species recognition characteristic because simply by observing the structural configuration of rostrum any body can be able to know the name of the species. Joychandran & Joseph (1990) superficially characterized the morphological structure of rostrum of *M. birmanicum choprae*. Some authors observed the rostrum taxonomically as – rostrum shorter than carapace, proximally 2/3 rd of upper edges of rostrum forms a highly convex keel bearing 8 – 10 teeth. (Kalita & Bhagwati, 2002); 1 to 3 small subdistal and 2 post orbital teeth in the upper margin of rostrum. (Joychandran & Joseph, 1990) and upturned rostral tip (Dutta, 2001), rostrum short, not reaching upto distal end of antennal scale but conspicuous dorsal crest on the basal two third of the upper edge of rostrum (De, 2002). These authors actually did not try to give a detail morphology of rostrum of this giant fresh water *Macrobrachium*. Rostral size is proportionate to its body length. It is strong and compact. The rostrum immediately after origin from the base of carapace showed greater elevation with the lesser concavity thereafter and finally inclined towards apex. Dorsally almost all spines are present in the convex part which are equidistant from each other. But ventrally all spines in the rostrum are almost equidistant from each other from base to apex. Ventrally the rostrum showed lesser convexity but without concavity after. In *M. malcolmsonii*, Sinha *et al*., (1996), Kalita & Bhagwati (2002) and Dutta (2001) found slightly upturned rostral tip. Sinha and his co-worker (1996) further reported that dorsally the rostrum bears more than 9 teeth. Joychandran & Joseph (1990) showed only 1 tooth in the distal half of upper margin of rostrum. According to De (2002) and Kanaujia (1999) the rostrum of *M. malcolmsonii* is straight, shorter than carapace and distally without teeth. Almost in conformity with the observation of Sinha (1996), Dutta (2001) and Kalita & Bhagwati (2002) and in almost disagreement with De (2002) and Kanaujia (1999) regarding the position of certain rostral spine it was carefully observed that - dorsally major parts of the rostrum are serrated and high convexity observed approximately at the middle of the rostrum. After convexity the rostrum shows inclination immediately after 5^{th} spine and half part of rostrum towards the proximal region are slightly upturned. Gaps shown by 1^{st} & 2^{nd} and 8^{th} & 9^{th} spines of the rostrum in between. Ventrally from the base of its origin, the rostrum shows slight convexity followed by caocavity and finally turned the convexed region of the rostrum immediately from the base origin, provded with some hair like out growth. Dorso-ventrally the rostrum shows strong and stout spines but they are not equidistant from each other.

Very limited information about the taxonomy of *M. menoni* were collected may be due to the endangered nature. Dutta (2001) described the rostrum as slightly inclined towards apex. According to present investigations the rostrum of *M. menoni* played the following characters – upper margin of the rostrum with convexity just behind the eye, concavity infront of the eyes; slightly inclined and lowered further. Ventrally the half part of the rostrum is almost straight and finally inclined. Dorsally the whole part of the rostrum starting from base beared thickly arranged spine upto tip and they are equidistant from each other and it is a significant character unlike that of other species. Ventrally half part of the rostrum from the base carried spines without having any space in between but the rest part upto apex is without spine. According to Dutta (2001) in *M. dayanum* the spines are not equidistant from each other in the dorsal side and ventrally a few teeth are equidistant from each other. But Kalita & Bhagwati (2002) reported the rostrum as small stout structure and it is slightly upturned. The present observation are in agreement with the observation of rostrum as described by Dutta (2001). But was in almost disagreement with the observation of Kalita & Bhagwati (2002) because the rostrum of this species shows well developed structure but it was not found as small stout straight structure. The present observations on rostrum are clearly discussed as – dorsally in the rostrum all spines are not equidistant from each other but ventrally, specially the second, third fourth and fifth are equidistant. Moreover, dorsally the rostrum shows slight convexity from the base. The concavity starts just immediately after 3rd spine and finally upturned towards apex. Ventrally the spines develop from the concavity apart. Dutta (2001) observed wide gap between 1st & 2nd, 2nd & 3rd and 3rd & 4th teeth on the dorsal edge of rostrum in *M. assamensis*. But the present investigation noticed that dorsally all the spines in the rostrum are equilistant from each other. Immediately after origin, from the base of carapace, the rostrum shows slight convexity and finally slightly horrizental at the tip. Towards the vetntral side convexity starts approximataley from the base of eye stalk followed by concativity and finally almost horizontal. Ventrally the rostral teeth, though few in number are not equidistant from each other. Present observation also further supported the observation of De (2002) that rostrum is broadly triangular in profile or upper edge is horizontal. Rostrum of *M. lamarrie* was long narrow sword shaped, sharper and slightly upturned distally as observed by Sinha *et al.*,(1996) and Kalita & Bhagawati (2002) which was also supported by present investigation. Dutta (2001) observed the presence of teeth on the dorsal edge throughout the rostrum. Almost in support of his observation the present work which found that the rostral length is greater than / equal the antennal scale; teeth on the dorsal edge present throughout the rostrum and rostrum shows convexity towards base followed by concavity and finally inclined at the tip. The present observation was almost in disagreement with De's (2002) observation because he found rostrum is equal or slightly larger then antennal scale and rostrum is more or less staright.

Present investigation shows *M. altifrons* and *M.tiwari* both are the less abundant species. The information collected about these species was found to be scanty. Dutta (2001) found the rostrum of *M. altifrons* species with horizontal to slightly upturned tip. The present work found almost straight shaped rostrum from base to apex; presence of spines in the rostrum both dorsally and ventrally from base to apex is a new observation in the present work. In *M. tiwari*, Dutta (2001) simply described the presence of teeth on the rostrum and a few on carapace. He never clearly discussed about the structural configuration of rostrum. Almost in support of his observation, the present investigations presented more information about it as unequal sized and irregularly arranged teeth both dorsally and vetrally, gradually inclined tip and almost straight rostarl edge ventrally from base to apex.

Rostral Formula: Various authors found rostral formula of *M. birmanicum* choprae as follows – $^{11\text{-}12}/_{4\text{-}5}$ (Dutta 2001), $^{9\text{-}14}/_{4\text{-}6}$ (De, 2002), $^{9\text{-}13}/_{6\text{-}7}$ (Sinha *et al.* 1996). The present observation was in agreement with that of Dutta (2001) observation and totally in disagreement with that of De (2002) and Sinha *at al.*,(1996). Kalita & Bhagawati (2002) simply described the presence of teeth on the upper edge of rostrum as $^{8\text{-}11}$ but they never mentioned about the number of spines on the lower edge. Joychandran & Joseph (1990) observed

1-3 small distal and 2 post orbital teeth in the upper margin of rostrum in this species. Regarding rostral formula of *M.malcolmsonii* also very limited information are available. $^{8-11}/_{4-7}$ Dutta (2001), $^{7-11}/_{4-7-}$ (De-2002), $^{4-12}/_{7-17}$ (Sinha *et al.* 1996) and $^{7-11}/_{4-7}$ as reported by Kalita & Bhagawati (2002). The present observation in support of Dutta 2001 and almost in support of De (2002) and Kalita & Bhagawati (2002) and totally disagree with Sinha *at al.* (1996). Similarly in case of *M.menani* also very limited information is found, Dutta (2001) reported rostral formula as $^{15-16}/_{7-8}$. The present investigation is in agreement with Dutta (2001). Information regarding *M. dayanum* is available to some extent. Dutta (2001) found rostral formula as $^{7-11}/_{5-9}$ but De (2002) reported as $^{8-9}/_{5-6}$. Kalita & Bhagawati (2002) mention as $^{7-11}/_{4-7}$. The present investigation is totally in agreement with Dutta (2001) but in disagreement with De (2002). Again the present investigation is in support of Kalita & Bhagawati (2002) referred rostral formula $^{8-10}/_{2-5}$. The present observation is almost in agreement with Dutta (2001) and partially in agreement with De(2002) and Kalita & Bhagawati (2002). Some references are available in case of M. lamarrie. Sinha *et al.* (1996) reported the rostral formula as $^{9-13}/_{6-7}$ and Kalita & Bhagawati (2002) reported rostral formula as $^{7-9}/_{8-9}$ and Dutta (2001) recorded rostral formula as $^{7-11}/_{4-8}$. The present findings show similarity with Dutta (2001) and fail to agree with the findings of Sinha *at al.* (1996) and Kalita & Bhagawati (2002). Regarding *M. altifrons* also and *M. tiwari* very limited information are available. Only Dutta (2001) contributed some amount of information about these two species as $^{10-12}/_{3}$ and $^{5-7}/_{2-5}$ respectively. The present works support the findigs of Dutta (2001).

Carapace: Rajyalakshmi 1974 & 1980, Sreekumar 1987, Philips & Subramanium 1990 and Joychandran & Joseph (1990) did not try to give a detail study about the carapace of *M. birmanicum choprae.* Only gave a proportionate study on carapace length to total body length. Kalita & Bhagawati (2002) found rostrum shorter than carapace. But observation found that rostrum $\leq$ carapace. According to Dutta (2001) the carapace of *M. birmanicum choprae* is small in young one, rough in adult and slightly pigmented. The present findings are almost in agreement with Dutta's observation that both young and adult one followed the above mentioned characteristics but young ones devoid of pigmentation. Presence of 3 pairs of distinct jointed spines antero laterally one pair at the base of antenna, next pair located afterwards and verythin delicate carapace posterior-laterally are the new observation in the present investigation. Nobody tried to study the structural configuration of *M. malcolmsonii.* Only Joychandran & Joseph (1990) simply observed smooth carapace in the body of this species and De (2002) reported that carapace > rostrum. The present work supported their observation. The above authors never tried to give an ellaborate description about it. Chitinous, hard and highly transluscent to transpareant carapace with calcium, scanty pigmentation and two pairs of strong pointed spines antero – laterally on either side are the newly observed characters in the present works.

It was never found any more references about carapace of *M. menoni*. In this context only Dutta (2001) mentioned that carapace is slightly pigmented. Almost in disagreement with Dutta's (2001) observation it was found that the presence of smooth, transparent and delicate carapace. In Assam the lion share in the field of taxonomy occupied by *M.dayanum*. Information about *M. dayanum* was found scanty. Kalita & Bhagawati (2002) mentioned 2-3 rostral teeth on carapace as only taxonomic characters and Dutta (2001) found highly pigmented carapace and De (2002), never mentioned any carapace characters. Present investigation is totally in disagreement with the observation of the previous authors because of the presence of highly pigmented with frequent changes of colour of carapace and also one pair of small pointed spine antero-laterally. Like that of *M. dayanum*, very limited information about carapace of *M. assamensis* were collected. Kalita & Bhagawati (2002) simply mentioned the presence of 3 rostral teeth on carapace without further study Dutta (2001) gave hint only about highly pigmented carapace without any further detail. But De (2002) never mentioned a single character about carapace. The information about *M. assamensis* was found very limited, may be because of less abundant nature of the species. Almost in agreement with the previous observation, it was found as smooth as carapace in young condition, rough in adult with freequent change of colour and one pair of small pointed spine antero-laterally towards the base of antenna. Though very few authours described taxonomy of *M. lamarrie* but never mentioned about carapace, except Dutta (2001). Dutta (2001) simply reported that the carapace is slightly pigmented but he never tried to give a detail about it. Almost in agreement with Dutta's (2001) investigation the present work found that carapace is very smooth and majority of this specis beared with coloured structure but only a small number containing very little pigment. Taxonomically the information about *M. altifrons* was very limited. Only Dutta (2001) identified the species as less abundant from Assam and decribing the presence of 3-4 but erect rostral teeth on carapace without any detaied study. The present findings critically described the carapace as smooth, transluscent and little bit hard with single pairs of indistinct, less developed spine antero – laterally. The information about *M.tiwari* was found scanty. It was the most less abundant species even from Assam during careful collection. Like Dutta (2001), one would be able to collect only very few number of this species from this state. According to him the carapace of this species is slightly pigmented bearing 3 rostral teeth. Almost in disagreement with the view of Dutta (2001), the present investigation found very smooth transparent and delicate carapace bearing only 2 small minute, delicate spines antero-laterally.

Eye stalk: Eye stalk is one of the most important identifying characters of prawns because of large distinct externally located compound eye with long eye stalk in comparism to body size. The information about this organ of prawn in the field of taxonomy was found almost nil. Only Kotpal (1975) and Kurian & Sebastian (1993) describe about some characters of it of a typical prawn viz. the compound eye is covered by a transparent cuticle and it is located in a hallow depression in precoxa of antennule. In support of their observation the present reports indicated that *M. birmanicum choprae*, *M. malcolmsonii*, *M. menoni* and *M. lamarrie* beared long narrow spherical eye stalk with deep black coloured large sized eye and M. dayanum, *M. assameniis M. altifroms* and *M.tiwari* beared short, stout almost spherical eye stalk with smaller sized light black coloured eye in comparism to body size (Table-1)

Antennule: Like wise the information about the external sensory structure of prawns was also found very less Kotpal (1973) and Kurrian & Sebastian (1993) found the origin of eye from the hollow depression of antennule and brought flat scale like expodite and very long endopodite in antenna. Kanaujia (2002) found biramous antennules shorter than antenna. In support of the above observation investigation critically found some similarities and dis-similarities in the characters of antennules among the members of the collected species of *Macrobrachium* of Assam. Pre coxa > coxa is the only similar characteristics shown by all the collected 8 species of *Macrobrachium* of Assam. Pre-coxa > coxa $\overline{<}$ basis – shown by *M. birmanicum choprae*, *M. menomi*, *M.dayanum and M. altifrons.* Pre coxa > Coxa < basis – shown by *M. lamarrie* and *M. assamensis*; but *M. malcolmsonii* and *M. tiwari* showed their own identity in antennule formation as pre coxa > coxa $\overline{>}$ basis and pre coxa > coxa = basis sequentially. All segments in the antennule of *M.*

birmanicum choprae, M. malcolmsonii, M. menoni and *M. attifrons* are more or less hairy. *M. dayanum* showed hair like structure in coxa and basis laterally. But *M. assamensis* showed sparsely few hair like structure on precoxa and coxa. *M. lamarrie* bears fine hair like structure only in coxa but M. tiwari showed devoid of such hair like structure in all the segments but with an indistinct spine in pre-coxa (Table-2)

Antenna: The antenna is an another important sensory structure of prawn and very limited investigator studied about it. According to Kurian & Sebastian (1993) the presence of broad flat scale like exopodite and very long endopodite in antenna of certain Penaeus also show similar identity as shown by all the collected species of *Macrobrachium.* Also in agreement with Kanaujia (2002) regarding the structure that antenna is longer then antennule with a thin plate like exopodite. Presence of very elongated, highly developed pigmented endopodite with muscular feeler plus distinct spines of endopodite, centrally located white coloured elongated sword shaped thicker plate of exopodite in antenna (*M. birmacum choprae*); well developed feeler in endopodite, uniform distribution of setae with a sword like ridge in exopodite (*M. malcolmsonii*); non muscular feeler of endopdite and thin transparent exopodite bearing less developed setae towards periphery *(M.menoni)*; leaf like exopodite with uniform distribution of setae and highly muscular feeler of endopodite (*M. dayanum* & *M. assamensis*); less developed feeler of endopodite and thin slightly transluscent endopodite without uniform distribution of peripherial setae (*M. altifrons*) and non pigmented exopodite without uniform distrubtion of peripherial setae (*M. tiwari*) are the new observation in the present investigation. But in *M. lamarrie*, the antenna is very delicate with indistinct exopodite and endopodite. The characteristic feature of the segment i.e. Coxa < basis was exhibited by *M. birmanicum choprae, M. malcolmsonii, M. dayanum, M. assamensis* and *M. altifrons* and the characteristic feature of the segment i.e. coxa $\overline{<}$ basis was played by *M. menoni, M. lamarrie* & *M. tiwari* (Table-2)

1^{st} and 2^{nd} Pareopod: Kotpal (1975) and Kurian & Sebastian (1993) described the detail morphology of Chelate legs of a typical prawn. Joychandran & Joseph (1990) mentioned chelate legs of *M. birmanicum choprae* simply as morphological structure. Sinha *et al.* (1996) and Kalita & Bhagawati (2002) found fully developed male bearing very long stout second chilliped even longer than the whole body. They never mentioned about the taxonomy of 1^{st} Pareopod. De (2002) also reported only the 2^{nd} chiliped in adult males as very long stout with longer chela than carpus, longer merus than propodus and propodus > dactylus.

But Dutta (2001) studied both First (Carpus> Chela) and second (merrus = Carpus > Propodus) pareopod. According to Dutta (2001) in the first pareopod, the carpus > chela and in the second pareopod the merus = carpus > propodus. Except Dutta (2001), other authors never tried to give a detail morphology of all segments of 1^{st} and 2^{nd} pareopod of M. birmanicum choprae. Almost in support of the observation of the above authors the present work presented about 1^{st} pareopod as highly muscular coxa and basis with rough surface, elongated merrus, rod like and laterally compressed carpus and hairy dactylus. Various segments of the first pareopod showed coxa = basis, ischium < merus, carpus < propodus > dactylus ; and 2^{nd} pareopod developed highly musculular walking legs with a pair of strong pointed chela; many wart like projection making the surface rough in all segments, strong elongated cylindrical and laterally compressed ischium, merus and carpus. Coxa > basis, ischium < merus, carpus > propodus > dactylus.

According to Sinha *et al.* (1996) and Kalita & Bhagawati (2002), the second stout chiliped in male M. malcolmsonii is much longer than the body. But they did not give a detail structural description about it Dutta (2001) also did try to give a thorough thought about the taxonomy of First & Second pareopod. He simply mentioned as – First Pareopod : Ischium < Chela and Second Pareopod: Ischium < merus, merus > carpus, dactylus> merus. De (2002) simply reported that merus is always shorter then palm. These characteristic of legs were also supported by the present observation. De (2002) never mentioned about the name of the chelate legs and did not give a thorough study about the legs. According to Kanaujia (2002), carpus of 2^{nd} pareopod > merus and Finger > palm and carpus but without giving a description about the 1^{st} parepod. Presence of rough surface with sparsely distributed hairs in all segments of 1^{st} pareopod; coxa $\leqslant$ basis, ischium =

merus, carpus < propodus > dactylus and presence of rod like coxa, basis, ischium, merus, carpus and propodus with laterally compressed merus and carpus and coxa = basis, ischium ⩽ merus, carpus > propodus > dactylus of the 2^{nd} parepod are the new contribution to the prawn taxonomy.

The information about the taxonomy of 1^{st} & 2^{nd} pareopod of *M. menoni* was very poor. Dutta (2001) reported 1^{st} Pareopod: ischium = chela, 2^{nd} pareopod: merus < carpus, carpus twice the length of palm. In agreement with the above observation, the present findings satisfied the taxonomy of both the chelate legs of the species is this way – 1^{st} Pareopod: all rough segments except coxa and basis are almost cylindrical and laterally compressed and their joints with bunches of hair like structure. Coxa = basis, ischium < merus, carpus < propodus > dactylus. 2^{nd} pareopod: muscular wart like projection in all segments with rough surface. Laterelly compressed merus and carpus. Coxa ⋜ basis, ischium < merus, carpus > propodus > dactylus.

The information about the taxonomy of 1^{st} and 2^{nd} pareopod of *M. lamarrie* was almost scanty. Joychandran & Joseph (1990) and Kalita & Bhagawati (2002) gave only a superficial touch about taxonomy of this species. But they never mentioned about this organ. Dutta (2001) considered the chelate legs as one of the most important species recognition character. According to him, 1^{st} pareopod showed – carpus = merus, finger = palm and 2^{nd} pareopod showed – merus > carpus, ischium rod like with inwardly curved immobile finger plus five minute teeth in mobile finger which are almost equidistant from each other. De (2002) mentioned only about 2^{nd} cheliped as a slender structure and chela < carpus by showing equal and little more than $1/3^{rd}$. body length. Almost in agreement with the observation of these two authors, the present report carefully further added that both 1^{st} & 2^{nd} less developed non muscular pareopod showed slender, rod like and slightly laterally compressed ischium, delicate chela and slightly blunt to inwardly curved immobile finger and 3-5 minute teeth instead of 5 on mobile finger.

1^{st} Pareopod is as : coxa $\geqslant$ basis, ischium > merus, carpus < propodus $\geqslant$ dactylus. 2^{nd} pareopod: coxa > basis, ischium = merus, carpus > propodus < dectylus.

The 1^{st} & 2^{nd} pareopod in both *M. dayanum* and *M. assemensis* showed similar structural configuration. The information about this structure are very limited. According to Kalita & Bhagawati (2002) – carpus > chela < palm, chela > carpus and finger > palm (finger = palm) in 2^{nd} pareopod of *M. assamensis*. Here simply mentioned only the 2^{nd} chiliped as stout long in mature male in *M. dayanum* (stout, muscular and long 2^{nd} cheliped in male both in *M. dayanum* and *M. assamensis*). Kalita (2002) further studied about *M. assamensis* but he never mentioned about this important structure. Dutta (2001) found ischium, merus, palm and finger of 1^{st} pareopod are hairy. But investigation found ischium and fingers are provided with tuft of setae and sparse distribution of hairs on the rest of the leg in *M. dayanum*. According to him ischium and palm of 2nd pareopod rod like. But present investigation found in this species ischium, merus and carpus are rod like and laterally compressed. Further, according to Dutta (2001) both these two pareopods in this species contained – 1st pareopod: merus = ischium (coxa = basis, ischium $\leqslant$ merus, carpus < propodus > dactylus) and 2nd pareopod: palm > finger, carpus = merus (coxa < basis, ischium = merus, carpus $\leqslant$ propodus > dactylus). In *M. assemesis*, according to Dutta (2001) 1st pareopod: showed carpus $\geqslant$ chela > merus (coxa $\leqslant$ basis, ischium = merus, carpus < propodus $\geqslant$ dectylus) and 2nd pareopod: merrus $\geqslant$ carpus (coxa < basis, ischium = merus, carpus $\leqslant$ propodus = dactylus). De (2002) described 2nd pareopod of *M. dayanum* as chela > carpus with slightly compressed palm laterally which was also supported by present observation. He never gave further thought about the characterstics of both pareopods. De (2002) studied only the 2nd chiliped of *M. assemensis* and found longitudinally grooved finger, palm $\geqslant$ carpus. Present work supported his observation. He neglected to describe the 1st chelate leg taxonomically. Presence of non muscular 1st pareopod, rough surfaces except coxa and basis and minute wart like projection in dactylus of 1st pareopod and highly muscular 2nd pareopod having laterally compressed cylindrical ischium, merus and carpus with uniform distribution of red pigments in all segments of *M. assamensis* are the new contributions to the present investigations.

Both *M. allifrons* and *M. tiwari* were found very few in number during very careful collection from the different districts of Assam. The information aboth both these species are very scanty may be due to less abundant nature Dutta (2001) during his survey found very less number of these two species but not from all district of Assam. He also gave a careful description about both 1st and 2nd pareopods. But still have certain disagreements with his view. According to Dutta (2001), in 1st pareopod of *M. altifrons*, dactylus $<$ carpus but obervation found dectylus = carpus. Hairy ischium, merus, propodus and dactylus of 1st pareopods are found by the above authors. But in the present work found cylindrical segments with loose joints plus wart like projection thinly in carpus, propodus and dactylus. Likewise in the 2nd chiliped of this species certain disagreements with Dutta's (2001) observation were noticed. He found 2-3 blunt teeth with 6 tubercules on immobile fingers and 3-4 unequal teeth with 4 tubercles in mobile fingers. But carefull investigation noticed 2-3 blunt teeth with 4-6 tubercules on immobile and irregularly arranged 3-4 unequal teeth with 4-5 tubercules in mobile fingers. He only mentioned propodus $\geq$ dactylus and palm broader than carpus. But the present findings were in this way – coxa $\geq$ basis ischium = merus, carpus $<$ propodus $>$ dactylus. Presence of weak chela with few irregularly arranged minute spinelike projections and few minute spiny cylindrical and laterally compressed segments except ischium in the less muscular 2nd pereopod are the new observation in the present work. Investigation supported the observation of Dutta (2001) regarding 1st pareopod of *M. tiwari* : carpus $\geqslant$ merus (coxa $\geqslant$ basis, ischium = merus, carepus > propodus > dactylus). But he never showed the relationship among other segments of this leg; present findings totally in disagreement with the view of above authors regarding the 2nd pereopod. According to him carpus > merus $\geqslant$ischium, propodus > dactylus. Present findings showed coxa $\leqslant$ basis, ischium = merus, carpus < propodus $\geqslant$ dactylus. Laterally compressed cylindrical ischium and carpus; very minute delicate thinly arranged hair like structure at the base of coxa, basis and ischium with smooth surface in the 1st pareopod and almost straight and cylindrical segments having slightly rough surface plus thinly arranged few wart like projection in chela in the 2nd non – muscular pereopod of *M. tiwari* are the new findings of the present research work (Table - 3 & 4)

Non – chelate leg : Although the five pairs of non chelate walking legs of the collected species of Macrobrachium during investigation show almost similar in structural configuration but interestingly some segments of this legs among the species bear certain morphological peculiarities. Kotpal (1975) and Kurian & Sebastian (1993) in their books described the detailed characteristics about the non chelate walking legs of a typical prawn. But Joychandran & Joseph (1990) simply mentioned these non – chelate legs as important taxonomic structure. Specieswise the authors, did not specifically mention about the morphological characteristic of any prawn. Dutta (2001) superficially studied the non chelate legs in the various species of *Macrobrachium* but he did not try to give even a little thought on this structure of *M. birmanicum choprae*. In support of the observation of Kotpal (1975) and Kurian & Sebastian (1993) the present work clearly described it as: wart like projection in all segments, laterally compressed carpus and propodus and coxa > basis, ischium < merus, carpus ½ of propodus > dactylus.

In the description of taxonomy of *M. malcolmsonii* by Sinha *et al.* (1996) and Kalita & Bhagawati (2002), the non chelate leg was not mentioned. Joychandran & Joseph (1990) found propodus < dactylus in the non chelate legs of the above mentioned species. But present findings show propodus > dactylus According to Dutta (2001) the dactylus and propodus are hairy in the non chelate legs. In disagreement with the view of the above authors, the present report found all hairy segments in the non chelate leg. 3 to 4 small conical teeth with minute spine in the mobile finger, 3 – 4 unequal sized conical teeth with few spine like processes in the immobile finger and coxa ≤ basis, ischium = merus, carpus ½ of propodus > dactylus are the new findings in the present investigation.

The information about the morphological feature of M. menoni is very less. May be due to less abundant nature of the species. Only Dutta (2001) found a very few numbers of this species from some districts of Assam. He never tried to study the taxonomy of non chelate legs. Presence of non muscular loosely arranged joints with smooth surface, laterally compressed segments and very few indistinct blunt tooth with few tentacles on the finger and coxa = basis, ischium < merus, carpus < propodus = dactylus are the new information of non chelate walking legs of the species.

Kalita & Bhagawati (2002) and De (2002) studied about 2nd chiliped but never studied about non chelate legs of *M. dayanum*. According to Dutta (2001), in non chelate leg all segments are hairy (except merus and carpus, all parts are hairy) and ischium > carpus (coxa = basis, ischium < merus, carpus < propodus > dactylus). He further reported that presence of 2 – 3 conical teeth having 7 – 8 minute spine in immobile (IM) finger (2 – 3 conical teeth with 7 – 9 minute spine) and 2 equal conical teeth having 5 minute spine like processes in mobile finger (IM) (3 equal sized conical teeth with 3 minute spine like processes)

The information about *M. assamensis* is very limited because of less abundant nature. Kalita & Bhagawati (2002), Kalita (2002) and De (2002) mentioned about the chelate legs but they never described the taxonomy of non chelate legs. According to Dutta (2001) in the non chelate legs all segments are hairy, 3 equal teeth on immobile finger (IMF) and 1 large and 2 small teeth on mobile finger (MF). In disagreement with the observation of Dutta (2001), the presence of curved, pointed dactylus, slightly rough surface leg and coxa = basis, ischius < merus, carpus < propodus > dactylus are the new observation characteristics.

Among all the collected species of *Macrobrachium* from Assam, the prodigality production of *M. lamerrie* was found very high. But the previous information about it was miraculously very negligible. Joychandran and Joseph (1990), Kalita & Bhagawati (2002) and Dutta (2001) very briefly mentioned some morphological character like rostrum, carapace and chelate legs but they never studied about the taxonomy of non chelate legs. The occurance of smooth surface of all the segments from coxa to dactylus and the leg formula viz. coxa < basis, ischium < merus, carpus < propodus > dactylus are the new observation of the present work.

But *M. altifrons* and *M. tiwari* are more less abundant species found even that of *M. assamensis*. The previous information about these two species were virtually found nil. Only Dutta (2001) collected very few number of species from some district of Assam. He never mentioned about the non chelate legs of *M. altifrons* during the description of taxonomical studies. According to him the taxonomy of non chelate legs of *M. tiwari* was 3^{rd}, 4^{th}, 5^{th} propodus $\geqslant$ merus. The present observation tried to give a thorough thought on the taxonomy of non chelate legs of both the above mentioned two species. Hairy dactylus, muscular coxa and basis, loosely arranged joints, almost straight and cylindrical segments with sparse distribution of few spines and coxa $\lesssim$ basis, ischium < merus, carpus $\lesssim$ propodus > dactylus in the non chelate leg of *M. altifrons* and loosely arranged very delicate segments, laterally compressed ischium and merus, cylindrical ischium, merus, carpus, and propodus with smooth surface, few minute, irregularly arranged spines like projections in the finger and coxa = basis, ischium < merus, carpus <

propodus > dactylus in the non chelate leg of *M. tiwari* are the new taxonomical studies (Table-5).

Physico-chemical Parameter :

Many authors reported their opinion regarding the relationships of the various physico-chemical parameters with the certain important species of the praw dissolved oxygen. Many giant fresh water prawn require their own requisite amount of dissolved oxygen from 2.0 – 7.6 mg/lt in different types of water bodies culturally for their batter survivality and juvenile growth. (Raman 1990, Durairaj *et al.* 1990, Biswas *et al.* 1990, Joseph *et al.* 1990, Sebastian *et al.* 1990, Unikrishnan *et al.* 1990, ICAR (CIFE) 1996, KSU Prawn Production Manual 2002, Rangacharyulu 2002). The above mentioned authors never mentioned the species wise relationship with the oxygen concentration in the water for better survivality. Only Boyd and Zimmermann (2004) mentioned that dissolved oxygen concentration below 1mg/lt for *M. rosenbergii* results exhaustion with serious physiological effects leading to suffocation. Reddy (2005) described that dissolved oxygen should be of not below 4 ppm for juvenile growth of both larvae and mature prawns. According to KSU Prawn Production Manual (2002), the adequate dissolved oxygen is necessary for survival and growth of prawns. Prawns become stressed below 2 ppm dissolved oxygen and usually die below 1 ppm. Almost in support of the above observation for the better suvivality of the various collected prawns, the present work found the following oxygen concentration in mg/lt (RI: 5.2 – 9.5, BL: 5.3 – 11.1 in *M. birmanicum choprae. M. malcolmsonii, M. menoni*; RI: 5.2 – 9.5, BL: 5.3 – 11.1, PN: 7.2 – 11.5; SW: 4.4 – 10.3, PF: 5.4 – 8.9 in *M. dayanum* and *M. assamensis*; RI: 5.2 – 9.5, BL: 5.3 – 11.1, SW: 5.8 – 10.3 in *M. lamarrie* and RI: 5.2 – 9.5, BL: 5.4 – 11.2 in *M. altifrons* and *M. tiwari*.

During the collection of various species of *Macrobrachium* from the different districts of Assam, it was critically noticed that the following related physico-chemical characteristics under which they survive. If the ponds water are not aerated, oxygen depleted water may accumodate near the pond bottom due to thermal stratification during summer. Prawn production is less in the deeper water because it receives less sunlight and may become cooler and deficient in dissolved oxygen. So much of the bottom habitat available to the prawn could become unsuitable due to the absence of dissolved oxygen. Prawn can tolerate temporary low dissolved oxygen conditions, however exposure should be avoided if possible. Full time aeration will reduce the risk of prawn loss and keep oxygen rich water circulating throughout the ponds. Since prawns are grown at lower stocking densities. The dissolved oxygen during decayed condition is less than 0.5 ppm. Dissolved oxygen below 2.5 ppm is causing distress to prawn (Raman, 1990). A sub surface platform made of bamboo strips and twigs fixed at about a foot below in the water surface is tried in the experiment with an idea of helping the prawn escape the oxygen depletion occurring mainly at the bottom. It appears to have served the purpose vary well. In fact, large number of prawns like *M. dayanum. M. assamensis, M. lararrie* are actually seen resting on the platform especially during the early morning hour when usually oxygen level go down at the bottom. Thus the prawns are able to enjoy the better oxygenated layer of water near that surface and escape the oxygen deficient bottom water. In addition the sub-surface platform provided additional source of food by way of attached algae and other biotic growth (Raman, 1990). During *Macrobrachium* culture, it is observed that, the rivers have better and larger periods of transperancy and steady dissolved oxygen level than that of the ponds (Raman, 1990). If a pond becomes stratified (layered), the bottom layer is typically lowest in oxygen. So aeration must be also, there. Though at the whole season, dissolved oxygen should be recorded in the morning and afternoon and P^H in the afternoon, and both should be graphed to better visualize their positive and negative trends. Dissolved oxygen should be checked at the low point before sunrise and high point late afternoon daily during prawn culture. (Table 7.1.1, 7.2.1 & 7.3.1)

Free Carbon Dioxide: According to Hattings *et al.* 1975 and Singh *et al.* 1985, the heavy mortality of prawn due to the increased concentration of free carbondioxide. In support of their observation the present work reported that the prawn collection specially *M. dayanum, M. assamensis* and *M. lamarrie* from standing water bodies containing heavy aquatic vegetation plus algal bloom was found of low percentage of return due to the increase carbon dioxide concentration upto 7.8 mg/L. Moreover in support of KSU Prawn Production Manual (2002) it was carefully observed that during sunlight the algal bloom consumes carbon dioxide through photosynthesis. Since carbon dioxide in water forms a weak acid and the water P^H tends to rise during the day after sunset the photosynthesis ceases P^H falls as the plants given out carbondioxide. According to Mahanty and Kanaujia (2002), high percentage of carbon dioxide show a nercotic effect on prawns. In support of their observation, red inflammation in the in the body of many *M. dayanum* during collection from standing water bodies was seen. But present findings never found this type of squamasal infection in the body of other collected species. Mahanty & Kanaujia (2002) further reported that, the prawn can survive in water upto 60 mg/lt of free carbondioxide. In disagreement with maximum limit of carbon dioxide concentration as 7.8 mg/lt. Above this value it was found that the population of *Macrobrachium* was found very negligible. But on the other hand these authors also showed that if consentration less than 10 mg/lt of free carbondioxide, per prawn grow well provided dissolved oxygen level are at saturation. In support of their observation present work collection healthy juvenile prawns like *M. birmanicum chopra, M. malcolmsonii, M. dayanum* from the water where carbon dioxide concentration was found less as 3.2 -7.1 mg/lt. Kanaujia & Mahanty (1999) further found that water supporting good prawn population normally contains less than 5mg/lt of free carbon dioxide. Present work also supported their views. (Table 7.1.1, 7.2.1 & 7.3.1)

Total Alkalinity: The better survavility for frewsh water prawn is shown by normal range of alkalinity as 90 – 100 mg/lt (Moeyle, 1960), 114 – 154 mg/lt (Durairaj and his co-worker, 1990), 51 – 96 mg/lt (Sebastian *et al.* 1990), 50 – 100 mg/lt (Reddy 2005) and 80 – 150 mg/lt (Mahanty & Kanaujia, 2002) Almost in agreement with the observation of the above mentioned authors, for the better survavility and juvenile growth of the various collected prawns, the present work indicates the total alkalinity range was 32.3 – 94.5 mg/lt in *M. birmanicum choprae, M. malcolmsonii* and *M. menoni*, 42.5 – 110.9 mg/lt in *M. dayanum* and *M. assmensis*, 34.1 – 96.8 mg/lt in *M. lamarrie* and 38.2 – 98.9 mg/lt in *M. attifrons* and *M. tiwari*, for normal growth, the lowest alkalinity value was recorded in giant fresh water prawns like *M. birmancium choprae, M. malcolsonii* etc. In support of the observation of Ahmed & Varghese (1990) it was also critically noticed that high alkalinity in the water causes the death and decay of plankton blooms by showing higher BOD. Higher alkalinity value helped to utilize calcium carbonate from water by prawns for development of exo-skeleton. During investigation, it was found that gradual increase of alkalinity concentration is due to the large number of fallen leaves which form a sort of mat in the water bottom and sometime even discoluring the water where the availability of mostly *M. dayanum* and *M. assamensis* was found. (Table 7.1.1, 7.2.1 & 7.3.1)

Hardness: For the better survavility of some fresh water prawns, the hardness must be ranged from 40 – 150 mg/lt (Sebastian *et al.* 1990) and 10 – 75 mg/lt (Boyd & Zimmerman, 2004). In almost support of the above observation, the following collected prawns maintained their normal growth and good health naturally by obtaining the hardness as 18.2 – 135.1 (*M. birmanisum choprae, M. malcolmsonii* and *M. menoni*) 17.9 – 133.2 mg/lt (*M. dayanum and M. assamnesis*); 27.5 – 136.4 mg/lt (*M. lamarrie*) and 18.3 – 134.8 (*M. altifrons* and *M. tiwari*). It was also confirmly found that the total hardness influence the occurance of prawns enhaencing phytoplankton for better production after liming. Extreme hardness limits the occurrence of the species. (Table 7.1.1, 7.2.1 & 7.3.1)

P^{H}: Various types of prawns require their own requisite amount of P^{H}: below 10.5 (Aquacop 1979, Boyd 1979 and Mercy & Sankaranan 1990); 7.0 – 8.5 (Sebastian *et al.* 1990); above 7.0 (Joseph and co-worker 1990); 8.2 – 8.5 (Unikrishnan *et al.* 1990) and 7.5 – 8.5 (ICAR(CIFE), 1996). Almost in support of the above observation the present findings found the following P^{H} ranges – 5.8 – 10.2 in *M. birmanicum choprae, M. malcolmsonii* and *M. menoni*; 5.8 – 10.2 in *M. dayanum* and *M. assamensis*; 5.8 – 8.1 in *M. lamarrie* and 5.8 – 8.1 *M. altifons* and in *M. tiwari* under which they survive. Very few numbered of *M. dayanum* and *M. assamensis* were collected from the standing water bodies may be due to high pH range and heavy aquatic vegetation. Mercy & Sankaran (1990) and KSU Prawn Production Manual

(2002) found that prawn mortality can occur if pH level reaches above 10.0. Mulla & Rouse (1985) showed greater fluctuation in pH can cause low survival and poor growth to prawns. This was also supported by the present observation. According to Joseph *et al.* (1990) P^H value in the water above 7.0 maintain good health to prawn. In support of his observation collection was made from the different water bodies number of healthy prawn viz. *M. birmanicum choprae, M. malcolmsonii, M. menoni, M. dayanum, M. assamensis* and *M. lamarrie* where the pH value ranges from 5.8 – 8.0. (Table 7.1, 7.2 & 7.3).

Transperancy: A sort of mat in the pond bottom is produced by a large number of fallen leaves causing discolouration to water (Joseph *et al.* 1990). In support of the observations of the above authors, heavy turbidity are noticed in the pond and beels due to the large number of fallen leaves where from a few number of *M. dayanum, M. assamensis* and *M. lamarrie* were collected. During the rainy season the value of transperancy was not properly observed in the river due to the sudden fluctuation of water thickness where from maximum number of *M. birmanicum choprae, M. malcolmsonii* and *M. menoni* and few numbers of *M. dayanum* and *M. assamensis* were collected. The water quality management programme of ICAR found that the ideal level of transperancy for prawn culture is 20 – 30cm. But even practically the prawn culture is not yet been developed in Assam. The occurance of 36.1 – 78.2 cm in river, 35.2 – 56.4 cm in beel, 34.6 – 62.7 cm in pond, 32.8 – 60.1

in swamp and 24.7 – 44.2 cm in paddy field as turbidity values are the new observation to the present investigation. (Table 7.1, 7.2 & 7.3)

Temperature: The ideal level of temperature for various prawn water quality management programme are 21.5 – 31.2^{0}C (Rao, 1990), 18 – 34^{0}C (Sebastian *et al.* 1990), 25 – 28^{0}C (Tripathi, 1990), 29 – 30^{0}C (Unikrishnan *et al.* 1990), 26.5 – 29^{0}C (Durairaj *et al.* 1990), 25 – 29^{0}C (Biswas *et al.* 1990), 25 – 28^{0}C (Zylva, 1990) 60^{0}F (KSU Prawn Production Manual 2002) and 29 – 31^{0}C (Reddy, 2005). Almost in support of the above observation under natural condition following limits of temperature tolerance are observed as 22.8 – 33.1^{0}C in *M. birmanicum choprae, M. malcolmsonii and M. Menoni*; 22.8 – 33.1^{0}C in *M. dayanum* and *M. assamensis*; 22.8 – 33.1 in *M. lamarrie* and 22.8 – 33.1^{0}C in *M. altiprons and M. tiwari*. The value above 31^{0}C was the mortality rate to most of the collected prawns. According to Kalita (2002), the optimum temperature under field condition is 19^0 – 20.6^{0}C which is not agreable by the present observation. Because the above authors did not mention the name of the actual season. (Table 7.1, 7.2 & 7.3)

Conductivity: The bibliography about the total conductivity of water for the normal growth of prawns was not found rich. According to Mahanty & Kanaujia (2002) conducted the conductivity range and found between 100 – 500 umho/cm is suitable for prawn culture. But in various natural water bodies the conductivity ranges as i.e., 81.2 – 208 umho/cm in river, 95.3 – 213.8 umho/cm in beel; 53.8 – 192.5 umho/cm in pond; 61.5 – 178.5

umho/cm in swamp and 55.8 – 205.7 umho/cm in paddy field where from various species of *Macrobrachium* were collected. (Table 7.1, 7.2 & 7.3)

Nitrate, Phosphorous and **Chloride:** The presence of certain related important elements like Nitrate, Phosphorous, Chloride etc. in water are found important for the growth of many prawns. Certain elements directly affect the body of the prawn and some elements are beneficial for the juvenile growth of the prawns. According to Mahanty and Kanaujia (2002) and Mahanty (2002) Nitrate is highly toxic to prawn and affect the tissue and blood colour development. They did not mention the total concentration of nitrate present in the water. In support of their observation present investigation recorded very negligible percentage of nitrate viz. 0.02 – 0.42 in river 0.03 – 0.48 in beel, 0.05 – 0.62 in pond and 0.08 – 0.91 in swampy where from various species of *Macrobrachium* were collected.

Phosphorous regulate the productivity of prawns in the water. Small amount of phosphorous with silica are relatively associated with the life cycle of phytoplankton. According to Mahanty (2002) and Kanaujia & Mahanty (2002) the phosphorous concentration of 0.1 – 1 ppm is optimum for general growth of prawn as well as plankton. In support of the above observation, the present work reported that 0.22 – 0.38 ppm in river; 0.25 – 0.39 ppm in beel; 0.31 – 0.37 ppm in pond; 0.32 – 0.72 ppm in swamp and 0.36 – 1.78 ppm in paddy field are found suitable for the collected species of *Macrobrachium* from Assam.

Chloride is also one of the most important elements for the normal growth of prawn. But the information about the role of chloride for the normal growth of a prawn are found nil. According to present observation the following amount of chloride were recorded from various water bodies where from the species of prawn collected as – 12.2 – 23.8 mg/lt in river; 14.1 – 20.5 mg/lt in beels; 13.2 – 19.5 mg/lt in ponds and 13.2 – 20.3 mg/lt in swamp and 13.1 – 21.4 mg/lt in paddy field. (Table 7.1.1, 7.2.1 & 7.3.1)

Plankton: Plankton plays an important role in prawn fishery. Their survival depends entirely on the production of thick swams of phyto – zooplankton and time of stocking in the water bodies. However, development of thick algal blooms cause super saturation of dissolved oxygen in water, often resulting gas troubles in bottom dwellers crustaceans like some prawns etc. resulting large scale mortality according to Ahmed & Varghese (1990) the high mortality of *Macrobrachium* species due to the death and decaying of plankton blooms resulted in higher BOD. In support of their observations the present work also noticed the death of plankton blooms in some of the standing water bodies like beel, pond with aquatic vegetations suppresses the growth of some Macrobrachium species like *M. dayanum, M. assamensis* and *M. lamarrie.*

Phytoplankton: Many authors described about the role of many phytoplankton in the growth of prawns. According to Zylva (1990) during the growth of certain species of *Macrobrachium* like *M. rosenbergii*, the growth of many filamentous algae like *spirogyra*, chladophora etc. causes some variation in P^H. Almost in support of the above observation, the present findings found high range of P^H in the standing water bodies with and without many phytoplankton like *Spirogyra, Chladophlora, Anabaena, Arthrospira* etc. where from *M. dayanum* & *M. assamensis* were collected. According to Thangadurai (1990) many spp. of phytoplankton viz. Nitzchia, Sprirogyra, Oscillatoria and Navicula are the favourite food of *M. malcolmsonii*. Almost in support of the above observation present investigation found – *Spirogyra* spp., *Cosmarium* spp., *Oscillataria* spp., *Anabaeba* spp., *Alphamocapsa* spp., *Arthrospira* spp., *Microcystis, Nostoc* spp., *Chlorophycea* spp., as algae, *Fragilaria* spp., *Synendra* spp., *Navicula* spp., *Pinnularia* spp. As diatoms; *Closterium* spp., *Cosmarium* spp., *Staurastrum* spp., *Euastrum* spp. as desmids are the favourite food of *M. birmanicum choprae*, *M. malcolmsonii* and *M. menoni*. In the present context, the opccurance of *Spirogyra* spp., *Cosmarium* spp., *Oscillatoria* spp., *Edurina* spp., as algae; *Fragilaria* spp., *Synendra* spp., *Navicula* spp., *Pinnularia* spp. and Diatoms; *Cosmarium spp., Closterium spp., Euastrum spp., Staurastrum spp.* as Desmids (*M. dayanum and M. assamensis); Spirogyra spp., Cosmarium spp., Oscillatoria spp., Edurina spp., Anabana spp., Aphenocapsa spp., Arthrospira spp., Microcystis spp, Nostoc spp. As algae; Fragilaria spp., Synendra spp., Navicula spp., Pinnularia spp., as Diatom and cosmarium spp., closterium spp., Eustrum spp., staurastrum spp. as Desmids (M. lamarrie) and Sprogyra spp.,* *Oscillatoria spp., Edurina spp. Pinnlaria spp., as Diatom and Cosmarium spp., Closterium spp., as algrae, Euastrum spp.,* and *Staurastrum* spp. as Desmids (*M. altifrons* and *M. tiwari*) are the favourite food. According to Raman (1990) high rate of mortality due to poor oxygen level in the pond caused by affecting growth and algal coating appearing on the body of prawns like *M. lamarrie* are some of the main problems. In support of his observation, we critically noticed the low percentage of prawn fishing like *M. lamarie, M. dayanum* and *M. assamensis* and few *M. malcolmsonii* because of poor oxygen level in the water bodies due to algal mat and heavy aquatic vegetation. In agreement with the views of Ahmed & Varghese (1990) the present observation, observed that high mortality of *Macrobrachium* spp. like *M. lamarrie, M. tiwari* and *M. altifrons*, due to the death and decay of plankton blooms resulting in higher BOD. In support of the observation of Andril & Thompson (1975) and Munbodh (1979), a common problem encountered in the rapid proliperation of the filamentous alage – *Spirogyra spp.* in which some fresh water *Macrobrachium* like *M. assamensis, M. lamarrie* and sometimes even some *M. dayamum* gets entagled and die. In support of the observation or Raman (1990) the present work found that many prawns die in the standing water bidies because their gills are fully coated with algal blomms with oxygen depletion. The present work also critically noticed the rapid proliferation of filamentous algae like *Spirogyra spp.* causes heavy mortality to certain *Macrobrachium* spp. like *M. dayanum, M.*

assamensis, M. lamarrie and sometime *M. malcolmsonii* also during collection. Moreover certain algae like *Chladocera, Dunaliella, Gymnodium* etc. are the good food not only for the adult *Macrobrachium* spp. but also for their larva. (Kurian & Sebastian, 1993).

Zooplankton : Rotifers are the good food of many prawns. (Natarajan 1981, Joseph *et al.* 1990, Thangadurai 1990, Kurian & Sebastian 1993). It was also found that rotifers and *Brachinus* are the favourite food of *M. birmanicum* choprae, *M. malcolmsonii* and *M. menoni.* In support of the previous observation of Natarajan (1981), Raje & Joshi 1990, Alikunhi & Ali (1984). Joseph *et al.* (1990) and Kurian & Sebastian (1990). The present findings reported that certain chadocerans spp. like *Moina* spp. etc is one of the nutrititive and favourite food of many *Macrobrachium* spp. like *M. birmanicum choprae, M. menoni, M. lamarrie* and sometime *M. attifrons* and *M. tiwari*. Ibrahim, 1962 found that *M. malcolmsonii* prefers to live in water where there is availability of chladocerans. The present work also collected certain *Chladocerans* spp. like *Eurycerus* spp., *Bosmina* and *Moina* spp. in the big river Brahmaputra, River Kalong, River Dihing, River Disang, River Dikhoi etc. where there was the availability of *M. malcolmsonii.*

Many species of Copepods are the favourite food of *Macrobrachium* spp. Ibrahim (1962) and Thangadurai (1990) reported that the *Crustacean* appendages and *Diaptomous* are the favourite food of *M. malcolmsonii*. But Alikunhi & Ali (1984) reported that the seed production of *M. malcolmsonii* is not very rich under the supplement of zooplankton. Almost in support of the observation of Thangudurai (1990) many copepods species like *Nauplia, Mesocyclop, Neo-diaptomus, Eucyclop* are the good food of *M. malcolmsonii*. This species also like to eat certain phytoplankton like *Oscillatoria, Arthrospira, Microcystis, Synendra, Navicula, Closesterium, Euastrum* etc. (Alikunhi & Ali, 1984). According to Sargloos (1978), *Artemia nauplii* is one of the best food for many fresh water prawns. Almost in support of his observation the present work further reported that *Artemia, Mesocyclop* spp., *Neo – diaptomus, Eucyclop* spp. etc. (*M. birmanicum choprae* and *M. menoni*); *Mesocyclop* and *Neo – diaptomus* (*M. dayanum* and *M. assmensis*); and *Nauplii, Neo diaptomus* (*M. altifrons* and *M. tiwari*) are the favourite food.

Occurrence of certain protozoa species viz. *Chilomonas, Euglena, Phaecus, Gonium, Didinium, Paramoecium, Litonotus* etc. (*M. birmanicum choprae, M. malcolmsonii* and *M. menoni*); *Paramoecium, Volvox, Euglena* (*M. dayanum* and *M. assamensis*); *Paramoecium, volvox, Euglena, Chilomonas, Nassula, Paranema* etc. (*M. lamarrie*) and *Paramoecium, Euglena, Volvox* etc. (*M. altifrons* and *M. tiwari* are the new findings of the present investigation.

Many of the collected species of *Macrobrachium* like *M. dayanum*, *M. assamensis, M. lamarrie* and scarcely *M. altifrons* and *M. tiwari* prefer to stay in the standing water bodies like beel, pond, ditches, deep paddy field with full of aquatic vegetation. During investigation we collected *M. birmanicum choprae, M. malcolmsonii* and *M. menoni* as giant fresh water prawn of Assam from the big river like Brahmaputra, River Kalong, River Dihing, River Dikhoi, River Dhansiri, River Beki etc. Except few water hyecinth and some amphibious vegetation, these rivers are free from any other aquatic vegetation due to the swift water current. During investigation we collected some *M. malcolmsonii* and few *M. menoni* from the big beel like Garjan beel, Dora beel, Kukurmara beel, Ghorajan beel, Silsakoo beel those have a direct connection with the great river like Brahmaputra. According to Ibrahim (1962) many aquatic vegetations like *Salvania* and *Eichornia* are the favourite food for *M. malcolmsonii*. Almost in support of the observation of the above authors, the present findings found that *M. malcolmsonii* like to stay in the mids of some aquatic vegetation like *Salvania, Eichornia, Lemna, Pistia, Nymphaea, Utricularia, Hydrilla, Potamogeton, Hygrorrhiza, Euryale, Nyriophyllum* etc. According to Kanaujia and Mahanty (2002) the ideal depth of *M. malcolmsonii* is from 1 to 1.6m but if the depth is less, the sunlight penetrate to the bottom helps to produce the submerged aquatic plants a mat of agal bloom which restrict the movement of prawns and also cause mortality due to oxygen depletion during night. In support of the above observation present work also found heavy siltation in the bed of both standing and running water year after year in most of the water bodies we also observed gradual increase in the mass of aquatic vegetation resulting in the production of harmful gases with high mortality of *M. dayanum*, *M. lamarrie* even *M. malcolmsonii* and few *M. menoni*. Rao (1990) further reported that many standing water bodies are mostly covered with aquatic vegetation i.e. *Eichornia* spp., *Ipomea* pp. etc. where from many *M. lamarrie* were collected. Almost in agreement with the observation of Rao (1990), the present work further found that *M. lamarrie* prefers to stay in the water bodies where there is availability of many aquatic vegetation like *Azolla, Silvenia, Pistia, Eichornia, Walffia, Spirodella, Nepturua, Trapa, Ipomea, Neptunea, Nymphoidus, Sagittaria, Ceratophytophyllum, Hydrilla, Vallisneria, Otteria, Myriophyllum* etc. The study on the relationship of fresh water prawn *Macrobrachium* with the various types of aquatic vegetation were found very limited. Very few authors studied about it. Presence of *Lemna, pistia, Nymphaea, Utricularia, Hydrilla, Potamogeton, Hygrorrhiza, Ludwigia* and very few *Nelumbo, Euryale, Nyriophyllum* (*M. birmanicum choprae* and *M. menoni*); *Azolla spp., Salvinia, Pistia, Eichornia, Wolffia, Spirodella, Nepturua, Trapa, Nelumbo, Nymphaea, Neptunea, Nymphoidus, Nepturia, Sagittaria, Ceratophyllum, Hydrilla, Vasllisneria, Ottleria, Najas, Potamogeton, Myriophyllum* (*M. dayanum* and *M. assamensis*) and *Pistia, Nymphaea, Utricularia, Hydrilla, Hygrorrhiza, Ludwigia*, very few *Nelumbo, Euryale, Nyriophyllum* etc. (*M. altifrons* and *M. tiwari*) where these types of prawns prefer to stay, are the new observation of the present investigation. During collection it was also critically noticed that many aquatic vegetation provides shelter to small and moulted soft prawn and even the adult. When macrophytes tended to choke the pond, part of it is removed to facilitate the free movements of juvenile prawns. Many water plants with gravel sticks, branches, shell etc. provide shelter for the prawn, thereby reducing aggressiveness (Ling 1962 & 1969, Sidhimunka & Choapnam 1968 and Fujimora & Okamoto 1970). In addition to oxygen supply, the aquatic vegetation provides shade, shelter, suitable hiding place and feeding posture for the prawns. (Table-9)

Soil: The soil texture where from the various species of *Macrobrachium* were collected were mostly sandy clay. The information about the soil texture class related prawns are very few. Mercy & Sankaranan (1990) & Joseph *et al.* 1990 described the soil texture of *M. rosenbergii* as sandy clay with pables. Almost insupport of their observation the present work found that the soil texture of the various collected species of *Macrobrachium* from Assam were sandy, loamy and clay (*M. birmanicum choprae*, *M. malcolmsonii* and *M. menoni*); mostly clay and sandy loamy (*M. dayanum* and *M. assamensis*); sandy and loamy (*M. lamarrie*) and mostly sandy to loamy clay (*M. altifrons* and *M. tiwari*). The sandy loamy and clay soil texture of *M. birmanicum choprae, M. malcolmsonii* and *M. menoni* has a profound role in reducing the aggressiveness during moulling which was also supported by Ling (1962 & 1969), Sidhimunka & Choapnam 1968 and Fujimora and Okamoto 1970 and cannibalism nature reported by Smith and Sandifer, (1975 & 1979). In agreement with the observation of Mercy & Sankaranan (1990), mortality was more among the prawns like *M. lamarrie, M. assamensis* - reared in tank with mud as substratum. The survival rate of prawn was significantly more in the sandy loamy soil with pebbles than clay. During collection we observed that many fresh water *Macrobrachium* like *M. dayanum, M. assamensis* exhibit a specific affinity towards the pebbles and this may be due to the availability of space among the pabbles for the prawn to hide by showing chance of less carnibalism. Almost in support of the observation of Tripathi (1990) we also found that many fresh water prawns like *M. lamarrie, M. menoni* and a few *M. malcolmsonii* prefer to stay in sandy / clay bottom bed with a little aquatic vegetation in the marginal areas. Almost like *M. rosenbergii*, Malecha *et al.* 1981, Smith *et al.* 1985, and Joseph et al. 1990). *M. birmanicum choprae* and *M. malcolmsonii* are the most popular candidates species of Assam for cultural practice and they like to stay in a sandy clay bed. Muthu and his co-workers (1990) described that many types of prawns do not normally burry in the substratum. They prefer a sand – mud bottom. They are generally burrowing species which prefer a smooth bottom. In support of the above observation many burrowing species like *M. birmanicum choprae, M. dayanum* and *M. assmaensis* posses highly muscular strong chelate and muscular non chelate legs forming a smooth bottom for resting.

The information about the composition of the soil was found very limited. Reddy (2005) studied the soil pH as 4.0 – 9.5 where from *M.*

rosenbergii was collected. Almost in support of his observation, the average values of the soil pH, the present work found that average value of the soil pH of all the collected species of *Macrobracium* from Assam was ranged from 5.3 – 7.2. Presence of organic carbon (2.8 – 7.6%), Nitrate – (0.15 – 0.53 mg/100gm), Sulphate (2.2 – 7.8 mg/100gm), Calcium (38.4 – 83.4 mg/100gm), Magnesium (21.2 – 54.2 mg/100gm) and organic matter (6.2 – 14.3%) (*M. birmanicum choprae*, *M. malcolmsonii* and *M. menoni*); Organic carbon 2.8 – 8.8%, Nitrate 0.15 – 0.78 mg/100gm, Sulphate 2.2 – 8.4 mg/100gm, Calcium 36.5 – 86.2 mg/100gm, Magnesium 20.8 – 63.4 mg/100gm and Organic matter 5.5 – 16.1% (*M. dayanum* and *M. assamensis*); Organic carbon 2.8 – 7.6 mg/100gm, Nitrate 0.15 – 0.53 mg/100gm, Sulphate 2.2 – 7.8 mg/100gm, Calcium 38.4 – 83.4 mg/100gm Magnesium 21.2 – 54.2 mg/100gm and Organic matter 6.2 – 14.3% (*M. altifrons, M. lamarrie* and *M. tiwari*) and Organic carbon 2.8 – 7.6%, Nitrate 0.15 – 0.53 mg/100gm, Sulphate 2.2 – 7.8 mg/100gm, Calcium 38.4 – 83.4 mg/100gm, Magnesium 21.2 – 54.2 mg.100gm and Organic matter 6.2 – 14.3% (*M. attifrons* and *M. tiwari*) are the new observation of the present investigation. (Table 8.1, 8.2 & 8.3)

Biochemical Constituents: Very few authotrs estimated certain biochemical constituents viz. Lipid, Protein, Ash, Cerotenoid, Dry Matters etc. from the body of prawns (Hawk 1952, Folch *et al.* 1957, Jackob 1958, Hassid and Abraham 1957, Mukundan *et al.* 1981, Fiske and Subbarow 1925, Achuthankutty and Parulekar (1984). Lowest quantity of fat was observed in the muscles of prawns (Mukundan *et al.* 1981). In support of his observation, we also observed very little fat in the body of the collected species of

Macrobracium as 0.61 to1.22 µg/g. Lowest quantity of Fat was observed in *M. Tiwari* and highet quantity was observed in *M. birmanicum choprae*. Labao *et al.* (1986), observed the proximate body composition of certain giant fresh water prawn like M. rosenbergii as Protein 20.7%, lipid 0.7% and ash 1.2%. Almost in agreement with the observation of the above authors the presence of Cerotenoid, 1.97 – 6.27 □g/g. Ash 1.12 – 11.85, dry Matters 13.25 – 32.08, Crude Protein 35.21 – 68.28, Crude Fat 0.61 – 1.22, Crude Fibre 0.75 – 2.48, Calcium 2.21 – 7.12, Phosphorous 0.75 – 2.04, Cu 0.018 – 0.307, Zn 0.067 – 0.736 and Fe 0.177 – 0.306 in the body of the collected species of *Macrobrachium* of Assam are the new findings of the present investigation. (Table 6 & 12)

Fishing Gears: Various conventional gears viz. Traps, Lines, Handnets, Sieves, Castnets, Dotnets and Bamboo basket packed with moist moss or aquatic plants were used to catch the various freshwater prawns (Gokhale 1957 and George 1969, Kurian & Sebastian 1990, Tripathi 1990). Almost in support of the observation of the above authors, the present findings reported that "Berjal", "Moijal", "Achrajal" and bamboo gears like "Hukuma", "Dalangi", "Ghani", "Dingora", "Boldha" *(M. birmancium choprae, M. malcolmsonii & M. menoni*); Manipuria jal, Dolonga, Jakoi, Chepa, Hukuma, Khewalijal, (*M. dayanum & M. assamensis*); Khewalijal, Jakoi, Chepa, Dalangi, Galphala, Thuha (*M. lamarrie*) and Khewalijal, Manipuriajal (*M. altifrons* and *M. tiwari*) are the various types of fishing gears used by the present work (Chart – A & B). In support of the observation of Tripathi (1990) the present work also observed that during extreme winter, the paddy field becomes dry and prawns like *M. dayanum, M. assamensis* and *M.*

PLATE - I

TRAPS *(Fishing Gear)*

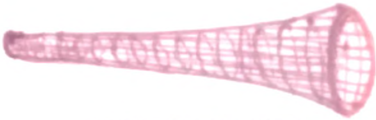
Boldha

Chunga

Dingora

Bamidhora

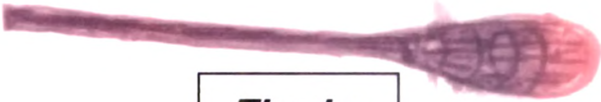
Cherha



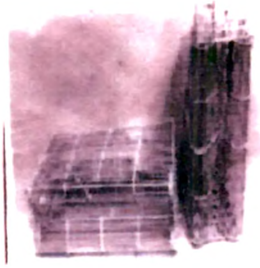
Cherha

Dori

Khoka

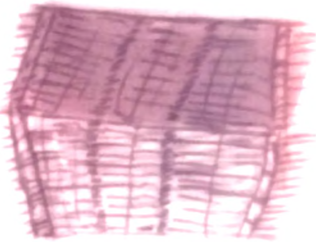


Thorka



Dalangi

Chepa



Tuna

Ghani

Derki

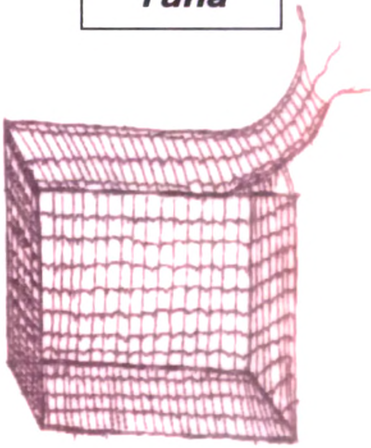


PLATE - II

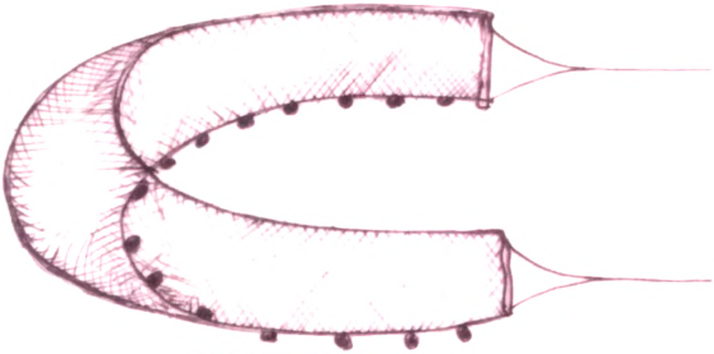
ENCIRCLING GEAR *(Fishing Gear)*

Juluki

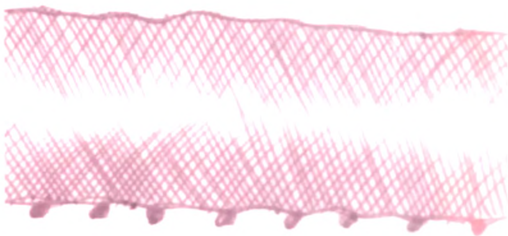
Polo

Polo

Jhupri



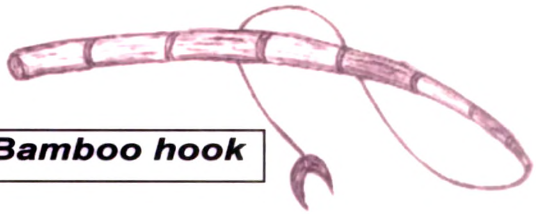
Berjal



Musari Jal

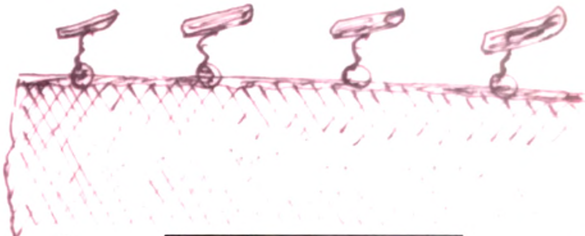
ENTANGLING GEAR *(Fishing Gear)*

Dhan barashi

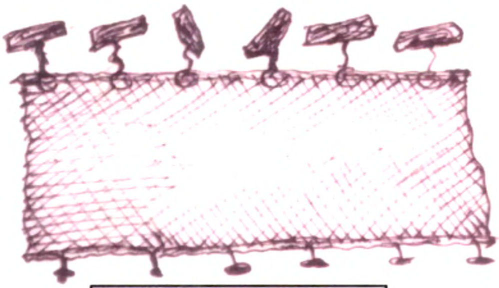


Bamboo hook

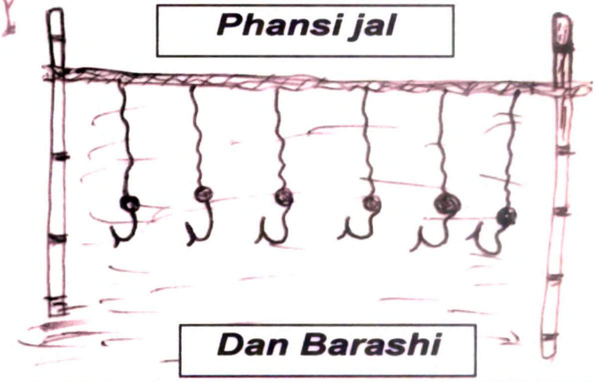
Sip barashi



Phansi jal



Langi jal

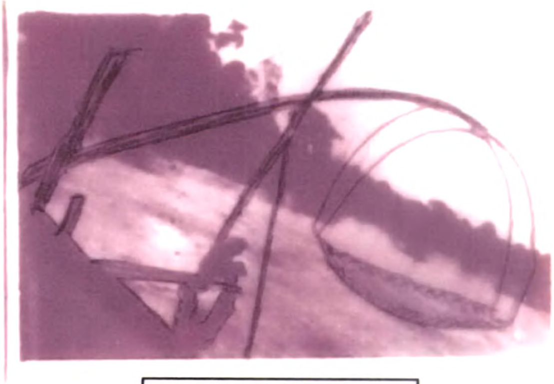


Dan Barashi

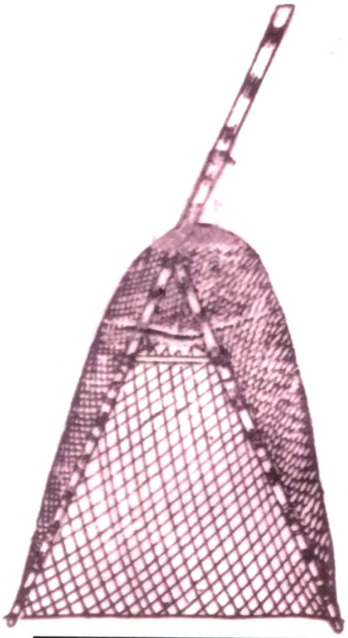
PLATE - III

TRAWLING GEAR *(Fishing Gear)*

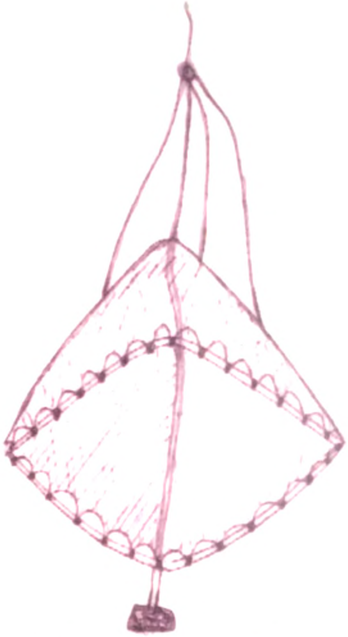
Jakoi



Dhenki Jal

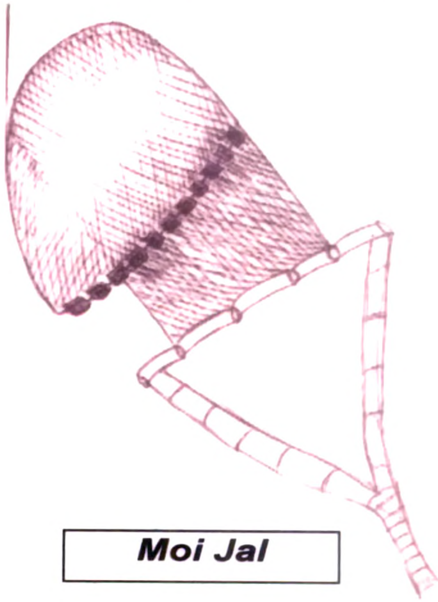


Pah Jal



Shangla Jal

Horhori Jal



Moi Jal

PLATE - IV

IMPALLING GEAR *(Fishing Gear)*

Jongar

Kol or Kati

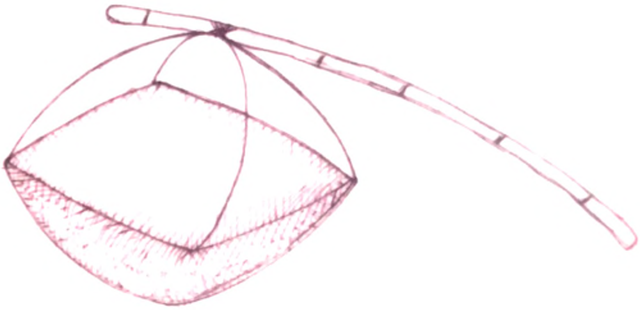
Jongar

Tiara

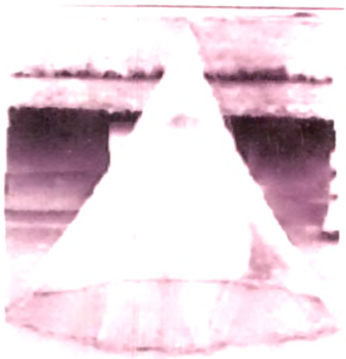
Jongar

Pokora

SCOOPING GEAR (Fishing Gear)



Dharma Jal



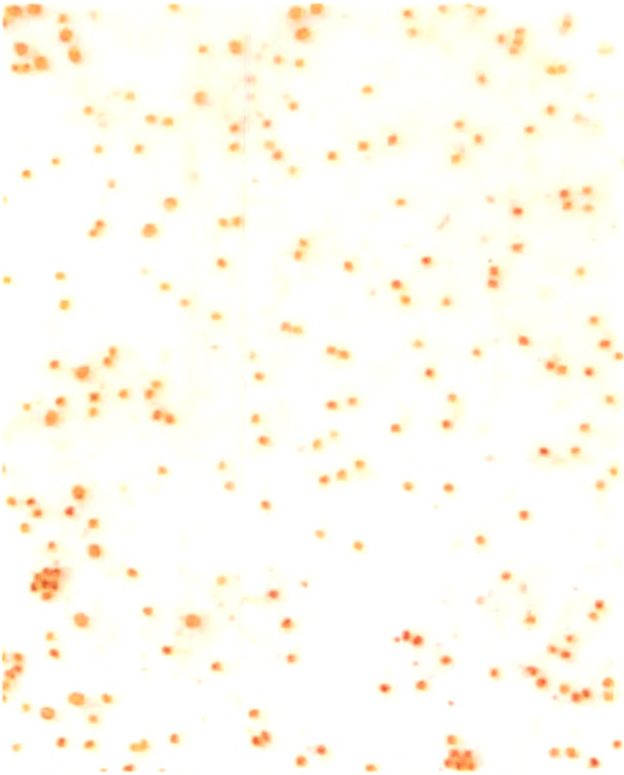
Khewali Jal

Angtha Jal

PLATE - 11

Sexual Dimorphism of
M. malcolmsonii

M. dayanum
(Containing eggs)



Eggs of
M. assamensis

Eggs of
M. dayanum

PLATE - 12

Eggs of
M. birmanicum choprae

Eggs of
M. malcolmsonii

lamarrie migrate to the trenches and channels in and around the paddy field where they are haunted by sieves and castnets. (Chart A & B)

Fecundity:

A good numbers of authors counted the total numbers of eggs from the various species of fresh water prawns *Macrobrachium*. The fecundity of eggs in *M. birmanicum choprae* reported by Kalita (2005 – 06) was 7000 – 12000 per individual. In disagreement with the observation of the above mentioned author, we found the egg fecundity as 25,000 – 30,000 during collection. During collection we carefully noticed that the mother prawn vibrate rapidly her pleopods the hatchings are disposed so that all the eggs are hatched out at a time. Some authors differently described the fecundity of *M. malcolmsonii* as 48,476 – 59,786 (Kutty *et al.* 2004), 6,000 – 80,000 (Kunaujia 2002) and 3360 – 12,000 (Kalita 2005 – 06), Kanaujia (2002) showed the great variation in the total number of egg during collection. Almost in disagreement of the observation of Kutty *et al.* (2004), the present work found 15,000 – 30,000 as egg fecundity in the above mentioned species with low larval survavility. Kalita (2002) recorded the fecundity of egg as 5 – 200 / individual in *M. lamarrie*. But we found 2000 – 5000/individual. In this species the above author showed a great variation in the number of egg. Kalita (2002) mentioned about the morphology of egg of *M. assamensis* but he did not mention the fecundity. But during the present observation it was found that fecundity of *M. assamensis* from 1000 – 1850 / individual; 1200 – 2000 (*M. dayanum*); 10,000 – 15,000 (*M. menoni*) and 5000 – 10,000 in *M. altifrons* & *M. tiwari* as egg fecundity are the new observation of the present work.

PLATE - 10

ROSTRUM OF DIFFERENT *MACROBRACHIUM* SPP.

M. birmanichum choprae

M. malcolmsonii

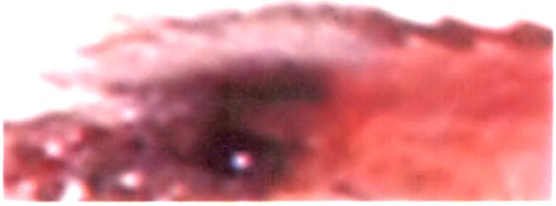
M. menoni

M. lamarrie

M. dayanum

M. assamensis

M. altifrons



M. tiwari

Discussion on Biological Parameters :

Length-Weight relationship :

The knowledge of the length -weight relationship of a species is indispensable as the relationship between length and growth helps in the understanding of various important biological aspects viz. general well being, appearance of prawn at the first maturity, onset of spawning etc. Though in fish, growth is a continuous process but is a specific adaptive property, ensured by the totality of the species and its environment (Nikolsky, 1999) as environmental condition effect growth of fish.

The length –weight relationship studies carried out by Rao (1990) in Kolleru Lake during 1979-80 on *M. rosenbergii* and *M. malcolmsonii* where in case of *M. malcolmsonii* the length varied from 232.5mm and 12.5mm. Similarly, Kurup *et. al,*(1990) made a comprehensive study on the length-weight relationship of *M. rosenbergii* and *M. idella* where regression co-efficient in the length-weight relationship of two species were tested against the value b=3, the value corresponding to the isometric growth using 't' test and it it was found that the observed value showed significant difference from 3. Hence it is inferred that irrespective of sex. *M. rosenbergii* and *M. idella* are characterized with allometric form of growth pattern.

The length–weight relationship was found out for four *Macrobrachium* species – viz. *M. dayanum, M. assamensis, M. birmanicum choprae and M.*

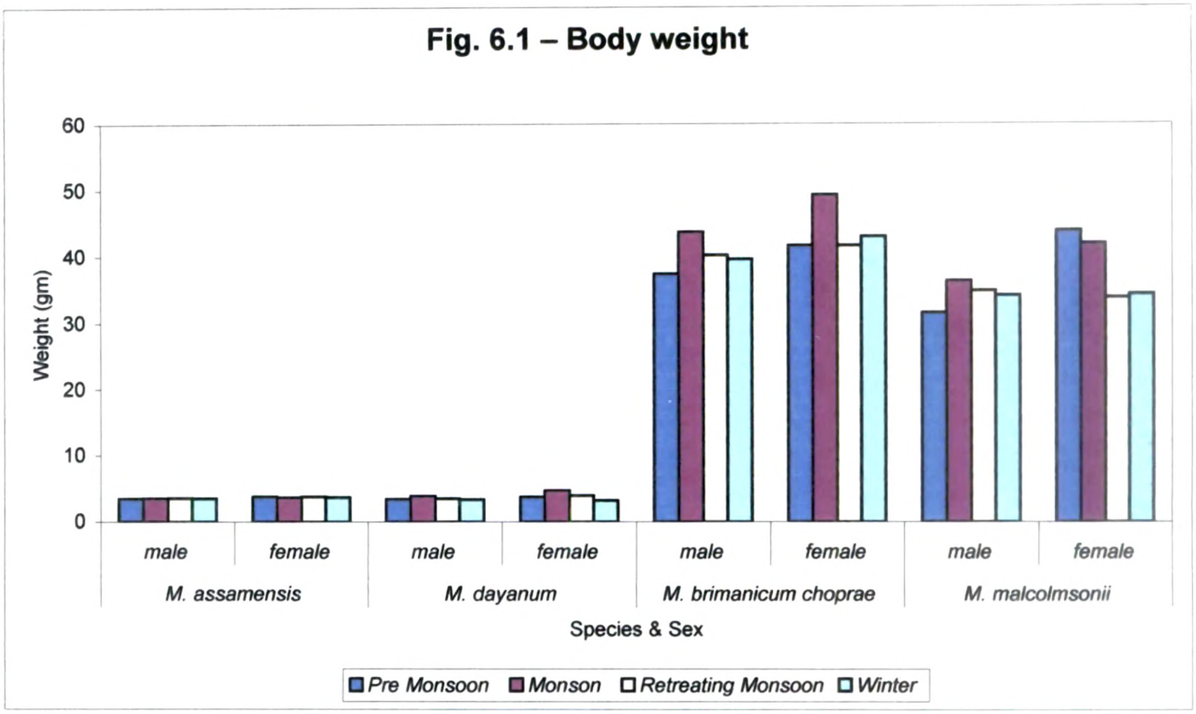
malcolmsonii. The average maximum length of *M. dayanum* was found in beel (70.0mm) during monsoon and average minimum length was found in paddy filed (45.35mm) during pre-monsoon. The corresponding body weight was found maximum (3.84g) in beel during monsoon and the minimum was found in paddy filed (3.19g) during pre-monsoon (Chart – 1& 2). In case of *M. assamensis,* the average maximum length found : average in beel (53.6mm) during monsoon and minimum in paddy field (39.65mm) during pre-monsoon and corresponding body weight was found maximum in beel (4.08g) during retreating monsoon and minimum in the paddy filed (3.14g) during pre-monsoon (Chart- 3 & 4). *M. birmanicum chopare* showed as – length : average maximum in river (142.7mm) during monsoon and average minimum in beel (102.4mm) during pre-monsoon and corresponding average maximum body weight in river (46.3g) during monsoon and minimum in the beel (34.0g) during pre-monsoon (Chart 7 & 8). The observation in *M. malcolmsonii* was – length : average maximum in the river (120.2mm) during monsoon and minimum in the beel (94.3mm) during pre-monsoon. The corresponding maximum body weight found maximum in the river (36.35g) during monsoon and average minimum also in river (29.75g) during pre-monsoon (Chart – 5&6). The body length was analyzed with ANOVA and found as – among species result was significantly different. But among season and habitat result is not significant. Similarly between species - season, species – habitat, season -Habitat and species – season – habitat in all cases the result found not significant. Regarding body weight, the ANOVA test indicates that among the season, sex and species the test shows significance differences but the Habitat- species- season, species- species - habitat, season -habitat and species-season-habitat show not significance. (Table - b)

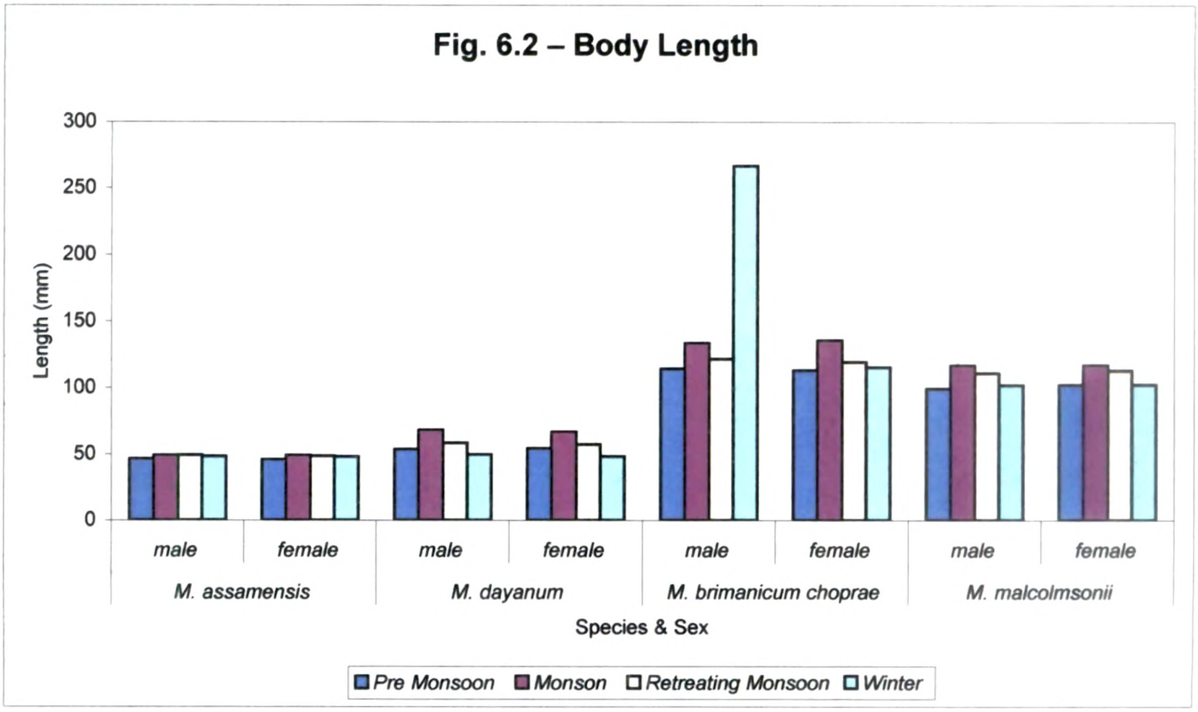
Gonado –Somatic Index (GSI) :

The Gonado–Somatic Ratio was studied in four *Macrobrachium* spp. Viz. *M. dyanum, M. assamenses, M. brimanicum choprae* and *M. malcolmsonii*. The GSR was found for both male and female of all the four species and result obtained according to the environmental condition and maturity of gonad. Through no specific studies were found in case of prawn but some specific studies were made in case of fish by some workers. According to Kaur (1981), Seasonal fluctuation may reflect the spawning cycle as the "K" is influenced by gonadal condition. Yoneda *at al,* (1998), has reported clear relationship of seasonal cycle of ovary, length and weight, gonado somatic index and condition factor in *Lophimus setigerus*. From the work done by Hollan *et al*, 2000, Hansen *et al,* 2001, and it becomes evident that the condition factor has direct relationship with gonado somatic ratio which is influenced by increase in length and weight of fish due to somatic increase because of gonadal development.

In the present investigation of GSI, *M. dayanum* (Male) the average weight of gonad found maximum during monsoon (0.28gm) where corresponding average body weight was 4.1gm and average minimum

FIG. 6 – SHOWING GONADO SOMATIC INDEX (GSI)





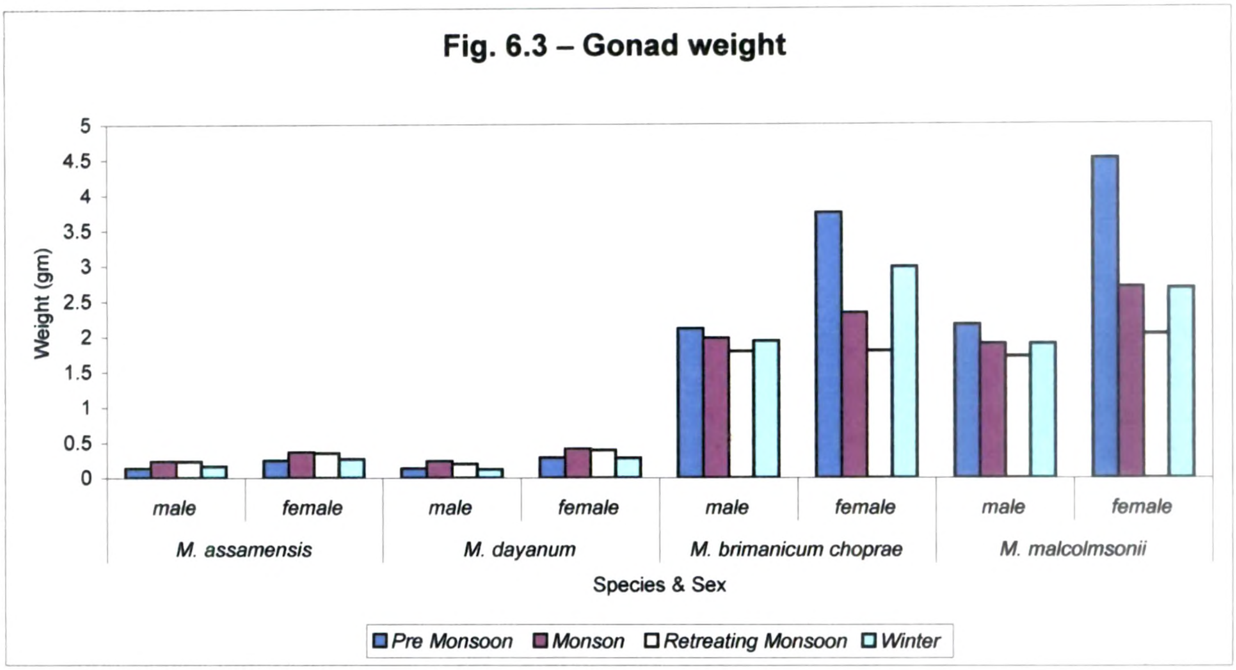


Fig. 6.3 – Gonad weight
Weight (gm)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
male
female
M. assamensis
M. dayanum
M. brimanicum choprae
M. malcolmsonii
Species & Sex
Pre Monsoon
Monson
Retreating Monsoon
Winter

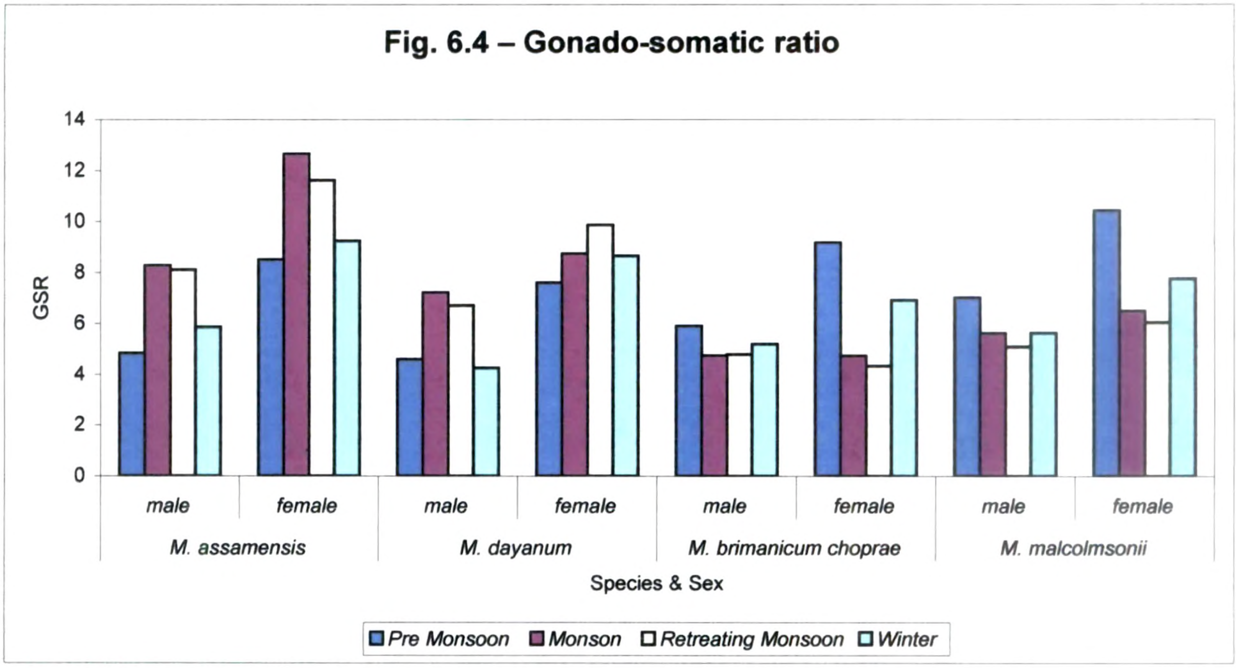


Fig. 6.4 – Gonado-somatic ratio
GSR
0
2
4
6
8
10
12
14
male
female
M. assamensis
M. dayanum
M. brimanicum choprae
M. malcolmsonii
Species & Sex
Pre Monsoon
Monson
Retreating Monsoon
Winter

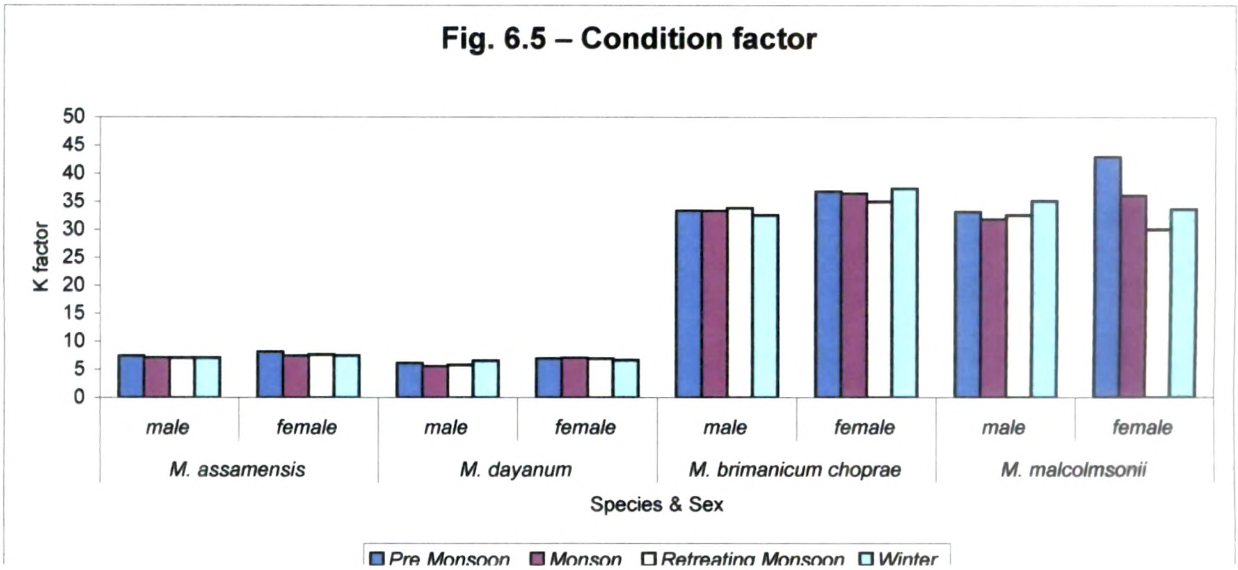


Fig. 6.5 – Condition factor
K factor
0
5
10
15
20
25
30
35
40
45
50
male
female
M. assamensis
M. dayanum
M. brimanicum choprae
M. malcolmsonii
Species & Sex
Pre Monsoon
Monson
Retreating Monsoon
Winter

gonadal weight was during pre-monsoon (0.07gm) where corresponding body weight was 3.4gm (Chart No. 1). Similarly in female *M. dayanum*, the average maximum gonadal weight was found in monsoon (0.45gm) where average body weight was 4.8gm and minimum gonadal weight was observed during winter and pre-monsoon (0.25gm) and their corresponding body weight was 3.0gm and 3.5gm (Chart No.2). The studies on *M. assamensis* : Male indicates that the average maximum gonadal weight was found in monsoon (0.26gm) and corresponding average body weight was 3.8gm (Chart No. 3) and in case of *M. assamensis* female the average maximum gonadal weight was also (0.26gm) and corresponding average body weight was 3.8gm and minimum gonadal weight was found during pre-monsoon (0.21gm) and corresponding average body weight was 4.3gm (Chart No. 4)

The GSI was also studied in *M. malcolmsonii* and in male maximum average gonadal weight was found in late pre-monsoon and early part of monsoon (2.24gm) and corresponding average body weight was 29.8gm (Chart No. 5). Similarly in female *M. malcolmsonii*, the maximum average gonadal weight was found in middle part of pre-monsoon (4.96gm) and corresponding average body weight was 42.6gm and the minimum average gonadal weight observed during later part of retreating monsoon (1.98gm) and corresponding body weight was 32.3gm (Chart No. - 6). The same type of studies were carried out in *M. birmanicum choprae* wherein male the maximum average gonadal weight was found during the middle part of pre-monsoon (2.15gm) and average body weight recorded as 38.0gm (Chart No. 7) and minimum average gonadal weight of female *M. birmanicum choprae* recorded during the early part of pre-monsoon (3.96gm) where corresponding average body weight was 36.4gm and minimum average gonadal weight was observed during early part of retreating monsoon (1.74gm) where corresponding body weight was 42.8gm (Chart No, 8)

The GSR and K. Factor was calculated in all the four varieties and ANOVA test was done **(Table - a)**. The outcome was regarding Gonad weight among the species, corresponding sex and season, the result showed having significance different. Again among the four species between species to sex, species to season, sex to season and species, sex and season altogether show significance **(Table a (1))**. ANOVA test was also done in case of GSR and revealed that among species to species, sex to sex, and species to season result found significance but season, species to sex and species. sex. season. exhibited not significance **(Table b)**. Same type of study was also made in K. Factor and result found as – species to species and sex to sex - there was significance but among season, species to sex, species to season, sex to season and species. sex. season had no significance **(Table b (1))**

Relative Gut Length :

Any living organism needs energy in the form of food for its survival, growth and development and reproduction to continue the generation. The prawn also needs food to maintain its life in aquatic environment. As the prawn are

FIG. 5 – SHOWING RELATIVE GUT LENGTH (RGL)

Fig. 5.1 – Body Length

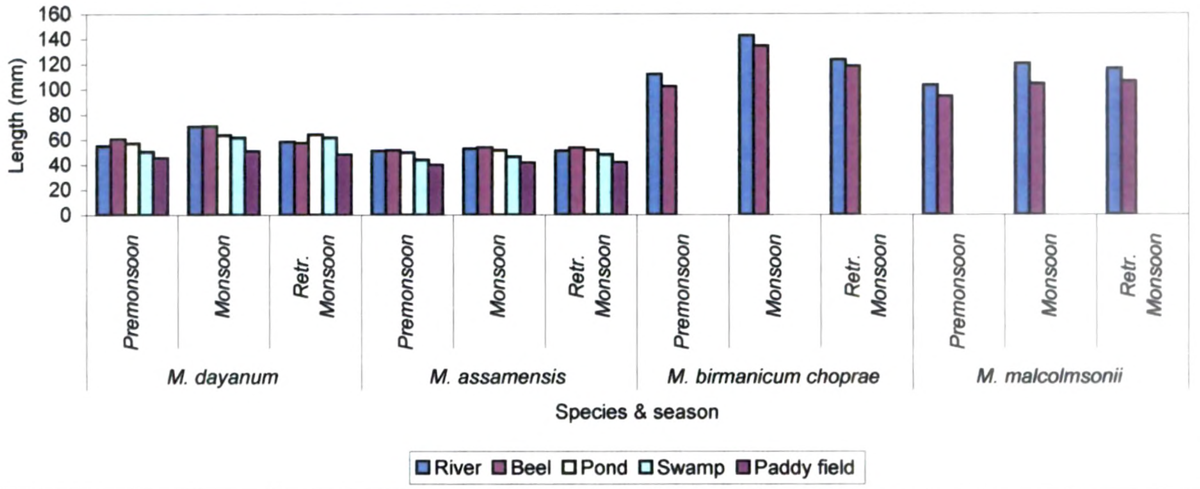


Fig. 5.2 – Gut -Length

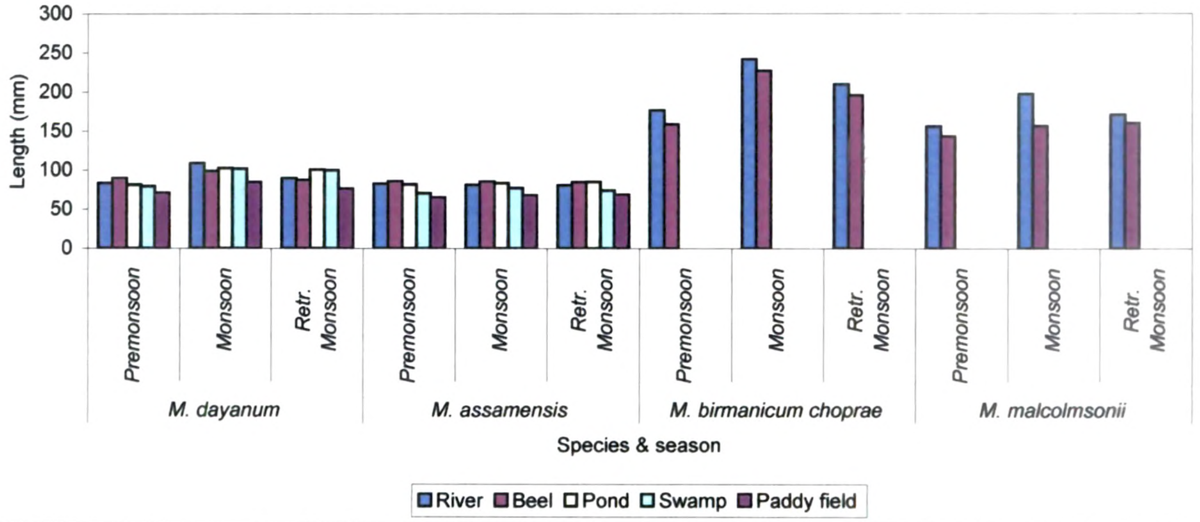
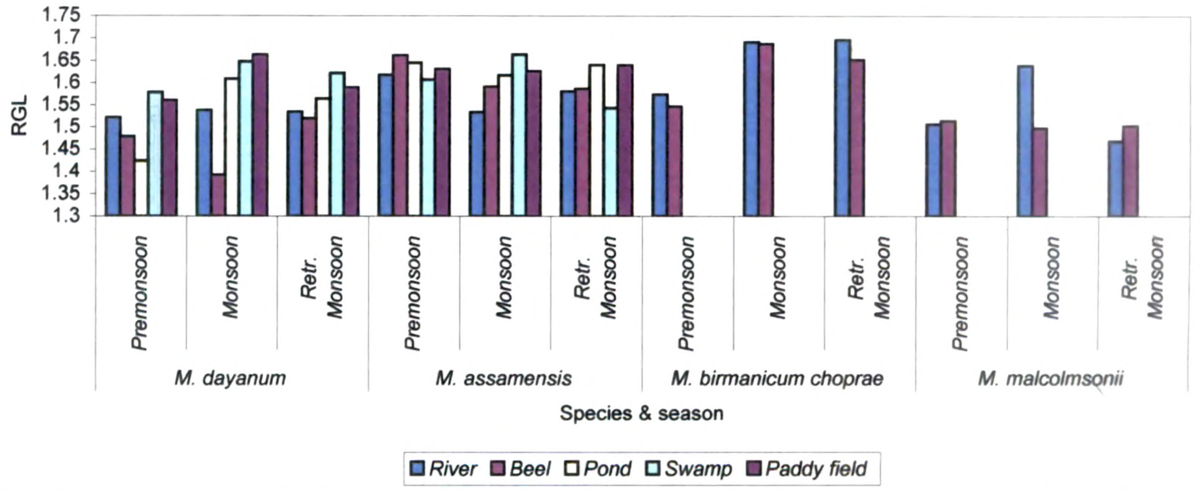


Fig. 5.3 – Relative gut length



poikilothermic animal, the amount of energy required for different prawn species is different depending on the environment where they live. Hence feeding habit may vary depending on the availability of food in the habitat and the area of living.

Every fish species adopts to its surrounding according to its feeding behaviour but adaptation to feeding does not remain constant throughout its life (Nikolsky, 1999). Therefore food and feeding habits have a great role to play on a particular species for its growth, development and reproduction. The length of digestive tract is also closely related to the type of food it consumes. The gastro –somatic index (GSI) is widely used to estimate the feeding intensity of fishes (Biswas, 1992).

Very limited study is done on the RGL of different prawn. In the present work, in four selected *Macrobrachium* species viz. *M. dayanum, M. assamesnsis, M. birmanicum choprae and M. malcolmsonii* RGL study was carried out in three seasons.

In *M. dayanum* maximum gut length was found in beel (154.2mm) during monsoon and the corresponding body length was 93mm and the minimum gut length was found in river (42.3mm) during monsoon and corresponding body length was 48.2mm.

In *M. assamensis* maximum gut length was found in beel (124mm) during late monsoon and corresponding body and length was 78.6mm and minimum gut length was found in paddy filed (36.5mm) during pre-monsoon and corresponding body length was 20.8mm.

In *M. brimanicum choprae* the maximum gut length was found in river (322.8mm) during monsoon and the corresponding body length was 180mm and minimum gut length was found in beel (96.8mm) during retreating monsoon and corresponding body length was 72.2mm.

In *M. malcolmsonii* the maximum gut length was found in river (288.6mm) during monsoon and corresponding body length was 162mm and minimum gut length was found in beel (84.4mm) during pre monsoon and corresponding body length was 62.4mm.

Discussion on analysis of variance of results:

The results obtained in the various observations were studied with analysis of variance (ANOVA) and the results obtained can be mentioned as –

Atmospheric temp: Analysis of variance for atmospheric temp. level in the water of different habitat in different season for the *Macrobrachium* under study shows that there are significantly ($P<0.05$) different in different species, Habitat and season (Table D & D_I): **Water temperature :** Analysis of variance for water temperature showed no significant different between the species wise and the water temperature found in different habitat and season were significantly different (Table E & E_I); **Total Hardness** : ANOVA test regarding Hardness of water analysis found as no significant different between the species and there were significant different in different habitat and season (Table F & F_I); **Conductivity**: In case of conductivity also the observation was no significant different between species and there were significant different in different Habitat and season (Table G & G_I); **Transparency**: The observation regarding transparency levels in the water of different habitat in different season for the species under study shows that there is no significant difference between the species and the level of transparency in different habitats and season are significantly different (Table H & H_I); Similar observation was found in case of dissolved oxygen of the water analysis (Table I & I_I); **P^H**: The analysis on P^H shows that there are no significant difference between the species, Habitat and seasons (Table J & J_I); **Total Alkalinity** : The ANOVA test for alkalinity of water bodies exhibit the results as there is no significant between the species but between Habitat and season there was significantly differences (Table K & K_I); **Free Carbondaioxide** : Similar was the observation in case of free carbondioxide of water bodies (Table L & L_I); **Phosphorus**: Analysis of variance for phosphorus levels in the water of different habitats in different seasons for the species under study shows that there was no significant difference between the specieswise phosphorus levels measured. The levels of phosphorus in different habitats and seasons were significantly ($p<0.05$) different. (Table M & M_I); **Chloride**: Chloride of the water bodies was calculated and ANOVA test shows that there were no significant difference between species, Habitat and season (Table N & N_I); **Nitrate** : The amount of nitrate from the water bodies was also estimated and the ANOVA test showed that though there were no significant difference between the species that between Habitat and season there were significant differences (Table O & O_I).

ANOVA test was also done in case of **soil parameters** among the species, habitat and season, which can be discussed as – **Organic Carbon**: Regarding organic carbon the ANOVA test revealed that there were no significant difference between the species but between season and Habitat there were significant different (Table I & I_a); **Organic Matter** : Similar type of result was found in the organic mater as shown in the Table (Table II &

II_a); **Magnesium** : ANOVA test was also in case of soil parameters and the results obtained found as the were no significant difference in case of Habitat and species and they are difference (Table III & III_a); **Calcium** : Calcium of the soil parameters was also studied and after ANOVA it was found that there were no significant difference between the but then were significant different between species and season habitat (Table IV & IV_a); **Nitrate** : Regarding nitrate the observation was not significant difference between the.species but there were significant difference between Habitat and season (Table V & V_a); **P^H**: The analysis of variance about P^H shows there are no significant different between species and Habitat but regarding season there are significant different (Table VI & VI_a); **Sulphate**: Regarding the observation about sulphate, between species there were no significant difference by between habitat and season there significant difference (VII & VII_a)

Analysis of variance (ANOVA) was also tried in all the **biochemical components** viz. calcium; Crude Fibre, Crude Fat, Crude Protein, Dry Matter, Total Ash and Carotenoid pigments. Except crude fibre all the components show similar results where there were no significant difference but crude fibre show significantly different (Table AFCBE ad A_I & B_I)

ANOVA test was also carried out in **Eye Stalk Fecundity** and **Body size** : In all the cases the results observed that there were no significant different between the groups (Table C & C_I)

Regarding the studies on biology of four *Macrobachium* species viz. *M. dayanum, M. assamensis, M. birmanicum choprae* and *M. malcomsonii,* and the parameters were "Length weight Relationship, Gonado Somatic Index (GSI) and Relation Gut Length (RGL). Regarding length and weight, there are no significant difference between species and only in case weight, the season showed significantly different. But it other observation, the result is not significance (Table b & b_I). In case of GSI: The Gonad weight exhibits significant difference between species, sex and season but in case of GSR and K-Factor between species and sex and no significance between season in GSR & K-Factor (Table a & a_I)

Relative Gut Length

Relative gut length study was made in four selected species viz. *M. dayanum, M. assamensis, M. birmanicum choprae* and *M. malcolmsonii.* The results obtained were tested with analysis of variance (ANOVA) and the conclusion was between the species, the length and gut length were significantly different. But in the other tests for season and habitat the out come was not significant different (Table b,$b_1$and b_2).

Table – A: Mean of different Biochemical Parameters of different *Macrobrachium* Spp.

Name of species	Calcium		Crude Fibre		Crude Fat		Crude Protein	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
M. dayanum	4.291	0.887	1.538	0.483	0.690	0.026	51.518	1.797
M. assamensis	5.083	1.510	1.604	0.558	0.798	0.030	53.875	2.005
M. birmanicum choprae	4.980	0.948	1.420	0.474	1.090	0.117	63.868	2.915
M. malcolmsonii	4.292	0.653	1.691	0.482	0.950	0.097	61.108	2.121
M. menoni	3.902	0.734	1.656	0.576	0.796	0.032	55.124	1.928
M. lamarrie	3.223	0.763	1.368	0.468	0.682	0.044	37.088	1.390
M. altifrons	3.455	0.963	1.396	0.475	0.701	0.045	37.544	0.952
M. tiwari	3.515	0.872	1.357	0.447	0.687	0.050	36.743	0.626

Table A_I: Results of Analysis of variance (ANOVA) for Calcium, Crude Fibre, Crude Fat, Crude Protein.

Parameters	Among Spp.	Sum of Squares	df	Mean Square	F	Sig.
Calcium	Between Groups	21.9	7	3.1222	3.3787	0.0058
	Within Groups	39.7	43	0.9241		
	Total	61.6	50			
Crude Fibre	Between Groups	0.8	7	0.1093	0.4496	0.8642
	Within Groups	9.2	38	0.2432		
	Total	10.0	45			
Crude Fat	Between Groups	0.8	7	0.1154	29.4150	0.0000
	Within Groups	0.1	35	0.0039		
	Total	0.9	42			
Crude Protein	Between Groups	3800.4	7	542.9101	154.7910	0.0000
	Within Groups	94.7	27	3.5074		
	Total	3895.1	34			

Table – B: Mean of different Biochemical Parameters of different *Macrobrachium* Spp.

Name of species	Dry Matters µg/g		Total Ash µg/g		Carotenoid (µg/g)			
					Carapace		Muscles	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
M. dayanum	19.143	2.096	3.490	1.313	19.356	1.792	4.967	0.739
M. assamensis	20.395	2.712	4.394	1.333	22.157	1.650	5.145	0.853
M. birmanicum choprae	29.180	2.070	9.106	2.050	65.070	1.522	4.410	0.617
M. malcolmsonii	25.306	2.096	7.390	1.650	58.455	2.027	3.980	0.630
M. menoni	22.614	2.491	5.148	1.461	42.270	2.063	2.955	0.557
M. lamarrie	16.110	1.917	2.455	1.050	14.350	1.231	4.603	0.507
M. altifrons	17.320	2.256	2.350	0.934	16.250	1.926	2.933	0.687
M. tiwari	17.590	2.485	2.128	0.870	17.576	1.505	3.205	1.159

Table B_I : Results of Analysis of variance (ANOVA) for Dry Matters, Total Ash, Carotenoid

Parameters	Among Spp.	Sum of Squares	df	Mean Square	F	Sig.
Dry Matters	Between Groups	674.1	7	96.2994	18.8224	0.0000
	Within Groups	143.3	28	5.1162		
	Total	817.3	35			
Total Ash	Between Groups	214.8	7	30.6876	15.4540	0.0000
	Within Groups	57.6	29	1.9857		
	Total	272.4	36			
Carotenoid (Carapace)	Between Groups	12320.5	7	1760.0667	583.3492	0.0000
	Within Groups	87.5	29	3.0172		
	Total	12408.0	36			
Carotenoid (Muscles)	Between Groups	27.8	7	3.9719	8.0169	0.0000
	Within Groups	17.3	35	0.4954		
	Total	45.1	42			

Table – C: Mean of some Morphometry Components of different *Macrobrachium* Spp.

Name of species	Eye Stalk (Breadth) mm		Eye Stalk (Length) mm		Fecundity		Body Size	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
M. dayanum	0.88	0.30	2.16	0.27	1656.00	306.48	57.5	25.44462
M. assamensis	0.98	0.22	1.80	0.32	1441.00	337.50	55.25	17.88623
M. birmanicum choprae	1.10	0.25	3.08	0.22	30066.00	4039.77	127.1667	39.66641
M. malcolmsonii	0.98	0.29	2.75	0.21	25110.00	4043.58	110.3818	42.8262
M. menoni	0.98	0.17	2.30	0.18	12670.00	2076.54	62.96	23.753
M. lamarrie	0.20	0.02	0.75	0.13	3620.00	1144.88	39.225	12.20184
M. altifrons	0.78	0.30	2.63	0.17	7486.00	1928.08	45.475	2.404683
M. tiwari	0.75	0.21	2.30	0.29	7666.00	1922.18	57.04	2.215401

Table C_I : Results of Analysis of variance (ANOVA) for Eye Stalk, Fecundity , Body Size

Parameters	Among Spp.	Sum of Squares	df	Mean Square	F	Sig.
Eye Stalk (Breath)	Between Groups	1.9	7	0.2663	4.4726	0.0024
	Within Groups	1.5	25	0.0595		
	Total	3.4	32			
Eye Stalk (Length)	Between Groups	14.3	7	2.0429	35.6553	0.0000
	Within Groups	1.5	27	0.0573		
	Total	15.8	34			
Fecundity	Between Groups	4108193359.4	7	586884765.6250	102.2600	0.0000
	Within Groups	183652500.0	32	5739140.6250		
	Total	4291845859.4	39			
Body Size	Between Groups	68625.8	7	9803.6801	11.7054	0.0000
	Within Groups	48576.9	58	837.5335		
	Total	117202.7	65			

Table – D : Mean Atmospheric Temperature of different habitats and seasons along with *Macrobrachium species*

Season	Name of Species	River		Beel		Pond		Swamp		PF	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Pre monsoon	**M. dayanum**	30.867	0.603	28.580	1.602	29.525	0.680	29.275	1.005	29.125	0.922
	M. assamensis	30.867	0.603	28.580	1.602	29.525	0.680	29.275	1.005	29.125	0.922
	M. birmanicum choprae	31.680	0.976	30.475	0.660						
	M malcolmsonii	31.680	0.976	30.475	0.660						
	M. menoni	31.680	0.976	30.475	0.660						
	M. lamarrie	29.733	0.404	29.300	0.700			28.700	0.200		
	M. altifrons	29.733	0.404	29.033	0.252						
	M. tiwari	29.733	0.404	29.033	0.252						
Pre monsoon Total		30.933	1.102	29.471	1.251	29.525	0.630	29.118	0.828	29.125	0.853
Monsoon	**M. dayanum**	32.900	0.173	31.500	0.100	30.800	0.700	30.867	0.702	31.525	0.544
	M. assamensis	32.900	0.173	31.500	0.100	30.800	0.700	30.867	0.702	31.525	0.544
	M. birmanicum choprae	32.800	0.300	31.300	0.100						
	M. malcolmsonii	32.800	0.300	31.300	0.100						
	M. menoni	32.800	0.300	31.300	0.100						
	M. lamarrie	32.800	0.300	30.767	0.451			29.300	0.800		
	M. altifrons	32.800	0.300	30.767	0.451						
	M. tiwari	32.800	0.300	30.767	0.451						
Monsoon Total		32.825	0.233	31.150	0.395	30.800	0.626	30.344	1.010	31.525	0.504
Retreating monsoon	**M. dayanum**	24.050	1.520	24.975	1.457	24.375	0.866	24.033	1.159	25.500	1.153
	M. assamensis	24.050	1.520	24.975	1.457	24.375	0.866	24.033	1.159	25.500	1.153
	M. birmanicum choprae	24.600	1.286	24.160	1.108						
	M. malcolmsonii	24.600	1.286	24.160	1.108						
	M. menoni	24.600	1.286	24.160	1.108						
	M. lamarrie	24.533	1.301	24.500	1.652			24.300	0.917		
	M. altifrons	24.533	1.301	24.500	1.652						
	M. tiwari	24.533	1.301	24.500	1.652						
Retreating monsoon total		24.444	1.212	24.459	1.236	24.375	0.801	24.122	0.948	25.500	1.032

Table D_I : Results of Analysis of variance (ANOVA) for Atmospheric Temperature

Source	Sum of Squares	df	Mean Square	F	Sig.
SPECIES	150.615	7	21.5165	20.7970	0.0000
HABITAT	39.570	4	9.8925	9.5617	0.0000
SEASON	437.220	2	218.6099	211.3000	0.0000
SPECIES * HABITAT	46.579	11	4.2345	4.0929	0.0000
SPECIES * SEASON	492.126	14	35.1519	33.9765	0.0000
HABITAT * SEASON	172.059	8	21.5074	20.7882	0.0000
SPECIES * HABITAT * SEASON	24.379	22	1.1082	1.0711	0.3817
Error	195.539	189	1.0346		
Total	**244009.030**	**258**			

Table – E : Mean Water Temperature of different habitats and seasons along with *Macrobrachium species*

Season	Name of Species	River		Beel		Pond		Swamp		PF	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Pre monsoon	**M. dayanum**	32.560	1.081	30.475	0.964	29.850	0.827	29.550	0.597	29.350	0.911
	M. assamensis	32.560	1.081	30.475	0.964	29.850	0.827	29.550	0.597	29.350	0.911
	M. birmanicum choprae	32.700	0.983	30.025	0.479						
	M. malcolmsonii	32.700	0.983	27.725	1.544						
	M. menoni	32.700	0.983	30.025	0.479						
	M. lamarrie	32.700	0.983	31.825	0.946			31.800	1.473		
	M. altifrons	32.700	0.983	31.825	0.946						
	M. tiwari	32.700	0.983	31.825	0.946						
Pre monsoon Total		32.659	0.903	30.525	1.564	29.850	0.765	30.164	1.324	29.350	0.843
Monsoon	**M. dayanum**	33.333	0.404	33.367	0.551	32.800	0.726	32.767	0.351	32.550	0.597
	M. assamensis	33.333	0.404	33.367	0.551	32.800	0.726	32.767	0.351	32.550	0.597
	M. birmanicum choprae	33.867	0.404	32.700	0.497						
	M. malcolmsonii	33.667	0.153	30.025	0.479						
	M. menoni	33.867	0.404	32.700	0.497						
	M. lamarrie	33.900	0.392	33.267	0.503			32.733	0.306		
	M. altifrons	33.900	0.392	33.267	0.503						
	M. tiwari	33.900	0.392	33.267	0.503						
Monsoon Total		33.741	0.399	32.641	1.225	32.800	0.672	32.756	0.292	32.550	0.553
Retreating monsoon	**M. dayanum**	23.400	0.864	25.200	0.400	27.475	0.737	27.000	1.707	27.725	1.031
	M. assamensis	23.400	0.864	25.200	0.400	27.475	0.737	27.000	1.707	27.725	1.031
	M. birmanicum choprae	27.625	1.524	27.540	0.984						
	M. malcolmsonii	33.867	0.404	32.700	0.497						
	M. menoni	33.867	0.404	32.825	0.714						
	M. lamarrie	26.250	3.688	27.633	1.069			27.600	1.768		
	M. altifrons	27.750	1.550	27.633	1.069						
	M tiwari	27.750	1.550	27.633	1.069						
Retreating monsoon total		27.597	3.946	28.561	2.954	27.475	0.682	27.200	1.590	27.725	0.954

Table E_I : Results of Analysis of variance (ANOVA) for Water Temperature

Source	Sum of Squares	df	Mean Square	F	Sig.
SPECIES	12.788	7	1.8269	1.9286	0.0676
HABITAT	55.179	4	13.7947	14.5630	0.0000
SEASON	1313.142	2	656.5712	693.1399	0.0000
SPECIES * HABITAT	0.960	11	0.0872	0.0921	0.9999
SPECIES * SEASON	26.206	14	1.8719	1.9761	0.0219
HABITAT * SEASON	39.677	8	4.9597	5.2359	0.0000
SPECIES * HABITAT * SEASON	12.676	22	0.5762	0.6083	0.9145
Error	167.662	177	0.9472		
Total	**202173.420**	**246**			

Table – F : Mean Total Hardness of different habitats and seasons along with *Macrobrachium species*

Season	Name of Species	River		Beel		Pond		Swamp		PF	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Pre monsoon	**M. dayanum**	73.880	34.418	75.380	41.689	86.280	41.856	89.200	36.322	79.100	46 456
	M. assamensis	73.880	34.418	75.380	41.689	86.280	41.856	89.200	36.322	79.100	46.456
	M. birmanicum choprae	78.920	32.950	78.300	42.868						
	M. malcolmsonii	78.920	32.950	78.300	42.868						
	M. menoni	78.920	32.950	78.300	42.868						
	M. lamarrie	76.960	34.270	72.880	43.097			79.325	44.025		
	M. altifrons	71.440	36.256	73.040	43.549						
	M. tiwari	71.440	36.256	73.040	43.549						
Pre monsoon Total		75.545	31.254	75.578	38.819	86.280	39.462	86.731	35.870	79.100	43.010
Monsoon	**M. dayanum**	65.200	19.090	72.050	13.877	70.450	18.170	58.650	12.968	80.900	26.013
	M. assamensis	65.200	19.090	72.050	13.877	70.450	18.170	58.650	12.968	80.900	26 013
	M. birmanicum choprae	63.980	17.076	72.580	12.553						
	M. malcolmsonii	63.980	17.076	72.580	12.553						
	M. menoni	63.980	17.076	72 580	12.553						
	M. lamarrie	64.975	19.731	71.500	13.118			61.175	15.639		
	M. altifrons	61.925	18.790	72.250	13.128						
	M. tiwari	61.925	18.790	72.250	13.128						
Monsoon Total		63.903	16.289	72.260	11.633	70.450	16.822	59.492	12.648	80.900	24 084
Retreating monsoon	**M. dayanum**	105.180	15.193	128.750	5.049	89.833	8.046	108.875	13 577	123.800	6.809
	M. assamensis	105.180	15.193	128.750	5.049	89.833	8 046	108 875	13.577	123.800	6.809
	M. birmanicum choprae	90.520	25.373	129.175	5.890						
	M. malcolmsonii	90.520	25.373	129.175	5.890						
	M. menoni	90.520	25.373	129.175	5.890						
	M lamarrie	105.740	15.036	128.150	5.379			103.925	12.297		
	M. altifrons	105.940	14.703	128.700	5.565						
	M. tiwari	105.940	14.703	128.700	5.565						
Retreating monsoon total		99.943	19.175	128 822	4.890	89.833	7.197	107.225	12.154	123.800	6 090

Table F_I : Results of Analysis of variance (ANOVA) for Total Hardness

Source	Sum of Squares	df	Mean Square	F	Sig.
SPECIES	118.944	7	16.9921	0.0227	1.0000
HABITAT	10423.731	4	2605.9327	3.4882	0.0086
SEASON	52890.531	2	26445.2653	35.3991	0.0000
SPECIES * HABITAT	472.006	11	42.9097	0.0574	1.0000
SPECIES * SEASON	1420.946	14	101.4961	0.1359	0.9999
HABITAT * SEASON	15070.481	8	1883.8102	2.5216	0.0119
SPECIES * HABITAT * SEASON	941.424	22	42.7920	0.0573	1.0000
Error	178547.670	239	747.0614		
Total	**2552457.830**	**308**			

Table – G : Mean Conductivity of different habitats and seasons along with *Macrobrachium species*

Name of Species	Habitat	Pre-monsoon		Monsoon		Retr. Monsoon	
		Mean	SD	Mean	SD	Mean	SD
M. dayanum	RI	95.083	9.618	184.383	25.066	154.040	11.412
	BL	101.750	6.283	198.767	13.349	117.700	14.163
	PN	76.233	21.518	156.733	33.809	105.633	8.458
	SW	86.275	17.364	152.733	23.456	97.333	4.508
	PF	76.733	21.257	190.067	16.743	106.133	7.726
M. assamensis	RI	95.083	9.618	184.383	25.066	154.040	11.412
	BL	101.750	6.283	198.767	13.349	117.700	14.163
	PN	76.233	21.518	156.733	33.809	105.633	8.458
	SW	86.275	17.364	152.733	23.456	97.333	4.508
	PF	76.733	21.257	190.067	16.743	106.133	7.726
M. birmanicum choprae	RI	95.667	9.292	177.140	25.562	154.925	11.971
	BL	101.600	6.189	201.620	9.838	119.900	13.040
M. malcolmsonii	RI	95.667	9.292	177.120	25.596	154.925	11.971
	BL	101.600	6.189	201.620	9.838	119.900	13.040
M menoni	RI	95.667	9.292	177.140	25.562	154.925	11.971
	BL	101.600	6.189	201.620	9.838	119.900	13.040
M. lamarrie	RI	85.920	17.531	180.275	29.595	156.000	13.372
	BL	101.850	6.214	189.667	22.027	121.000	12.753
	SW	84.050	17.210	153.925	22.158	97.567	4.050
M. altifrons	RI	85.920	17.531	180.275	29.595	155.950	13.370
	BL	101.850	6.214	189.667	22.027	121.000	12.753
M. tiwari	RI	85.920	17.531	180.275	29.595	155.950	13.370
	BL	101.850	6.214	189.667	22.027	121.000	12.753

Table G_I : Results of Analysis of variance (ANOVA) for Conductivity

Source	Sum of Squares	df	Mean Square	F	Sig.
SPECIES	308.602	7	44.0859	0.1588	0.9926
HABITAT	25725.203	4	6431.3007	23.1692	0.0000
SEASON	219350.904	2	109675.4519	395.1136	0.0000
SPECIES * HABITAT	138.701	11	12.6092	0.0454	1.0000
SPECIES * SEASON	424.207	14	30.3005	0.1092	1.0000
HABITAT * SEASON	33078.642	8	4134.8302	14.8960	0.0000
SPECIES * HABITAT * SEASON	1116.187	22	50.7358	0.1828	1.0000
Error	57736.552	208	277.5796		
Total	**5437397.030**	**277**			

Table – H : Mean Transparency of different habitats and seasons along with *Macrobrachium species*

Name of Species	Habitat	Pre-monsoon		Monsoon		Retr. Monsoon	
		Mean	SD	Mean	SD	Mean	SD
M. dayanum	RI	58.883	12.462	44.420	6.988	61.383	12.999
	BL	46.025	6.912	37.400	2.030	49.400	5.687
	PN	44.850	8.177	36.075	1.544	60.475	1.979
	SW	31.733	2.801	23.850	4.086	31.600	2.173
	PF	31.500	5.943	31.100	2.094	42.325	2.012
M. assamensis	RI	58.883	12.462	44.420	6.988	61.383	12.999
	BL	46.025	6.912	37.400	2.030	49.400	5.687
	PN	44.850	8.177	36.075	1.544	60.475	1.979
	SW	31.733	2.801	23.850	4.086	31.600	2.173
	PF	31.500	5.943	31.100	2.094	42.325	2.012
M. birmanicum choprae	RI	58.767	12.482	45.960	6.790	56.200	13.823
	BL	48.620	6.119	37.440	1.613	48.800	5.085
M. malcolmsonii	RI	58.767	12.482	45.960	6.790	56.200	13.823
	BL	48.620	6.119	37.440	1.613	48.800	5.085
M. menoni	RI	58.767	12.482	45.960	6.790	56.200	13.823
	BL	48.620	6.119	37.440	1.613	48.800	5.085
M. lamarrie	RI	48.260	29.908	48.425	7.810	60.725	14.784
	BL	49.000	6.570	37.633	1.150	50.100	5.624
	SW	31.175	2.011	23.550	3.804	31.700	2.663
M. altifrons	RI	60.325	14.907	48.425	7.810	60.725	14.784
	BL	49.000	6.570	37.633	1.150	50.100	5.624
M. tiwari	RI	60.325	14.907	48.425	7.810	60.725	14.784
	BL	49.000	6.570	37.633	1.150	50.100	5.624

Table H_I- : Results of Analysis of variance (ANOVA) for Transparency

Source	Sum of Squares	df	Mean Square	F	Sig.
SPECIES	107.775	7	15.3964	0.1827	0.9887
HABITAT	17223.003	4	4305.7507	51.0983	0.0000
SEASON	5134.560	2	2567.2801	30.4671	0.0000
SPECIES * HABITAT	96.103	11	8.7367	0.1037	0.9999
SPECIES * SEASON	287.203	14	20.5145	0.2435	0.9979
HABITAT * SEASON	1118.231	8	139.7788	1.6588	0.1094
SPECIES * HABITAT * SEASON	330.039	22	15.0018	0.1780	1.0000
Error	19717.788	234	84.2641		
Total	**712335.950**	**303**			

Table – I : Mean Dissolved Oxygen of different habitats and seasons along with *Macrobrachium species*

Name of Species	Habitat	Pre-monsoon		Monsoon		Retr. Monsoon	
		Mean	SD	Mean	SD	Mean	SD
M. dayanum	RI	7.660	1.352	6.025	0.768	7.540	1.488
	BL	7.660	1.352	6.025	0.768	7.540	1.488
	PN	7.540	1.513	6.160	0.730	7.780	1.455
	SW	7.540	1.513	6.160	0.730	7.780	1.455
	PF	7.540	1.513	6.160	0.730	7.780	1.455
M. assamensis	RI	7.640	1.405	6.200	0.804	7.500	1.317
	BL	7.667	1.329	6.220	0.722	7.667	1.378
	PN	7.667	1.329	6.220	0.722	7.667	1.378
	SW	8.200	1.286	6.075	0.613	8.960	1.488
	PF	8.200	1.286	6.075	0.613	8.960	1.488
M. birmanicum choprae	RI	8.340	1.137	6.080	0.545	9.380	1.564
	BL	8.340	1.137	6.080	0.545	9.380	1.564
M. malcolmsonii	RI	8.340	1.137	6.080	0.545	9.380	1.564
	BL	8.180	1.256	6.000	0.730	9.020	1.318
M. menoni	RI	8.440	1.137	6.140	0.555	9.400	1.380
	BL	8.440	1.137	6.140	0.555	9.400	1.380
M. lamarrie	RI	9.950	1.215	7.550	0.265	10.225	0.911
	BL	9.950	1.215	7.550	0.265	10.225	0.911
	SW	8.333	0.153	4.600	0.200	9.925	0.350
M. altifrons	RI	8.333	0.153	4.600	0.200	9.925	0.350
	BL	8.400	0.100	6.000	0.200	9.867	0.404
M. tiwari	RI	8.475	0.350	5.825	0.377	7.000	0.516
	BL	8.475	0.350	5.825	0.377	7.000	0.516

Table I_I - : Results of Analysis of variance (ANOVA) for Dissolved Oxygen

Source	Sum of Squares	df	Mean Square	F	Sig.
SPECIES	1.936	7	0.2765	0.2286	0.9782
HABITAT	105.060	4	26.2650	21.7176	0.0000
SEASON	261.470	2	130.7350	108.1004	0.0000
SPECIES * HABITAT	1.232	11	0.1120	0.0926	0.9999
SPECIES * SEASON	2.128	14	0.1520	0.1257	1.0000
HABITAT * SEASON	68.987	8	8.6234	7.1304	0.0000
SPECIES * HABITAT * SEASON	2.179	22	0.0990	0.0819	1.0000
Error	299.927	248	1.2094		
Total	**19588.870**	**317**			

Table – J : Mean P^H of different habitats and seasons along with *Macrobrachium species*

Name of Species	Habitat	Pre-monsoon		Monsoon		Retr. Monsoon	
		Mean	SD	Mean	SD	Mean	SD
M. dayanum	RI	6.575	0.634	7.075	0.640	7.150	0.700
	BL	7.675	0.457	7.800	0.300	8.975	1.072
	PN	7.567	0.306	7.500	0.265	7.567	0.306
	SW	7.500	0.300	7.800	0.200	7.633	0.252
	PF	7.500	0.100	7.967	0.231	7.867	0.153
M. assamensis	RI	6.575	0.634	7.075	0.640	7.150	0.700
	BL	7.675	0.457	7.800	0.300	8.975	1.072
	PN	7.567	0.306	7.500	0.265	7.567	0.306
	SW	7.500	0.300	7.800	0.200	7.633	0.252
	PF	7.500	0.100	7.967	0.231	7.867	0.153
M. birmanicum choprae	RI	12.740	13.242	7.025	0.634	7.125	0.685
	BL	7.675	0.377	7.700	0.440	9.080	0.923
M malcolmsonii	RI	6.740	0.669	7.025	0.634	7.125	0.685
	BL	7.675	0.377	7.700	0.440	9.080	0.923
M. menoni	RI	12.740	13.242	7.025	0.634	7.125	0.685
	BL	7.675	0.377	7.700	0.440	9.080	0.923
M. lamarrie	RI	6.740	0.669	7.025	0.634	7.125	0.685
	BL	7.675	0.377	7.875	0.377	7.675	0.377
	SW	7.500	0.200	7.800	0.300	7.700	0.200
M. altifrons	RI	6.625	0.714	7.025	0.634	7.125	0.685
	BL	7.675	0.377	7.875	0.377	7.675	0.377
M. tiwari	RI	6.625	0.714	7.025	0.634	7.125	0.685
	BL	7.675	0.377	7.875	0.377	7.675	0.377

Table J_I - : Results of Analysis of variance (ANOVA) for P^H

Source	Sum of Squares	df	Mean Square	F	Sig.
SPECIES	48.345	7	6.9065	0.9029	0.5053
HABITAT	16.235	4	4.0588	0.5306	0.7134
SEASON	4.343	2	2.1714	0.2839	0.7532
SPECIES * HABITAT	32.829	11	2.9844	0.3902	0.9588
SPECIES * SEASON	76.216	14	5.4440	0.7117	0.7611
HABITAT * SEASON	33.770	8	4.2212	0.5518	0.8161
SPECIES * HABITAT * SEASON	93.989	22	4.2722	0.5585	0.9456
Error	1461.014	191	7.6493		
Total	**17436.660**	**260**			

Table–K: Mean Total Alkalinity of different habitats and seasons along with *Macrobrachium species*

Name of Species	Habitat	Pre-monsoon		Monsoon		Retr. Monsoon	
		Mean	SD	Mean	SD	Mean	SD
M. dayanum	RI	58.380	13.698	57.750	12.949	62.625	15.107
	BL	88.300	16.674	66.725	13.053	79.975	6.155
	PN	75.675	14.989	49.500	7.928	77.600	9.143
	SW	77.125	11.997	72.000	9.798	69.633	8.021
	PF	80.075	11.508	59.367	7.953	82.300	10.835
M. assamensis	RI	58.380	13.698	57.750	12.949	62.625	15.107
	BL	88.300	16.674	66.725	13.053	79.975	6.155
	PN	75.675	14.989	49.500	7.928	77.600	9.143
	SW	77.125	11.997	72.000	9.798	69.633	8.021
	PF	80.075	11.508	59.367	7.953	82.300	10.835
M. birmanicum choprae	RI	57.420	15.377	52.700	16.646	63.625	15.557
	BL	80.400	12.311	68.675	12.441	79.500	5.881
M. malcolmsonii	RI	57.420	15.377	52.700	16.646	63.625	15.557
	BL	80.400	12.311	68.675	12.441	79.500	5.881
M. menoni	RI	57.420	15.377	52.700	16.646	63.625	15.557
	BL	80.400	12.311	68.675	12.441	79.500	5.881
M. lamarrie	RI	56.375	16.880	56.325	16.956	67.500	15.460
	BL	82.425	12.108	68.550	12.605	77.633	7.130
	SW	74.550	11.525	72.933	9.265	70.500	8.253
M. altifrons	RI	57.360	15.374	57.567	17.459	64.367	17.281
	BL	84.600	12.604	69.400	15.617	79.300	7.051
M. tiwari	RI	57.360	15.374	57.567	17.459	64.367	17.281
	BL	84.600	12.604	69.400	15.617	79.300	7.051

Table K_I - : Results of Analysis of variance (ANOVA) for Total Alkalinity

Source	Sum of Squares	df	Mean Square	F	Sig.
SPECIES	137.573	7	19.6532	0.1130	0.9974
HABITAT	16271.314	4	4067.8285	23.3922	0.0000
SEASON	5210.712	2	2605.3561	14.9822	0.0000
SPECIES * HABITAT	29.248	11	2.6589	0.0153	1.0000
SPECIES * SEASON	177.933	14	12.7095	0.0731	1.0000
HABITAT * SEASON	3977.215	8	497.1519	2.8589	0.0050
SPECIES * HABITAT * SEASON	311.211	22	14.1459	0.0813	1.0000
Error	34431.628	198	173.8971		
Total	**1325746.110**	**267**			

Table–L: Mean Free Carbondioxide of different habitats and seasons along with *Macrobrachium species*

Name of Species	Habitat	Pre-monsoon		Monsoon		Retr. Monsoon	
		Mean	SD	Mean	SD	Mean	SD
M. dayanum	RI	4.620	1.045	5.080	0.691	5.680	0.986
	BL	4.050	0.465	6.700	0.100	4.675	0.457
	PN	4.650	0.387	7.425	0.299	6.025	0.608
	SW	4.525	0.685	7.200	0.365	4.575	0.634
	PF	4.467	0.252	6.650	0.465	4.550	0.569
M. assamensis	RI	4.620	1.045	5.080	0.691	5.680	0.986
	BL	4.050	0.465	6.700	0.100	4.675	0.457
	PN	4.650	0.387	7.425	0.299	6.025	0.608
	SW	4.525	0.685	7.200	0.365	4.575	0.634
	PF	4.467	0.252	6.650	0.465	4.550	0.569
M. birmanicum choprae	RI	4.600	1.077	5.280	0.773	5.820	0.669
	BL	3.925	0.350	6.933	0.153	4.725	0.377
M. malcolmsonii	RI	4.600	1.077	5.280	0.773	5.820	0.669
	BL	3.925	0.350	6.933	0.153	4.725	0.377
M. menoni	RI	4.600	1.077	5.280	0.773	5.820	0.669
	BL	3.925	0.350	6.933	0.153	4.725	0.377
M lamarrie	RI	4.600	1.147	5.150	0.751	5.850	0.854
	BL	3.950	0.311	6.767	0.153	4.600	0.500
	SW	4.625	0.665	7.125	0.299	4.650	0.557
M. altifrons	RI	4.500	1.077	5.050	0.806	5.850	0.854
	BL	3.975	0.263	6.800	0.100	4.600	0.337
M. tiwari	RI	4.500	1.077	5.050	0.806	5.850	0.854
	BL	3.975	0.263	6.800	0.100	4.600	0.337

Table L_I -: Results of Analysis of variance (ANOVA) for Free carbondiaoxide

Source	Sum of Squares	df	Mean Square	F	Sig.
SPECIES	0.299	7	0.0428	0.0951	0.9985
HABITAT	14.642	4	3.6605	8.1374	0.0000
SEASON	140.676	2	70.3382	156.3623	0.0000
SPECIES * HABITAT	0.054	11	0.0049	0.0109	1.0000
SPECIES * SEASON	0.423	14	0.0302	0.0671	1.0000
HABITAT * SEASON	91.201	8	11.4001	25.3426	0.0000
SPECIES * HABITAT * SEASON	0.287	22	0.0130	0.0290	1.0000
Error	96.266	214	0.4498		
Total	**8124.960**	**283**			

Table–M: Mean Average Phosphorus of different habitats and seasons along with *Macrobrachium species*

Name of Species	Habitat	Pre-monsoon		Monsoon		Retr. Monsoon	
		Mean	SD	Mean	SD	Mean	SD
M. dayanum	1	0.240	0.020	0.303	0.068	0.273	0.035
	2	0.270	0.020	0.373	0.040	0.373	0.040
	3	0.403	0.118	0.473	0.078	0.455	0.070
	4	0.433	0.092	0.483	0.082	0.480	0.098
	5	0.608	0.195	1.215	0.464	1.170	0.443
M. assamensis	1	0.240	0.020	0.303	0.068	0.273	0.035
	2	0.270	0.020	0.373	0.040	0.373	0.040
	3	0.403	0.118	0.473	0.078	0.455	0.070
	4	0.433	0.092	0.483	0.082	0.480	0.098
	5	0.608	0.195	1.215	0.464	1.170	0.443
M. birmanicum choprae	1	0.240	0.020	0.303	0.068	0.273	0.035
	2	0.270	0.020	0.373	0.040	0.373	0.040
M. malcolmsonii	1	0.240	0.020	0.303	0.068	0.273	0.035
	2	0.270	0.020	0.373	0.040	0.373	0.040
M. menoni	1	0.240	0.020	0.303	0.068	0.273	0.035
	2	0.270	0.020	0.373	0.040	0.373	0.040
M. lamarrie	1	0.240	0.020	0.303	0.068	0.273	0.035
	2	0.270	0.020	0.373	0.040	0.373	0.040
	4	0.433	0.092	0.483	0.082	0.480	0.098
M. altifrons	1	0.243	0.025	0.320	0.040	0.277	0.040
	2	0.277	0.021	0.373	0.042	0.360	0.040
M. tiwari	1	0.243	0.025	0.320	0.040	0.277	0.040
	2	0.277	0.021	0.373	0.042	0.360	0.040

Table M_I -: Results of Analysis of variance (ANOVA) for Average Phosphorus

Source	Sum of Squares	df	Mean Square	F	Sig.
SPECIES	0.000	7	0.0000	0.0015	1.0000
HABITAT	7.660	4	1.9151	94.5480	0.0000
SEASON	0.774	2	0.3871	19.1090	0.0000
SPECIES * HABITAT	0.001	11	0.0001	0.0030	1.0000
SPECIES * SEASON	0.001	14	0.0001	0.0031	1.0000
HABITAT * SEASON	1.158	8	0.1448	7.1478	0.0000
SPECIES * HABITAT * SEASON	0.001	22	0.0000	0.0013	1.0000
Error	3.221	159	0.0203		
Total	**55.345**	**228**			

Table–N: Mean Chloride of different habitats and seasons along with *Macrobrachium species*

Season	Name of Species	River		Beel		Pond		Swamp		PF	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Pre monsoon	**M. dayanum**	15.525	2.732	18.775	1.340	17.567	2.060	16.775	3.014	18.500	1.900
	M assamensis	15.525	2.732	18.775	1.340	17.567	2.060	16.775	3.014	18.500	1.900
	M. birmanicum choprae	15.500	2.486	18.775	1.387						
	M. malcolmsonii	15.500	2.486	18.775	1.387						
	M. menoni	15.500	2.486	18.775	1.387						
	M lamarrie	15.475	2.626	18.825	1.323			16.775	2.958		
	M. altifrons	15.950	2.665	18.850	1.323						
	M tiwari	15.950	2.665	18.850	1.323						
Pre monsoon Total		15.616	2.306	18.800	1.189	17.567	1.842	16.775	2.709	18 500	1.699
Monsoon	**M. dayanum**	19.850	3.325	20.600	1.761	15.833	1.750	17.000	2.229	14.867	1.801
	M assamensis	19.850	3.325	20.600	1.761	15.833	1.750	17.000	2.229	14.867	1.801
	M. birmanicum choprae	20.560	3.369	20.700	1.817						
	M. malcolmsonii	20.560	3.369	20.700	1.817						
	M. menoni	20.560	3.369	20.700	1.817						
	M. lamarrie	20.150	3.814	20.225	1.765			16.700	2.022		
	M. altifrons	20.475	3.634	20.525	1.839						
	M. tiwari	20.475	3.634	20 525	1.839						
Monsoon Total		20.331	3.108	20.572	1.593	15.833	1.565	16.900	1.961	14.867	1.611
Retreating monsoon	**M. dayanum**	16.825	3.019	16.175	1.727	16.167	2.950	18.067	2.155	19 367	2 159
	M assamensis	16.825	3.019	16.175	1.727	16 167	2.950	18.067	2.155	19.367	2.159
	M. birmanicum choprae	20.980	5.275	16.725	1 852						
	M malcolmsonii	20.980	5.275	16.725	1.852						
	M. menoni	20.980	5.275	16.725	1.852						
	M lamarrie	16 600	3.412	16.433	2.350			18 300	2.200		
	M altifrons	17 125	2.988	16.775	1.910						
	M tiwari	17.125	2.988	16.775	1.910						
Retreating monsoon total		18 709	4.280	16.568	1.670	16.167	2.639	18.144	1.883	19 367	1.931

Table N$_I$ -: Results of Analysis of variance (ANOVA) for Chloride

Source	Sum of Squares	df	Mean Square	F	Sig.
SPECIES	31.631	7	4.5187	0.6240	0.7357
HABITAT	45.344	4	11.3359	1.5655	0.1850
SEASON	21.206	2	10.6032	1.4643	0.2338
SPECIES * HABITAT	19.766	11	1.7969	0.2482	0.9934
SPECIES * SEASON	46.166	14	3.2976	0.4554	0.9534
HABITAT * SEASON	440.968	8	55.1210	7.6121	0.0000
SPECIES * HABITAT * SEASON	38.989	22	1.7722	0.2447	0.9998
Error	1419.287	196	7.2413		
Total	**89419.990**	**265**			

Table–O : Mean Nitrate of different habitats and seasons along with *Macrobrachium species*

Season	Name of Species	River		Beel		Pond		Swamp		PF	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Pre monsoon	**M. dayanum**	0.030	0.010	0.210	0.141	0.343	0.256	0.480	0.382	0.230	0.144
	M assamensis	0.030	0.010	0.210	0.141	0.343	0.256	0.480	0.382	0 230	0.144
	M birmanicum choprae	0.030	0.010	0.222	0.127						
	M malcolmsonii	0.030	0.010	0.222	0.127						
	M menoni	0.030	0.010	0.222	0.127						
	M. lamarrie	0 240	0.203	0.200	0.142			0.432	0.259		
	M altifrons	0.270	0.176	0.272	0.168						
	M tiwari	0.270	0.176	0.272	0.168						
Pre monsoon Total		0.128	0.157	0.231	0.132	0.343	0.237	0 462	0.310	0.230	0.133
Monsoon	**M. dayanum**	0.220	0.052	0.345	0.128	0.333	0.091	0.657	0.222	1.220	0.361
	M. assamensis	0.220	0.052	0.345	0.128	0 333	0.091	0.657	0.222	1.220	0.361
	M. birmanicum choprae	0.223	0.053	0.344	0.118						
	M. malcolmsonii	0.223	0.053	0.344	0.118						
	M menoni	0.223	0.053	0.344	0.118						
	M. lamarrie	0.225	0.050	0.340	0.151			0.647	0.219		
	M altifrons	0.327	0.150	0.348	0.100						
	M tiwari	0.327	0 150	0.348	0 100						
Monsoon Total		0.243	0.081	0.345	0.106	0.333	0.081	0.653	0.192	1.220	0.334
Retreating monsoon	**M. dayanum**	0.200	0.151	0.218	0.128	0.260	0.171	0.493	0.319	1.103	0 493
	M assamensis	0.200	0.151	0.218	0.128	0.260	0.171	0.493	0 319	1.103	0.493
	M birmanicum choprae	0.184	0.128	0.380	0.358						
	M. malcolmsonii	0.184	0.128	0.380	0.358						
	M. menoni	0 184	0.128	0.380	0.358						
	M lamarrie	0.200	0.120	0.350	0.040			0.613	0.406		
	M altifrons	0.218	0.128	0.270	0.151						
	M tiwari	0.218	0.128	0 270	0.151						
Retreating monsoon total		0.197	0.116	0 313	0.242	0.260	0.153	0 525	0.312	1.103	0.457

Table O_I -: Results of Analysis of variance (ANOVA) for Nitrate

Source	Sum of Squares	df	Mean Square	F	Sig.
SPECIES	0.159	7	0.0228	0.5183	0.8202
HABITAT	8.075	4	2.0187	45.9501	0.0000
SEASON	1.883	2	0.9415	21.4304	0.0000
SPECIES * HABITAT	0.167	11	0.0152	0.3449	0.9743
SPECIES * SEASON	0.200	14	0.0143	0.3258	0.9902
HABITAT * SEASON	3.186	8	0.3983	9.0653	0.0000
SPECIES * HABITAT * SEASON	0.138	22	0.0063	0.1427	1.0000
Error	8.874	202	0.0439		
Total	**56.034**	**271**			

Table – I : Mean of Organic Carbon of soil in different habitats and seasons along with the *Macrobrachium* spp.

Name of Species	Habitat	Pre-monsoon		Monsoon		Retr. Monsoon	
		Mean	SD	Mean	SD	Mean	SD
M. dayanum	RI	5.340	1.785	5.180	1.616	5.160	1.764
	BL	5.680	1.654	5.340	1.172	6.650	0.881
	PN	5.425	1.775	5.350	1.245	6.525	0.640
	SW	5.680	1.238	6.700	1.943	7.100	0.622
	PF	6.175	1.021	6.925	1.156	7.525	0.591
M. assamensis	RI	5.340	1.785	5.180	1.616	5.160	1.764
	BL	5.680	1.654	5.340	1.172	6.650	0.881
	PN	5.425	1.775	5.350	1.245	6.525	0.640
	SW	5.680	1.238	6.700	1.943	7.100	0.622
	PF	6.175	1.021	6.925	1.156	7.525	0.591
M. birmanicum choprae	RI	4.900	1.694	5.120	1.648	4.940	1.730
	BL	5.580	1.704	5.075	1.289	6.600	0.833
M. malcolmsonii	RI	4.900	1.694	5.120	1.648	4.940	1.730
	BL	5.580	1.704	5.075	1.289	6.600	0.833
M. menoni	RI	4.900	1.694	5.120	1.648	4.940	1.730
	BL	5.580	1.704	5.075	1.289	6.600	0.833
M. lamarrie	RI	4.900	1.694	5.120	1.648	4.940	1.730
	BL	5.580	1.704	5.075	1.289	6.600	0.833
	SW	5.680	1.238	6.700	1.943	7.100	0.622
M. altifrons	RI	4.900	1.694	5.120	1.648	4.940	1.730
	BL	5.580	1.704	5.075	1.289	6.600	0.833
M. tiwari	RI	4.900	1.694	5.120	1.648	4.940	1.730
	BL	5.580	1.704	5.075	1.289	6.600	0.833

Table – I_a : Results of Analysis of variance (ANOVA) for Organic Carbon in Soil

Source	Sum of Squares	df	Mean Square	F	Sig.
SPECIES	1.287	7	0.1838	0.0847	0.9990
HABITAT	79.996	4	19.9991	9.2131	0.0000
SEASON	29.909	2	14.9543	6.8891	0.0012
SPECIES * HABITAT	0.327	11	0.0297	0.0137	1.0000
SPECIES * SEASON	0.125	14	0.0089	0.0041	1.0000
HABITAT * SEASON	34.921	8	4.3651	2.0109	0.0458
SPECIES * HABITAT * SEASON	0.591	22	0.0269	0.0124	1.0000
Error	529.656	244	2.1707		
Total	**10721.720**	**313**			

ABBREVIATION : **RI**- River, **BL**- Beel, **PN**- Pond, **SW**- Swamp, **PF**- Paddy Filed, **df**- Degree of Freedom , **Sig.** – Significance

Table – II : Mean of Organic Matter of soil in different habitats and seasons along with the *Macrobrachium* spp.

Name of Species	Habitat	Pre-monsoon		Monsoon		Retr. Monsoon	
		Mean	SD	Mean	SD	Mean	SD
M. dayanum	RI	9.980	2.303	9.040	2.361	10.420	2.257
	BL	9.740	2.993	9.060	2.078	11.400	1.608
	PN	8.767	2.540	9.460	2.147	11.380	1.339
	SW	9.800	2.163	10.020	3.500	13.640	0.902
	PF	10.860	1.846	12.067	2.778	12.320	0.856
M. assamensis	RI	9.980	2.303	9.040	2.361	10.420	2.257
	BL	9.740	2.993	9.060	2.078	11.400	1.608
	PN	8.767	2.540	9.460	2.147	11.380	1.339
	SW	9.800	2.163	10.020	3.500	13.640	0.902
	PF	10.860	1.846	12.067	2.778	12.320	0.856
M. birmanicum choprae	RI	9.980	2.303	9.040	2.361	10.420	2.257
	BL	9.740	2.993	9.060	2.078	11.400	1.608
M. malcolmsonii	RI	9.980	2.303	9.040	2.361	10.420	2.257
	BL	9.740	2.993	9.060	2.078	11.400	1.608
M. menoni	RI	9.980	2.303	9.040	2.361	10.420	2.257
	BL	9.740	2.993	9.060	2.078	11.400	1.608
M. lamarrie	RI	9.980	2.303	9.040	2.361	10.420	2.257
	BL	9.740	2.993	9.060	2.078	11.400	1.608
	SW	9.800	2.163	10.020	3.500	13.640	0.902
M. altifrons	RI	9.980	2.303	9.040	2.361	10.420	2.257
	BL	9.740	2.993	9.060	2.078	11.400	1.608
M. tiwari	RI	9.980	2.303	9.040	2.361	10.420	2.257
	BL	9.740	2.993	9.060	2.078	11.400	1.608

Table – II_a : Results of Analysis of variance (ANOVA) for Organic Matter in Soil

Source	Sum of Squares	df	Mean Square	F	Sig.
SPECIES	0.000	7	0.0000	0.0000	1.0000
HABITAT	111.452	4	27.8629	5.2747	0.0004
SEASON	179.210	2	89.6048	16.9629	0.0000
SPECIES * HABITAT	0.000	11	0.0000	0.0000	1.0000
SPECIES * SEASON	0.000	14	0.0000	0.0000	1.0000
HABITAT * SEASON	80.056	8	10.0070	1.8944	0.0609
SPECIES * HABITAT * SEASON	0.000	22	0.0000	0.0000	1.0000
Error	1436.809	272	5.2824		
Total	**37563.550**	**341**			

Table – III : Mean of Magnesium of soil in different habitats and seasons along with the *Macrobrachium* spp.

Name of Species	Habitat	Pre-monsoon		Monsoon		Retr. Monsoon	
		Mean	SD	Mean	SD	Mean	SD
M. dayanum	RI	32.420	6.738	39.600	11.054	31.975	5.494
	BL	29.225	6.735	39.625	13.174	28.175	4.271
	PN	26.800	5.724	44.733	14.979	30.200	4.651
	SW	30.033	8.140	40.933	6.929	32.533	4.050
	PF	32.950	8.466	50.367	14.282	26.267	2.055
M. assamensis	RI	32.420	6.738	39.600	11.054	31.975	5.494
	BL	29.225	6.735	39.625	13.174	28.175	4.271
	PN	26.800	5.724	44.733	14.979	30.200	4.651
	SW	30.033	8.140	40.933	6.929	32.533	4.050
	PF	32.950	8.466	50.367	14.282	26.267	2.055
M. birmanicum choprae	RI	32.420	6.738	39.600	11.054	31.975	5.494
	BL	29.225	6.735	39.625	13.174	28.175	4.271
M. malcolmsonii	RI	32.420	6.738	39.600	11.054	31.975	5.494
	BL	29.225	6.735	39.625	13.174	28.175	4.271
M. menoni	RI	32.420	6.738	39.600	11.054	31.975	5.494
	BL	29.225	6.735	39.625	13.174	28.175	4.271
M. lamarrie	RI	32.420	6.738	39.600	11.054	31.975	5.494
	BL	29.225	6.735	39.625	13.174	28.175	4.271
	SW	30.033	8.140	40.933	6.929	32.533	4.050
M. altifrons	RI	32.420	6.738	39.600	11.054	31.975	5.494
	BL	29.225	6.735	39.625	13.174	28.175	4.271
M. tiwari	RI	32.420	6.738	39.600	11.054	31.975	5.494
	BL	29.225	6.735	39.625	13.174	28.175	4.271

Table – III_a : Results of Analysis of variance (ANOVA) for Magnesium in Soil

Source	Sum of Squares	df	Mean Square	F	Sig.
SPECIES	0.000	7	0.0000	0.0000	1.0000
HABITAT	403.194	4	100.7984	1.4149	0.2304
SEASON	5106.730	2	2553.3648	35.8406	0.0000
SPECIES * HABITAT	0.000	11	0.0000	0.0000	1.0000
SPECIES * SEASON	0.000	14	0.0000	0.0000	1.0000
HABITAT * SEASON	820.298	8	102.5372	1.4393	0.1822
SPECIES * HABITAT * SEASON	0.000	22	0.0000	0.0000	1.0000
Error	13963.484	196	71.2423		
Total	**324439.750**	**265**			

Table – IV : Mean of Calcium of soil in different habitats and seasons along with the *Macrobrachium* spp.

Name of Species	Habitat	Pre-monsoon		Monsoon		Retr. Monsoon	
		Mean	SD	Mean	SD	Mean	SD
M. dayanum	RI	61.450	14.475	66.150	14.628	63.560	13.202
	BL	58.620	11.092	57.660	15.045	58.725	3.087
	PN	54.350	12.700	54.025	15.543	65.733	6.924
	SW	66.725	15.989	70.075	13.930	64.800	9.938
	PF	65.875	14.283	76.025	19.929	72.875	9.630
M. assamensis	RI	61.450	14.475	66.150	14.628	63.560	13.202
	BL	58.620	11.092	57.660	15.045	58.725	3.087
	PN	54.350	12.700	54.025	15.543	65.733	6.924
	SW	66.725	15.989	70.075	13.930	64.800	9.938
	PF	65.875	14.283	76.025	19.929	72.875	9.630
M. birmanicum choprae	RI	61.450	14.475	66.150	14.628	63.560	13.202
	BL	58.620	11.092	57.660	15.045	58.725	3.087
M. malcolmsonii	RI	61.450	14.475	66.150	14.628	63.560	13.202
	BL	58.620	11.092	57.660	15.045	58.725	3.087
M. menoni	RI	61.450	14.475	66.150	14.628	63.560	13.202
	BL	58.620	11.092	57.660	15.045	58.725	3.087
M. lamarrie	RI	61.450	14.475	66.150	14.628	63.560	13.202
	BL	58.620	11.092	57.660	15.045	58.725	3.087
	SW	66.725	15.989	70.075	13.930	64.800	9.938
M. altifrons	RI	61.450	14.475	66.150	14.628	63.560	13.202
	BL	58.620	11.092	57.660	15.045	58.725	3.087
M. tiwari	RI	61.450	14.475	66.150	14.628	63.560	13.202
	BL	58.620	11.092	57.660	15.045	58.725	3.087

Table – IV_a : Results of Analysis of variance (ANOVA) for Calcium in Soil

Source	Sum of Squares	df	Mean Square	F	Sig.
SPECIES	0.000	7	0.0000	0.0000	1.0000
HABITAT	4710.866	4	1177.7165	6.9019	0.0000
SEASON	393.001	2	196.5007	1.1516	0.3180
SPECIES * HABITAT	0.000	11	0.0000	0.0000	1.0000
SPECIES * SEASON	0.000	14	0.0000	0.0000	1.0000
HABITAT * SEASON	1159.883	8	144.9854	0.8497	0.5599
SPECIES * HABITAT * SEASON	0.000	22	0.0000	0.0000	1.0000
Error	38564.014	226	170.6372		
Total	**1188306.780**	**295**			

Table – V : Mean of Nitrate of soil in different habitats and seasons along with the *Macrobrachium* spp.

Name of Species	Habitat	Pre-monsoon		Monsoon		Retr. Monsoon	
		Mean	SD	Mean	SD	Mean	SD
M. dayanum	RI	0.235	0.070	0.457	0.055	0.280	0.066
	BL	0.257	0.071	0.470	0.047	0.330	0.050
	PN	0.293	0.112	0.488	0.087	0.333	0.116
	SW	0.363	0.125	0.560	0.136	0.503	0.136
	PF	0.490	0.161	0.677	0.111	0.507	0.241
M. assamensis	RI	0.235	0.070	0.457	0.055	0.280	0.066
	BL	0.257	0.071	0.470	0.047	0.330	0.050
	PN	0.293	0.112	0.488	0.087	0.333	0.116
	SW	0.363	0.125	0.560	0.136	0.503	0.136
	PF	0.490	0.161	0.677	0.111	0.507	0.241
M. birmanicum choprae	RI	0.210	0.070	0.465	0.047	0.290	0.057
	BL	0.254	0.055	0.480	0.050	0.258	0.058
M. malcolmsonii	RI	0.210	0.070	0.465	0.047	0.290	0.057
	BL	0.254	0.055	0.480	0.050	0.258	0.058
M. menoni	RI	0.210	0.070	0.465	0.047	0.290	0.057
	BL	0.254	0.055	0.480	0.050	0.258	0.058
M. lamarrie	RI	0.210	0.070	0.465	0.047	0.290	0.057
	BL	0.254	0.055	0.480	0.050	0.258	0.058
	SW	0.363	0.125	0.560	0.136	0.503	0.136
M. altifrons	RI	0.210	0.070	0.465	0.047	0.290	0.057
	BL	0.254	0.055	0.480	0.050	0.258	0.058
M. tiwari	RI	0.210	0.070	0.465	0.047	0.290	0.057
	BL	0.254	0.055	0.480	0.050	0.258	0.058

Table – V_a : Results of Analysis of variance (ANOVA) for Nitrate in Soil

Source	Sum of Squares	df	Mean Square	F	Sig.
SPECIES	0.004	7	0.0006	0.0722	0.9994
HABITAT	0.916	4	0.2291	29.8662	0.0000
SEASON	1.487	2	0.7433	96.9232	0.0000
SPECIES * HABITAT	0.004	11	0.0003	0.0440	1.0000
SPECIES * SEASON	0.007	14	0.0005	0.0678	1.0000
HABITAT * SEASON	0.091	8	0.0114	1.4878	0.1635
SPECIES * HABITAT * SEASON	0.017	22	0.0008	0.1005	1.0000
Error	1.526	199	0.0077		
Total	**41.397**	**268**			

Table – VI : Mean of P^H of soil in different habitats and seasons along with the *Macrobrachium* spp.

Name of Species	Habitat	Pre-monsoon		Monsoon		Retr. Monsoon	
		Mean	SD	Mean	SD	Mean	SD
M. dayanum	RI	5.700	0.392	6.650	0.342	6.850	0.342
	BL	6.600	0.200	6.433	0.252	6.400	0.400
	PN	6.467	0.252	6.567	0.252	6.567	0.351
	SW	6.025	0.377	6.800	0.400	6.433	0.404
	PF	6.375	0.512	6.700	0.337	6.467	0.252
M. assamensis	RI	5.700	0.392	6.650	0.342	6.850	0.342
	BL	6.600	0.200	6.433	0.252	6.400	0.400
	PN	6.467	0.252	6.567	0.252	6.567	0.351
	SW	6.025	0.377	6.800	0.400	6.433	0.404
	PF	6.375	0.512	6.700	0.337	6.467	0.252
M. birmanicum choprae	RI	5.750	0.387	6.675	0.350	6.800	0.337
	BL	6.600	0.183	6.450	0.208	6.375	0.350
M. malcolmsonii	RI	5.750	0.387	6.675	0.350	6.800	0.337
	BL	6.600	0.183	6.450	0.208	6.375	0.350
M. menoni	RI	5.750	0.387	6.675	0.350	6.800	0.337
	BL	6.600	0.183	6.450	0.208	6.375	0.350
M. lamarrie	RI	5.750	0.387	6.675	0.350	6.800	0.337
	BL	6.600	0.183	6.450	0.208	6.375	0.350
	SW	6.025	0.377	6.800	0.400	6.433	0.404
M. altifrons	RI	5.750	0.387	6.675	0.350	6.800	0.337
	BL	6.600	0.183	6.450	0.208	6.375	0.350
M. tiwari	RI	5.750	0.387	6.675	0.350	6.800	0.337
	BL	6.600	0.183	6.450	0.208	6.375	0.350

Table – VI_a : Results of Analysis of variance (ANOVA) for P^H in Soil

Source	Sum of Squares	df	Mean Square	F	Sig.
SPECIES	0.000	7	0.0000	0.0003	1.0000
HABITAT	0.443	4	0.1107	1.0036	0.4069
SEASON	4.947	2	2.4737	22.4181	0.0000
SPECIES * HABITAT	0.001	11	0.0001	0.0009	1.0000
SPECIES * SEASON	0.022	14	0.0016	0.0142	1.0000
HABITAT * SEASON	16.455	8	2.0568	18.6403	0.0000
SPECIES * HABITAT * SEASON	0.012	22	0.0005	0.0048	1.0000
Error	20.634	187	0.1103		
Total	**10684.800**	**256**			

Table –VII : Mean of Sulphate of soil in different habitats and seasons along with the *Macrobrachium* spp.

Name of Species	Habitat	Pre-monsoon		Monsoon		Retr. Monsoon	
		Mean	SD	Mean	SD	Mean	SD
M. dayanum	RI	3.975	0.873	5.650	1.256	5.800	1.210
	BL	2.700	0.416	5.640	1.780	5.100	1.581
	PN	3.050	0.597	5.575	1.127	5.225	1.228
	SW	3.850	0.854	6.250	1.245	5.650	1.320
	PF	4.100	1.117	6.950	1.269	5.775	1.176
M. assamensis	RI	3.975	0.873	5.650	1.256	5.800	1.210
	BL	2.700	0.416	5.640	1.780	5.100	1.581
	PN	3.050	0.597	5.575	1.127	5.225	1.228
	SW	3.850	0.854	6.250	1.245	5.650	1.320
	PF	4.100	1.117	6.950	1.269	5.775	1.176
M. birmanicum choprae	RI	3.975	0.873	5.650	1.256	5.800	1.210
	BL	2.700	0.416	5.640	1.780	5.100	1.581
M. malcolmsonii	RI	3.975	0.873	5.650	1.256	5.800	1.210
	BL	2.700	0.416	5.640	1.780	5.100	1.581
M. menoni	RI	3.975	0.873	5.650	1.256	5.800	1.210
	BL	2.700	0.416	5.640	1.780	5.100	1.581
M. lamarrie	RI	3.975	0.873	5.650	1.256	5.800	1.210
	BL	2.700	0.416	5.640	1.780	5.100	1.581
	SW	3.850	0.854	6.250	1.245	5.650	1.320
M. altifrons	RI	3.975	0.873	5.650	1.256	5.800	1.210
	BL	2.700	0.416	5.640	1.780	5.100	1.581
M. tiwari	RI	3.975	0.873	5.650	1.256	5.800	1.210
	BL	2.700	0.416	5.640	1.780	5.100	1.581

Table – VII_a : Results of Analysis of variance (ANOVA) for Sulphate in Soil

Source	Sum of Squares	df	Mean Square	F	Sig.
SPECIES	0.000	7	0.0000	0.0000	1.0000
HABITAT	39.819	4	9.9549	6.3606	0.0001
SEASON	207.712	2	103.8558	66.3585	0.0000
SPECIES * HABITAT	0.000	11	0.0000	0.0000	1.0000
SPECIES * SEASON	0.000	14	0.0000	0.0000	1.0000
HABITAT * SEASON	16.583	8	2.0728	1.3244	0.2323
SPECIES * HABITAT * SEASON	0.000	22	0.0000	0.0000	1.0000
Error	349.011	223	1.5651		
Total	**7918.600**	**292**			

Table –a : Mean value of Bodyweight, Bodylenght, Gonad weight, GSR and K-factor of four *Macrobachium* spp.

Species	Sex	Season	Bodyweight		Bodylength		Gonadweight		GSR		K factor	
			Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
M. dayanum	Male	PM	3.42	1.37	53.69	7.85	0.13	0.05	4.59	2.73	6.17	1.69
		MO	3.91	1.51	68.14	13.42	0.24	0.03	7.20	3.21	5.54	1.27
		RM	3.50	1.41	58.37	15.04	0.20	0.02	6.70	3.09	5 81	1.10
		WN	3.39	1.43	49.77	15.84	0.12	0.03	4.25	2 37	6.59	0.89
	Female	PM	3.77	0.25	54.27	3.46	0.29	0.04	7.59	0 59	6.94	0.23
		MO	4.70	0.26	66.68	3.50	0.41	0.03	8.73	0 49	7.05	0.02
		RM	4.00	0.28	57.30	4.38	0.40	0.05	9.86	0.54	6.98	0.04
		WN	3.23	0.25	48.20	2.46	0.28	0.03	8.65	0.28	6.71	0.46
M assamensis	Male	PM	3.49	1.61	46.26	20.36	0.13	0.04	4.83	2.99	7.46	0.34
		MO	3.51	1.54	49.12	21.69	0.23	0.02	8.27	4.39	7.15	0.33
		RM	3.59	1.60	49.20	19.17	0.24	0.01	8.10	4.35	7.12	0.71
		WN	3.54	1.60	48.37	18.94	0.17	0.04	5.86	3.31	7.13	0.59
	Female	PM	3.78	1.68	45.80	20.37	0.25	0.03	8.50	5.19	8.18	1.27
		MO	3.66	1.57	48.95	21.72	0.37	0.03	12.64	6 99	7.47	0 85
		RM	3.80	1.65	48.62	19.17	0.35	0.02	11 61	6.85	7 67	1.36
		WN	3.68	1.61	48.02	18.94	0.27	0.03	9.24	5.13	7.48	0.89
M. malcolmsonii	Male	PM	31.56	4.33	99.41	26.59	2.17	0.06	7.00	1.17	33.09	6.71
		MO	36.34	9.48	116.78	36.38	1.90	0.13	5.60	1.70	31.75	3.75
		RM	34.87	6.48	111.15	33.65	1.72	0.04	5.08	0.99	32.50	5.37
		WN	34.20	3.71	102.09	27.86	1.90	0.06	5.62	0 67	35.02	6.47
	Female	PM	43.90	3.92	102 47	6.10	4.51	0.66	10.41	2.28	42.91	4 00
		MO	41.98	7.10	117.20	3.63	2.70	0.35	6.47	0.71	35.94	7 07
		RM	33.85	2.19	113.15	3.75	2.04	0.08	6.03	0.14	29.90	0.95
		WN	34.37	1.20	102.50	3.95	2.68	0.87	7.75	2 25	33.59	2 47
M birmanicum choproae	Male	PM	37.41	8.53	114.41	33.41	2.11	0.03	5.89	1 28	33.29	2.63
		MO	43.72	9.32	133 72	36 15	1.98	0.06	4.73	1.10	33.25	2 47
		RM	40.25	11 55	121.62	41.80	1.79	0 03	4.78	1.40	33.78	2 88
		WN	39.64	9.88	266.81	474 16	1 94	0.07	5.18	1 38	32.47	11.58
	Female	PM	41.67	6.13	113.17	5.07	3.75	0.19	9.16	1 72	36.71	3.74
		MO	49.25	3.58	135.83	6.14	2 34	0 36	4.72	0.41	36.37	3 88
		RM	41.70	1.56	119.45	4.31	1.80	0.08	4.32	0.36	34.91	0 04
		WN	43.00	2.03	115 53	4.70	2 98	0.82	6 91	1.76	37 27	2.62

ABBREVIATION : **PM**- Pre-monsoon, **MO**- Monsoon, **RM**- Retreating Monsoon, WN- Winter, GSR- Ganado Somatic Ratio

Table –a_I : Result of Analysis of variance (ANOVA) for Bodyweight, Bodylenght, Gonad weight, GSR and K-factor of four *Macrobachium* spp.

Parameter	Source	Type III Sum of Squares	df	Mean Square	F	Sig.	p<0.05
Body Weight	SPECIES	51977	3	17325.726	638.844	0.000	*
	SEX	175	1	174.823	6.446	0.012	*
	SEASON	244	3	81.190	2.994	0.032	*
	SPECIES * SEX	142	3	47.253	1.742	0.160	NS
	SPECIES * SEASON	300	9	33.323	1.229	0.280	NS
	SEX * SEASON	97	3	32.381	1.194	0.313	NS
	SPECIES * SEX * SEASON	180	9	19.964	0.736	0.675	NS
	Error	4990	184	27.120			
	Total	**151221**	**216**				
Body Length	SPECIES	236033	3	78677.813	7.639	0.000	*
	SEX	3484	1	3483.785	0.338	0.562	NS
	SEASON	8445	3	2815.116	0.273	0.845	NS
	SPECIES * SEX	9864	3	3287.970	0.319	0.811	NS
	SPECIES * SEASON	29882	9	3320.238	0.322	0.967	NS
	SEX * SEASON	11352	3	3783.993	0.367	0.777	NS
	SPECIES * SEX * SEASON	30737	9	3415.172	0.332	0.964	NS
	Error	1895226	184	10300.143			
	Total	4032800	216				
Gonad weight	SPECIES	187	3	62.188	2279.035	0.000	*
	SEX	11	1	10.775	394.870	0.000	*
	SEASON	7	3	2.275	83.374	0.000	*
	SPECIES * SEX	7	3	2.184	80.038	0.000	*
	SPECIES * SEASON	11	9	1 208	44.260	0.000	*
	SEX * SEASON	4	3	1.407	51 557	0 000	*
	SPECIES * SEX * SEASON	5	9	0.579	21.221	0.000	*
	Error	5	184	0.027			
	Total	**505**	**216**				
Gonado Somatic Ratio	SPECIES	215	3	71.687	6.377	0 000	*
	SEX	229	1	228.709	20.345	0.000	*
	SEASON	10	3	3.398	0.302	0.824	NS
	SPECIES * SEX	46	3	15.322	1.363	0 256	NS
	SPECIES * SEASON	283	9	31.456	2.798	0 004	*
	SEX * SEASON	21	3	7.043	0.626	0.599	NS
	SPECIES * SEX * SEASON	30	9	3.322	0.296	0.975	NS
	Error	2068	184	11.242			
	Total	**13570**	**216**				
K Factor	SPECIES	30587	3	10195.753	718.848	0.000	*
	SEX	119	1	118.635	8 364	0.004	*
	SEASON	73	3	24.430	1.722	0.164	NS
	SPECIES * SEX	51	3	16.996	1 198	0.312	NS
	SPECIES * SEASON	128	9	14.233	1 004	0.439	NS
	SEX * SEASON	67	3	22 296	1.572	0.198	NS
	SPECIES * SEX * SEASON	167	9	18.583	1 310	0 234	NS
	Error	2610	184	14 183			
	Total	**119187**	**216**				

Table –b : **Mean value of Bodylenght, Bo+566dyweight, of four *Macrobachium* spp. With ANOVA Results showing length with relationship.**

Length

Species	season	1		2		3		4		5	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
M. dayanum	PM	54 8	10 4	60 5	7 5	57 1	6 9	50.3	17 9	45 35	15 15
	MO	70 5	18.1	70 6	22 4	63 55	20 95	61 7	18 9	50 7	17 9
	RM	58 25	20 15	57 35	18 85	64 15	24 05	61 5	25 1	47 9	16 7
M. assamensis	PM	51	19 2	51 4	19	49 6	18 8	43 8	18 6	39 65	18 85
	MO	52 7	22 1	53.55	25.05	51 4	21.2	46.35	21 85	41 45	19.05
	RM	50.9	19 4	53 3	20 9	51 7	18 9	47 9	17 3	41.45	17 05
M. birmanıcum ~~choprae~~	PM	112 1	32 1	102.4	34 1						
	MO	142 7	37 3	134 3	41 9						
	RM	123.5	47 1	118.35	46 15						
M malcolmnsonii	PM	103 35	29 15	94 3	31 9						
	MO	120 2	41 8	104 2	33 8						
	RM	116.15	40 05	106.15	33 95						

Length

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	p<0.05
SPECIES	64178.8	3	21392.917	31.965	0.000	*
SEASON	2621.0	2	1310.523	1.958	0.148	NS
HABITAT	2432.2	4	608.050	0.909	0.463	NS
SPECIES * SEASON	1603.0	6	267.174	0.399	0.878	NS
SPECIES * HABITAT	647.7	6	107.945	0.161	0.986	NS
SEASON * HABITAT	245.3	8	30.662	0.046	1 000	NS
SPECIES * SEASON * HABITAT	190.0	12	15.836	0.024	1.000	NS
Error	56217.8	84	669.259			
Total	**798921.7**	**126**				

Weight

Species	season	1		2		3		4		5	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
M dayanum	PM	3 45	1 63	3 72	1 48	3 63	1 47	3 4	1 68	3 19	1 63
	MO	3 75	1 67	3 84	1 88	3 8	1 88	3 49	1 53	3 41	1 71
	RM	3 43	1 65	3 42	1 6	3 78	1 86	3 67	1 95	3 29	1 69
M assamensıs	PM	3 525	1 725	3 63	1 79	3 58	1 78	3 27	1 59	3 14	1 58
	MO	3 53	1 75	3 54	1 82	3 53	1 71	3 41	1 77	3 37	1 75
	RM	3 575	1 725	4 08	2 12	3 7	1 62	3 39	1 57	3 28	1 58
M bırmanıcum ~~chopıae~~	PM	35 65	6 85	34	6 8						
	MO	46 3	9 9	45 15	10 45						
	RM	39 85	12 45	39 5	11 3						
M malcolmnsonıı	PM	29 75	6 65	31 3	3 1						
	MO	36 35	12 15	36 1	6 1						
	RM	34 05	8 75	35 65	5 15						

Weight

Source	Type III Sum of Squares	df	Mean Square	F	Sıg.	
SPECIES	20362 9	3	6787 649	281 492	0 000	*
SEASON	209 7	2	104 830	4 347	0 016	*
HABITAT	2 0	4	0 503	0 021	0 999	NS
SPECIES * SEASON	252 7	6	42 120	1 747	0 120	NS
SPECIES * HABITAT	9 5	6	1 588	0 066	0 999	NS
SEASON * HABITAT	1 9	8	0 232	0 010	1 000	NS
SPECIES * SEASON * HABITAT	3 6	12	0 302	0 013	1 000	NS
Error	2025 5	84	24 113			
Total	53180 1	126				

Table C : Showing average Gut Length of four *Macrobrachium* spices in different habitat

Habitat and Data											
		River		Beel		Pond		Swamp		Paddy field	
Species	**Season**	**Average of gut length**	**StdDev of gut length**	**Average of gut length**	**StdDev of gut length**	**Average of gut length**	**StdDev of gut length**	**Average of gut length**	**StdDev of gut length**	**Average of gut length**	**StdDev of gut length**
M. dayanum	PM	83.35	20.95	89.45	18 85	81 3	14.9	79.35	31.15	70.7	27.9
	MO	108.4	40.2	98.25	55.95	102.25	42.05	101.65	40.85	84.3	28 1
	RM	89.35	35.15	87.1	30 9	100.3	44.7	99.75	44.45	76.1	28.9
M. assamensis	PM	82.5	34.3	85.4	32.8	81.6	33.4	70.4	28.1	64.65	28.15
	MO	80.8	35.6	85.2	38.8	83.1	37.3	77.1	35.1	67.4	27.2
	RM	80.4	31 8	84.55	33.75	84.8	30.2	73 9	28 4	68 2	28
IM. birmanicum choprae	PM	176.3	61.1	158.3	60.1						
	MO	241.45	81.35	226.75	78.45						
	RM	209.55	100.95	195 5	98.7						
M. malcolmsonii	PM	155 6	57 2	142.7	57 9						
	MO	197	91.6	155.95	60.45						
	RM	170.45	77.95	159.4	60.8						

Table C$_1$: **Showing Length of four *Macrobrachium* spices of different habitat**

Length and Habitat											
		River		Beel		Pond		Swamp		Paddy field	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Species	**Season**										
M. dayanum	PM	54 8	10.4	60.5	7.5	57.1	6.9	50.3	17.9	45.35	15.15
	MO	70 5	18.1	70.6	22.4	63.55	20.95	61.7	18.9	50.7	17.9
	RM	58.25	20.15	57.35	18.85	64.15	24 05	61.5	25 1	47.9	16.7
M. assamensis	PM	51	19 2	51.4	19	49.6	18.8	43 8	18.6	39.65	18.85
	MO	52 7	22 1	53.55	25.05	51.4	21 2	46.35	21 85	41.45	19.05
	RM	50.9	19.4	53.3	20.9	51.7	18.9	47.9	17.3	41 6	17.2
M. birmanicum choprae	PM	112.1	32.1	102.4	34.1						
	MO	142 7	37.3	134.35	41.85						
	RM	123.5	47.1	118.35	46.15						
M. malcolmsonii	PM	103.35	29 15	94.3	31.9						
	MO	120.2	41.8	104 2	33.8						
		116.15	40 05	106 15	33.95						

Table C_2 : Showing Analysis of variance (ANOVA) of Gut length and Body length of four *Macrobrachium* species

Tests of Between-Subjects Effects							
Source	**Dependent Variable**	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**	
SPECIES	LENGTH	64185.19712	3	21395.06571	31.96721	0.0000	*
	GUTLNGTH	176952.9516	3	58984.31721	24.05932	0.0000	*
SEASON	LENGTH	2624.021426	2	1312.010713	1 960327	0.1472	NS
	GUTLNGTH	11459 60287	2	5729.801435	2 337149	0.1029	NS
HABITAT	LENGTH	2423.549125	4	605.8872813	0.90528	0.4648	NS
	GUTLNGTH	5038.013375	4	1259.503344	0.513743	0.7258	NS
SPECIES * SEASON	LENGTH	1606.128875	6	267.6881458	0.399963	0.8771	NS
	GUTLNGTH	8052.15575	6	1342.025958	0.547404	0.7707	NS
SPECIES * HABITAT	LENGTH	648.374125	6	108 0623542	0.16146	0.9861	NS
	GUTLNGTH	2213.085875	6	368.8476458	0.150451	0.9885	NS
SEASON * HABITAT	LENGTH	245 208875	8	30.65110938	0.045797	1.0000	NS
	GUTLNGTH	798.29875	8	99.78734375	0 040703	1.0000	NS
SPECIES * SEASON * HABITAT	LENGTH	190.026125	12	15.83551042	0.02366	1 0000	NS
	GUTLNGTH	911 66425	12	75 97202083	0.030988	1.0000	NS
Error	LENGTH	56219.65	84	669 2815476			
	GUTLNGTH	205936.075	84	2451.61994			
Total	LENGTH	**799001.305**	126				
	GUTLNGTH	**2082928.368**	126				