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A Study on Fish Reproduction with Reference to Temperature Anomalies in Kosi Region of Bihar

Shweta Kumari[1], Pankaj Kumar[2]

[1]PhD Scholar & Corresponding Author, Faculty of Science (Zoology); B.N.Mandal University, Madhepura, Bihar , India

Abstract: ***Changes in temperature and climatic condition affect aquatic life. Temperature is a fundamental physical regulatory factor in the lives of fishes and its effect expressed particularly strongly in the control of all reproductive processes. In the present study an attempt has been made to analyse the main objective like the effect of temperature anomalies. This study has revealed that water temperature has inverse effect on reproduction process of fishes. Water temperature above optimum range will slow the reproduction process. There is an optimal temperature range for breeding of fishes. Critical temperature limits exist, above and below which fish will not reproduce. Warm temperature plays a primary role in stimulating the maturation of gonads in many fishes. Temperature has a direct effect on gonads, regulating their ability to respond to pituitary stimulation and effects on primary synthesis and release of gonadotropins. Carps labeo rohita have thermal tolerances in the 22–32℃ range. Most of fish species show gonadal activity during July- Sep (Temp. range 20° C - 32° C) in the study area of koshi region of bihar depending on their geographical location. Since the Indian major carps show gonadal activity from March to June, at a time when both photoperiod and temperature are increasing, it is summarised that these two factors are involved in initiating gonadal recrudescence. Warm temperatures and long photoperiod coupled with good diet are responsible for accelerated growth and gonadal maturity. In the present study, The scholar has recorded the average temperature range in different months of year 2011 and correlated it with the stage of oocyte of fishes collected from its natural habitat of kosi region. The oocytes of collected specimen were observed and are counted based on the stage of maturity. The observation showed that the study area of kosi region of Bihar where winter and summer seasons are so clearly defined , the only time when temperature conditions remain fairly uniform is that of the monsoons . All fishes, therefore, breed preferably during this season under optimum temperature ranging between 20℃ to 32°C. In this period, Due to prevailing flood conditions in koshi region, there is no competition for space. Each species, therefore, gets the best chance of finding suitable grounds to settle. Elevated temperatures increase the metabolism, respiration and oxygen demand of fish and other aquatic life, approximately doubling the respiration for a 10°C rise in temperature. Hence the demand for oxygen is increased under conditions where oxygen supply is lowered.***

Keywords: Fish reproduction, Temperature, Kosi Region, Carps

1. Introduction

Temperature is a fundamental physical regulatory factor in the lives of fishes and this effect is expressed particularly strongly in the control of all reproductive processes from gamete development, maturation, ovulation, spermiation, spawning, embryogenesis and hatching, to larval as well as juvenile development and its survival. In reproductively mature adults, temperature is generally considered to be a secondary to photoperiod in phasing reproductive seasonality but it has a major role in synchronising the final stages of reproductive maturity and also in truncating reproductive episodes. The effects of temperature can be differentially expressed depending on when in the annual thermal cycle spawning normally occurs, with increasing water temperatures being required for maturation in spring and early summer (February -May) spawners, but elevated temperatures delaying the onset of maturation and ovulation in autumn-spawning species (November - January). Temperature has a similarly important role in the modulation of post-fertilisation processes both through its rate-determining effects on embryogenesis and hatching and subsequent larval development growth and survival.

Changes in temperature and climatic condition affect aquatic life. Temperature determines which organisms will thrive and which will diminish in numbers and size. For each organism there is a thermal death point. Also there is a range of temperature of that produces optimal abundance. The effects of temperature upon life of a cold blooded or poikilotherm are profound. Poikilothermic animals, such as fish, are those whose body temperatures follow closely the temperature of their medium. Water temperature has a very marked effect on the physiological and biochemical processes in fish, and a raised temperature regime has complex effects on fish reproductive, nerve and endocrine systems. Increased temperature affects fat synthesis, metabolism, and the endocrine system which results in the failure of the generative process. Effects of cooling water discharge on gametogenesis have been observed in cyprinid. Gametogenesis has been observed to be accelerated by cooling water discharges, especially in females.

In the present study an attempt has been made to analyse the main objective like the effect of temperature anomalies of fish reproduction. Further, it has been sought to evaluate the effect in the natural habitat of fishes as well as in captivity in laboratory. The universe of the study is Kosi River Zone of Bihar. Further this study has revealed that water temperature has inverse effect on reproduction process of fishes. Water temperature above optimum range will slow the reproduction process. There is an optimal temperature range for breeding of fishes. Critical temperature limits exist, above and below which fish will not reproduce. Warm temperature plays a primary role in stimulating the maturation of gonads in many fishes. Temperature has a direct effect on gonads, regulating their ability to respond to pituitary stimulation and effects on primary synthesis and release of gonadotropins. Major carps breed within a range of temperature varying from 24-31°C.

Complications in the assessment of the effects of temperature in the natural environment arise from the fact that much of our current understanding is generated from controlled laboratory experiments that typically test thermal tolerances rather than behavioral preferences. For example, studies on fishes show that there is often a wide gap between tolerance and preference profiles. Carps *labeo rohita* have upper thermal tolerances in the 22–32℃ range. This means that temperatures that might not be high enough to elicit tolerance-related responses in captivity can induce significant preference-related effects in the natural environment. Single-domain temperature experiments also generally ignore the synergistic interaction of temperature with other physical and biotic variables. Temperature effects on reproduction can be differentially expressed under different photoperiod regimes and recent experiments on tropical common fish show that temperature effects are modulated by nutritional status (Donelson *et al*. 2010). Finally, some species exhibit variation in thermal reaction norms across their geographic range that indicates some capacity for acclimation and adaptation to temperature gradients (Angilletta 2009;Gardiner *et al*. 2010), and potentially to a changing climate.

The adverse effects on fish reproduction caused by raised water temperature may be related to two unconnected phenomena. Firstly, the elevated temperature regime during the winter period may deplete the fat stores by increasing the metabolism at a time of the year when feeding opportunities are scarce. This situation may harm the female production of gametes more than the male and may eventually lead to regression of the ovaries as was observed in roach. Secondly, the water temperature anomalies may interfere with the hormonal regulation of gametogenesis. The combination of these two effects of an elevated temperature regime could lead to regression of gonads as well as other types of gonadal malfunctions.

In the present study, fishes of koshi region (study area) for example the species Labeo rohita, Catla catla, and Cirrhina mrigala, are known to breed only once a year during the monsoon season (July - September). Photoperiod, temperature and seasonal rainfall, among other factors, are important in regulating reproductive cycles in fishes. These species Labeo rohita, Catla catla and Cirrhina mrigala, show gonadal activity during July - Sep (Temp. range 20° C - 32° C) in this study area depending on their geographical location. Since the Indian major carps show gonadal activity from March to June, at a time when both photoperiod and temperature are increasing, it is summarised that these two factors are involved in initiating gonadal recrudescence. Warm temperatures and long photoperiod coupled with good diet are responsible for accelerated growth and gonadal maturity.

Temperature anomalies have many effects on fish reproduction. As observed the Higher temperatures diminish the solubility of dissolved oxygen and thus decrease the availability of this essential gas. Elevated temperatures increase the metabolism, respiration and oxygen demand of fish and other aquatic life, approximately doubling the respiration for a 10°C rise in temperature. Hence the demand for oxygen is increased under conditions where oxygen supply is lowered. The solubility of many toxic substances is increased as well as intensified as the temperature rises. Higher temperatures militate against desirable fish life by favoring the growth of sewage fungus and the putrification of sludge deposits, and finally even with adequate dissolved oxygen, there is a maximum temperature that each species of fish or other organism can tolerate. Higher temperatures produce death. The maximum temperatures that adult fish can tolerate vary with the species of fish , prior acclimatization, oxygen availability and the synergistic effects of other pollutants . A Median Tolerance Limits (MTL) have been recorded between 20-32℃ for all species in this region. As observed the Indian major carps are relatively tolerant of high temperatures.

2. Materials and Method

In order to study the effect of temperature anomalies and aquatic variation on fish reproduction in the various fish species of the study area, seasonal samplings were done from various study plots. Various sampling methods or fishing gears such as cast net, scoop net, gill net and a circular net (with very small mesh size and sinkers around the edge) were used. Visual count (bank side count) was the regular method adopted for monitoring the population fluctuations in the study area. Counts were made fortnightly from 24 different fixed stations covering an area of one meter square in the study plots and the fish population was estimated separately for both fragile ecosystem habitat (F) and natural habitats (NH) and expressed in average.

A number of studies were carried out on the fish fauna of various protected areas in Saharsa. Here we Studied the species wise distribution of fishes. The scholar found 40 species from Koshi region. The most dominant family was Cyprinidae with 26 species. Scholar made a review of fresh water fishes from Bihar. A total of 146 species belonging to *10* orders, 27 families and 61 genera were recorded so far from Bihar. This includes 24 species of fishes of which 19 were reported from Southern Saharsa and 05 from Northern Saharsa. They also noticed that species richness was more in Southern Saharsa than that of Northern Saharsa. Cyprinidae was the most dominant family recorded .

Scholar has studied the effect of temperature anomalies and aquatic variations on the fishes of study area in saharsa and most of observation and result are made in their natural habitat. However, for study of effect of temperature and aquatic variations in captivity, some experiments were also performed on *L. rohita* commonly known as 'Rohu' at Zoology lab of T.P. College, Madhepura of B.N.M. University ,Madhepura.

Effect of Temperature Anomalies in natural habitat:

In the present study, the scholar observed the effect of temperature changes and seasonal changes on reproductive behavior of fishes of family Cyprinidae in natural habitat of koshi region having different photoperiod during different season. The water temperature is recorded with mercury thermometer. It is observed that there is an optimal temperature range for breeding of fishes.

Method:

Different species which were studied include carps, catfishes, murrels, and other species. To establish the breeding season of each species, observations were made on its gonad condition according to an arbitrary scheme *(see* below) over a greater part of the year. Ripening or ripe ovaries were then taken from the main breeding months, cut into small portions and fixed in Bouin's fluid. On hardening, they were opened in glass dishes and the oocytes carefully separated from the adhering tissues. All the oocytes thus obtained were measured under a micrometer eye-piece. In making measurements, the small yolkless cells which were much more numerous than the oocytes and apparently belonged to the immature class were omitted. In those species where the ovary was very large, only a portion was taken for the oocyte measurements. Generaly three to four average sized individuals of each species were selected for the oocyte study and from these fishes a typical condition was laid down on the basis of its predominance to illustrate the distribution of oocytes in that species. In each individual roughly 50 to 100 eggs were measured indiscriminately.

Gonad Condition and Nature of Oocytes in Maturing Ovary -

The degree of maturity of gonads in various species was determined according to the arbitrary scheme used for *B. pholis* and C. *gunnel/us* (Qasim,1957*).* In all, five maturity stages were defined as follows:-

(1) Immature virgins	Ovaries thin and ribbon-like, eggs microscopic
(2) Maturing virgins & Recovered Spent	Ovaries swollen and containing eggs just visible to the naked eye
(3) Ripening	Ovaries enlarged and containing con spicuous opaque eggs
(4) Ripe	Ovaries distended and containing large translucent eggs
(5) Spent	Ovaries collapsed with no eggs seen by the naked eye. In some cases a few residual eggs present.

In riverine forms, the occurrence of various stages of maturity was noted in specimens obtained from the local fish market. Depending upon the availability of each species, it became only possible to make observations for a definite period of the year, generally two months before the onset of monsoons (April and May), three months during the monsoons (June to August) and three months after the monsoons (September to November), Pond fishes, on the other hand, were collected by the scholar herself. They were thus made available in large numbers throughout the year and were used for more intensive studies.

On the seasonal changes in gonads are given in the form of time and duration of breeding seasons (Table I), as deduced by the occurrence of ripe and spent stages in various months, Ripening and ripe ovaries of fishes contained oocytes of several different kinds, Those fishes which contained a single group of oocytes, free, large, ripe ova formed the main bulk. The other type present was that of small yolkless cells which were generally embedded in the tissues and probably included follicle cells and oogonia. Other species which possessed multiple groups of eggs, the oocytes were at various stages of development. In addition to the immature yolkless cells, there were also maturing ova which could be distinguished as small opaque eggs provided with little yolk; free mature ova, well supplied with yolk and large translucent ripe ova, full of yolk. Prabhu (1956) made similar observations on the oocytes of maturing ovaries of marine and estuarine fishe

In Carps, Size frequency distributions of oocytes in all the species of carps studied are given as histograms below. In each species the month to which the data refer has also been indicated in the figure. As can be seen from the figure, in the four riverine forms, namely, *Labeo rohila, Labeo calbasu, Cirrhina mrigaia* and *Barbus sarana,* conditions shown by the ovaries are very similar. All these species possess a single group of large oocytes evidently destined to be spawned in a single spawning act The time and duration of spawning in all these species are practically the same, the breeding seasons last for about two months during the monsoons, July and August(Table I). A short spawning season, as is shown by these fishes, seems a characteristic feature of all those species which possess it single group of oocytes (Qasim, 1956 *a).*

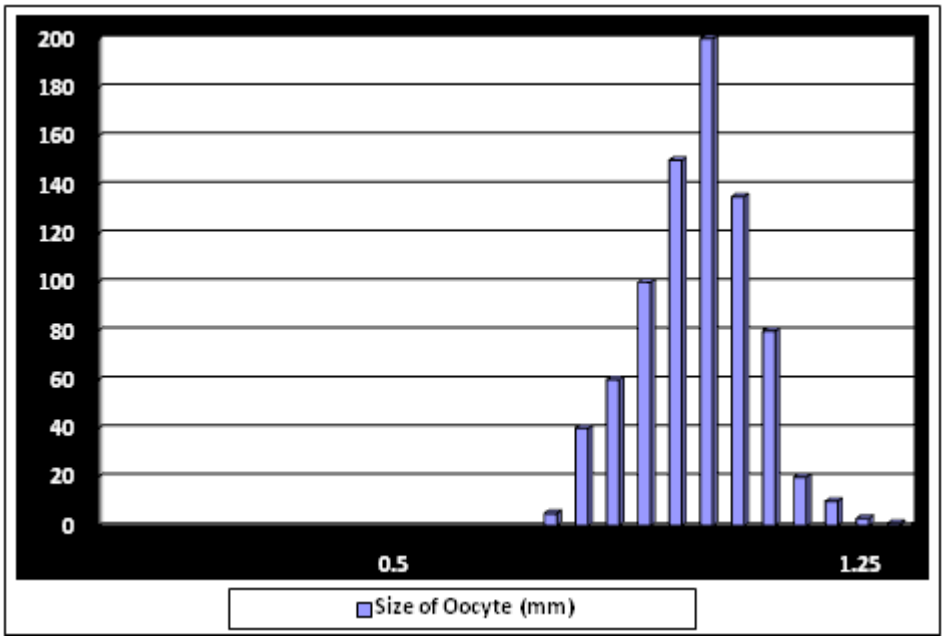


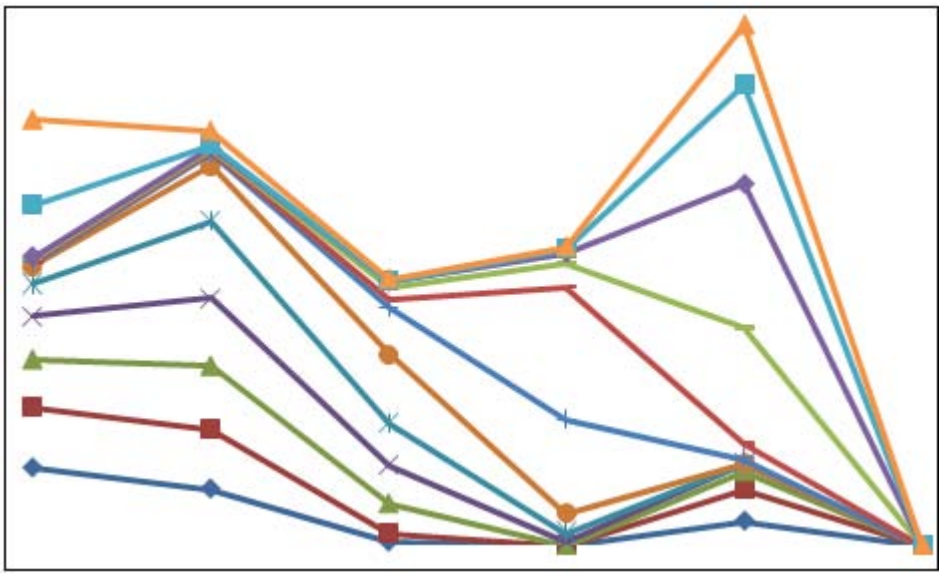
Figure: Histogram showing size frequency distribution of oocytes in maturing ovaries of carps in the month of July-August

The factor which affects the spawning of fishes is the temperature. Many instances of optimum temperature conditions as a prerequisite for spawning have been reported earlier (Khan, 1945; Das and Das Gupta, 1945; Smith, 1945) and the temperature range at which the major carps have been observed to breed seems 75 to 86° F. (Hora, 1945). Seasonal changes in temperature also seem to regulate the breeding of fishes (table-2). From January onward the atmospheric temperature shows a regular rise reaching its maximum in mid-June. In these months there is also a greater range of variation in the daily maximum and minimum temperatures. Towards the end of June, after the monsoon rains have set in, the temperature falls, and throughout the monsoon months it maintains relatively a uniform range. The daily fluctuations do not exceed more than 5 to 10° C. which are in contrast to the pre-monsoon months when daily variations in temperature may be of 18 to 20° C. Soon after the monsoons over, and the winter conditions begin to prevail, the temperature decreases. It finally reaches its minimum in January. From October onwards daily variations in temperature also become more and more pronounced.

The scholar has recorded the average temperature range in different months of year 2011 and correlated it with the stage of oocyte of fishes namely *Labeo rohita, Labeo calbasu* and *Cirrhina mrigaia* collected from its natural habitat of kosi region. The oocyte of collected specimen were observed and are counted based on the stage of maturity. The observation was presented in table below:

Table

Month 2011	Average Temperature Range˚C	Type of oocyte found (%)				
		Immature	Maturing	Ripening	Ripe	Spent
Jan	5-20	48	35	02	0	15
Feb	10-28	38	37	05	0	20
Mar	15-36	30	40	19	0	11
Apr	18-40	27	42	24	02	05
May	22-42	20	48	26	06	0
Jun	24-46	11	34	43	12	0
Jul	25-35	02	08	29	58	03
Aug	22-34	01	01	05	83	10
Sep	20-36	02	02	08	15	73
Oct	18-35	01	01	03	06	89
Nov	15-33	32	02	01	03	62
Dec	10-30	53	08	01	01	37



3. Result & Discussion

The health and subsequent growth and reproduction of fish are directly related to the quality of water in which the fish are raised. Water temperature is one of the most important physical factors affecting fish reproduction. Fish are cold-blooded animals which assume approximately the same temperature as their surroundings. Typically, fish are classified broadly as cold, cool, or warm water, depending on their tolerance for particular temperature ranges. Within each temperature classification, fish survival is bounded by an upper and lower temperature, between which an optimum temperature range for reproduction exists. When temperatures vary outside the optimum range, reproduction decreased and in some cases, mortalities may result, depending on the magnitude of the deviation from the optimum temperature. Not only the organism survival, but growth and reproduction of each organism have critical temperature ranges. Each organism must be favored by the proper temperature if the individual or its population is going to survive. For instance, temperature influences enzymatic reactions through hormonal and nervous control to digestion, from respiration and osmoregulation to all aspects of an organism's performance and behavior. High and low temperatures that are lethal to individual organism of a species determines the distribution and abundance it's populations. However, more often the distribution and abundance of populations is determined by less than lethal temperatures interacting with other environmental factors that either tend to favor or not to favor reproduction and growth.

Temperature, Photoperiod and seasonal rainfall, among other factors, are important in regulating reproductive cycles in fishes. The Indian major carps, Labeo rohita, Catla catla and Cirrhina mrigala, and other fishes show gonadal activity during July- Sep in the study area of koshi region of bihar depending on their geographical location. Since the Indian major carps show gonadal activity from March to June, at a time when both photoperiod and temperature are increasing, it is surmised that these two factors may be involved in initiating gonadal recrudescence. Exposure of males and females to a long photoperiod (LD 14:10 or 18:6) at ambient temperatures (19° to 30°C) hastens gonadal recrudescence; males attain maturity earlier than females. However, when fish are subjected to gradually increasing photoperiod from LD 4:20 to 14:10 and finally to 20:4, females mature earlier than males at ambient temperatures, whereas at elevated temperatures (27.1° to 31°C), males mature earlier than females. Further, males kept in constant darkness mature simultaneously with those under natural photoperiod, whereas in females, constant light hastens and constant darkness retards functional maturity. Since the males of the Indian major carps show gonadal recrudescence earlier than females under natural conditions, it is surmised that the threshold temperature for testicular recrudescence is lower than that for ovarian recrudescence. Properly designed experiments with rigorously controlled photoperiod-temperature regimes have to be conducted to understand the relative roles of these two factors in gonadal recrudescence.

In the present study, The scholar has recorded the average temperature range in different months of year 2011 and correlated it with the stage of oocyte of fishes namely *Labeo rohita, Labeo calbasu* and *Cirrhina mrigaia* collected from its natural habitat of kosi region. The oocyte of collected specimen were observed and are counted based on the stage of maturity. The observation was presented in table above clear that the study area of kosi region of Bihar where winter and summer seasons are so clearly defined, the only time when temperature conditions remain fairly uniform is that of the monsoons. All fishes, therefore, breed preferably during this season under optimum temperature ranging between 20℃ to 32° C. In this period, Due to prevailing flood conditions in koshi region, there is no competition for space. Each species, therefore, gets the best chance of finding suitable grounds to settle. Probably this is the season when most of the physical factors favour natural reproduction.

To sum up, it seems that breeding in freshwater fishes is so adjusted that the larval hatch during a season when conditions of temperature and shelter are at their optimum. Considering the significance of such a behaviour in terms of adaptive advantage to the species, the disparity in breeding habits is not so well marked as might be anticipated from the

conditions revealed by their ovaries. In each individual the cycle of spawning occurs only once a year and the state of maturity at any given time is fairly uniform throughout the population. Individuals belonging to the second category have a succession of spawnings. Their breeding seasons are relatively longer and last for about four to five months. At no time of the year there is an exclusive preponderance of one maturity stage in these fishes. Fishes belonging to the third category are characterised by a non seasonal breeding. Gravid individuals occur over a greater part of theyear and it seems that if conditions for spawning are favourable, the cycle can occur at any time of the year. Spawning in each individual is not synchronous with those of other individuals of the population.

In this study area of kosi region, most fishes breed during the monsoon months when seasonal temperature remains fairly uniform. Peak spawning occurs when the monsoon rains have properly set in. It is suggested that the breeding cycle, in freshwater fishes are well suited to the conditions that prevail in this part of the country. The breeding seasons are adapted to provide optimum conditions of temperature and shelter for the newly hatched fishes. Increased water temperature is an important consideration when toxic substances are present in water. Many substances (i.e. cyanides, phenol, xylene, zinc) exhibit increased toxicity at elevated temperatures. These toxicities and other physiological interactions are also influenced by temperature acclimation or history of the species. We can gain a clearer understanding of these interactions through consideration of lethal temperature levels. In relation to the survival of individual organisms, the upper and lower lethal temperatures define the total temperature gradient. Within this temperature gradient, there is a range in which the species can function at or near optimum. In this range, growth and reproduction temperature requirements are met and the species will be found in greatest abundance. Outside the optimum range, there are zones of physiological stress. In these zones, organisms become infrequent because activities are limited more by temperatures that produce discomfort or stress. The period of time an organism can live under physiological stress is a function of how far the temperature is from the lethal level.

Most changes in water temperature as a result of land use activity generally trend upward. An exception is the release of cold bottom water from stratified artificial impoundments that may alter the flora and fauna for many miles downstream from a dam. Most other activities generally raise the temperature of receiving waters with the following effects:

a) Higher temperatures diminish the solubility of dissolved oxygen and thus decrease the availability of this essential gas.
b) Elevated temperatures increase the metabolism, respiration and oxygen demand of fish and other aquatic life, approximately doubling the respiration for a 10° C. rise in temperature. Hence the demand for oxygen is increased under conditions where oxygen supply is lowered.
c) The solubility of many toxic substances is increased as well as intensified as the temperature rises.
d) Higher temperatures militate against desirable fish life by favoring the growth of sewage fungus and the putrification of sludge deposits, and finally
e) Even with adequate dissolved oxygen, there is a maximum temperature that each species of fish or other organism can tolerate. Higher temperatures produce death. The maximum temperatures that adult fish can tolerate vary with the species of fish, prior acclimatization, oxygen availability and the synergistic effects of other pollutants.

Median Tolerance Limits (MTL)have been reported are shown in the following table. Species have been arranged in the order of heat tolerance. As shown by this table, Goldfish, Bass and Carp are relatively tolerant of high temperatures, whereas Trout and Salmon are more sensitive. These temperatures, however, apply to adult fish. For spawning and hatching of eggs, much lower temperatures are required. Many species spawn only above or below certain temperatures.

Rising temperatures also influence swimming and other recreational uses of water. Increased temperatures can stimulate the decomposition of sludge, formation of sludge gas, multiplication of saprophytic bacteria and fungi and in the consumption of oxygen by decomposition processes thus affecting the aesthetic value of a water resource. On the other hand, increasing temperatures may be beneficial to recreation by lengthening the swimming season.

4. Conclusion

Temperature is a fundamental physical regulatory factor in the lives of fishes and this effect is expressed particularly strongly in the control of all reproductive processes development and its survival. that water temperature has inverse effect on reprouctiom processes of fishes. The Water temperature above optimum range will slow the reproduction process. There is an optimal temperature range for breeding of fishes. Critical temperature limits exist, above and below which fish will not reproduce. fishes of koshi region (study area) for example the species Labeo rohita, Catla catla, and Cirrhina mrigala, are known to breed only once a year during the monsoon season (July – September). Seasonal changes in temperature also seem to regulate the breeding of fishes (table-2). From January onward the atmospheric temperature shows a regular rise reaching its maximum in mid-June. In these months there is also a greater range of variation in the daily maximum and minimum temperatures. Towards the end of June, after the monsoon rains have set in, the temperature falls, and throughout the monsoon months it maintains relatively a uniform range. All fishes, therefore, breed preferably during this season under optimum temperature ranging between 20℃ to 32° C. In this period, Due to prevailing flood conditions in koshi region, there is no competition for space. Each species, therefore, gets the best chance of finding suitable grounds to settle. Probably this is the season when most of the physical factors favour natural reproduction. The maximum temperatures that adult fish can tolerate vary with the species of fish, prior acclimatization, oxygen availability, the synergistic effects of other pollutants and other aquatic variations

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