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Research Article

Analysis of length- weight relationship and relative condition factor of the hillstream fish *mastacembelus armatus* (lacepede) from river nayar, garhwal, uttarakhand

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ABSTRACT

One of the important aspects of fish biology is the length weight relationship and relative condition factor. In the hillstream fish *Mastacembelus armatus,* a relationship between total length and body weight was studied sex wise and season wise. The length and body weight ranged from 10 to 59.2cm. and 7.0 to 250 gm. in males and 21.2 to 56.3 cm. and 37 to 229 gm. in females respectively. The regression coefficient for sex wise and pooled data varied from a maximum of 3.997 for male (r = 0.794) and minimum of 3.977 for female (r = 0.414) fishes. Sex wise seasonal data ranged from 1.811 (r = 0.207) during the autumn months to 5.658 (r = 0.820) during summer for the males. However, in female it ranged from 4.043 (r = 0.339) during autumn to 6.682 (r = 0.245) during summer seasons. The relative condition factor was maximum for males as 1.265 ± 0.199 and for females 1.339 ± 0.074 in the month of February. The lowest value was observed 0.779 ± 0.167 for males and 0.888 ± 0.058 for females in the month of July. Season wise the Kn values were observed high 1.016 ± 0.181 for males and 1.009 ± 0.229 for female fishes in spring. It is also observed that the second next peak values were found during winter for both sexes (For male: 1.003 ± 0.391 and female: 1.002 ± 0.411) which represent good condition of fish on the basis of active feeding and suitability of the environment.

INTRODUCTION

Length - weight relationships is very useful in understanding the health and proper development of fish. It provides standard information for the management in fish culture. The exact relationship between length and body mass differs among species according to their inherited body shape and within a species according to the ambient conditions (robustness) of individual fish. In variable and dynamic ambient condition, individual fish even in same sample vary considerably as well as average condition of each population also varies seasonally and yearly. Sex and gonadal development are other important variables in some species. The body parameters of a fish continually changes with ageing. In the present study, length - weight relationship and relative condition factor is analyzed to know about growth and development of a hillstream fish *Mastacembelus armatus* in river Nayar. Monthly and season wise length fluctuations of relative condition factor were obtained and interpreted with respect to breeding and feeding pattern of the fish.

The length-weight relationship and relative condition factor is widely studied in fishes. Some of the important contributors are King (1965), Chatterji, *et.al*., (1977), Kader and Rahman (1978), Bagenal and Tesch (1978), Mohan and Sankaran (1988), Jayasankar (1991), Reddy and Rao (1992), Umesh *et.al*., (1996), Goncalves *et.al*., (1997), Das *et.al*., (1997), Garcia *et.al*.,(1998), Sarkar et,al., (1999), Mortuza and Mokarrama (2000), Sunil (2000), Schneider *et.al*., (2000), Kleanthidis *et.al*., (2000), Blackwell, *et.al*., (2000), Khaironizam and Norma-Rashid (2002), Borges, *et.al*., (2003), Sivashanthini and Abeyrami (2003), Saravankumar *et.al*., (2004), Frota, *et.al*., (2004), Narejo*et.al*., (2004), Bahuguna *et.al*. (2005), Oscoz *et.al*., (2005), Rajsegar (2005), Froese (2006), Andreu-Soler *et.al*., (2006), Kumar *et.al*., (2006), Miranda *et.al*.,(2006), Laleye (2006), Leunda (2006), Hossain *et.al*., (2006), Ayoade and Ikulala (2007), Pervin and Mortuza (2008), Mohanraj (2008), Heydarnejad (2009), Abowei (2009), Bahuguna *et.al*., (2009, 2010), Muchlisin *et.al*., (2010), Imam *et.al*., (2010), Deekae *et.al*., (2010), Kar and Barbhuiya (2010), Gupta, *et.al*., (2011), Oribhabor *et.al*.,(2011), Pepple and Ofor (2011), Khan *et.al*., (2011),

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Kamaruddin *et.al*., (2012), Ibrahim *et.al*.(2012), Mahmood (2012), Bahuguna and Joshi (2012), Dobriyal (2012), Luca *et.al*., (2013), Kharat and Khillare.(2013), Sakar *et.al*., (2013), Chaudhary and Srivastava (2013), Gogoi and . Goswami (2014), Joshi, *et.al*., (2014), Das *et.al*., (2015), Verma (2015), Sharma *et.al*. (2015), Krishna and Dobriyal (2015), Panda and Datta (2017), Kalita, *et.al*., (2017), Bahuguna *et.al*., (2017) and Kurbah and Bhuyan (2018). The present study is in continuation with earlier studies and is dealing with Length - weight relationship and relative condition factor of *Mastacembelus armatus*. This is for the first time that this species is being studied from Garhwal hills.

MATERIALS AND METHODS

Fishes for the present study were collected from the Western Nayar, a tributary of the Ganga river. Monthly samples of different length groups were collected from January 2014 to December 2015.Total length and body weight of fish was measured in fresh condition and relationships were established based on 75 specimens (42 Male and 33 Female) of *Mastacembelus armatus* by using the parabolic equation (Le Cren 1951), i.e., $W = a L^{n}$

Where: W = Total weight of fish, L = Total length of the fish, a = slope, b = Regression coefficient.

The Relative condition factor was calculated using the formula: $K_n = W^o / W^c$

Where: K_n = Relative condition factor, W^o = Observed weight of fish in gm, W^c = Calculated weight of the fish in gm.

RESULTS

In *Mastacembelus armatus* the length and body weight ranged from 10 to 59.2cm. and 7.0 to 250 gm. in males and 21.2 to 56.3 cm. length and 37 to 229 gm. in females respectively. The length-weight relationship after regression analysis for different sexes, different seasons and pooled data is presented in Table 1. The collected samples were grouped for different season which showed a close relationship between their length and weight. Table 1 shows that the regression coefficient for sex wise and pooled data varied from a maximum of 3.997 for male (r=0.794) and minimum of 3.977 for female (r = 0.414) fishes. Sex wise seasonal data ranged from 1.811 (r = 0.207) during the autumn months to 5.658 (r = 0.820) during summer for the males. However, in female it ranged from 4.043 (r = 0.339) during autumn to 6.682 (r = 0.245) during summer seasons.

Table 1 Regression analysis and coefficient of correlation on length-weight relationship of *M. armatus* during 2014- 2015.

S.N.	Condition	Parabolic Equation	Correlation Coefficient "r"
		Sex wise and pooled data	
1	Male	$W = -43.755\ L^{3.997}$	0.794
	Female	$W = -19.951\ L^{3.977}$	0.414
	Pooled data	$W = -29.837\ L^{3.895}$	0.637
2	Season and Sex wise		
	Male		
	Winter (Dec, Jan, Feb)	$W = -41.264\ L^{4.124}$	0.917
	Spring (Mar, Apr)	$W = -45.687\ L^{4.604}$	0.972
	Summer (May, Jun)	$W = -120.95\ L^{5.658}$	0.820
	Monsoon (Jul, Aug)	$W = -90.826\ L^{5.007}$	0.467
	Autumn (Sep, Oct, Nov)	$W = 21.184\ L^{1.811}$	0.207
	Female		
	Winter (Dec, Jan, Feb)	$W = -73.518\ L^{5.546}$	0.633
	Spring (Mar, Apr)	$W = -334.36\ L^{5.949}$	0.545
	Summer (May, Jun)	$W = -98.705\ L^{6.682}$	0.836
	Monsoon (Jul, Aug)	$W = -24.736\ L^{4.214}$	0.483
	Autumn (Sep, Oct, Nov)	$W = -32.014\ L^{4.043}$	0.436

The relative condition factor (K_n) was calculated for each fish and finally the average Kn values for different sexes during each month was calculated and presented in Table 2. The lowest value was observed 0.779 ± 0.167 for males and 0.888 ± 0.058 for females in the month of July. The relative condition factor was maximum in males as 1.265 ± 0.199 and in females 1.339 ± 0.074 in the month of February. Relative condition factor (K_n) for different sexes and pooled data o*f M. armatus* are presented in Table 3. The values were highest for both the sexes during spring (1.016 ± 0.181 and 1.009 ± 0.229 for male and female respectively). The relative condition factor values during spring for both the sexes were higher than monsoon and autumn, which indicated the suitable feeding grounds for the fishes. The K_n values were also recorded highest during the month of June for both the sexes (For male, 1.003 ±0.146 and for female, 1.005 ± 0.283) may be due to the sexual maturity of the fish.

DISCUSSION

The cube law stated that the fish maintains the same shape and specific gravity throughout life (Allen, 1938). But when the fish changes its shape during further growth, the length weight relationship deviates from the cube law. It happens in many fishes. Thus, it is considered general parabolic equation $W = a L^{n}$ to express the length-weight relationship of fish in general (Martin, 1949).

Table 2 Monthly fluctuation in Relative condition factor (Kn) for different sexes of *M. armatus* during 2014- 2015

Months	Male				Female			
	Min	Max	Average	S.D	Min	Max	Average	S.D
January	0.994	1.750	0.912	±0.199	0.539	0.885	0.712	±0.245
February	0.687	1.065	1.265	±0.354	1.287	1.391	1.339	±0.074
March	0.790	1.296	1.012	±0.232	0.722	1.417	1.020	±0.298
April	0.805	1.168	1.013	±0.140	0.968	0.995	0.982	±0.019
May	0.901	1.086	1.000	±0.093	0.756	1.198	0.926	±0.238
June	0.842	1.305	1.025	±0.181	0.725	1.362	1.063	±0.320
July	0.713	0.828	0. 779	±0.167	0.811	0.994	0.888	±0.053
August	0.643	1.233	0.969	±0.268	0.750	.938	0.898	±0.115
September	0.882	1.173	1.015	±0.147	1.033	1.337	0.941	±0.144
October	0.828	1.154	1.028	±0.059	1.770	1.725	1.137	±0.180
November	1.016	1.618	1.317	±0.426	0.861	1.020	1.155	±0.112
December	0.384	0.704	0.602	±0.226	0.872	1.170	0. 915	±0.088

In the present study on length and weight growth, a close relationship was observed in *Mastacembelus armatus.* The value of regression coefficient "b" was obtain 3.997 for males (r = 0.794), 3.977 (r = 0.414) for females and 3.895 (r = 0.637) for the pooled data. (Figs 1-3). It is also noticed that correlation coefficient (r) of male (0.794) is found to be higher when compared to that of female (0.414). From this trend it is presumed that male gained more weight with increase in length, indicating a better well-being.

Table 3 Seasonal fluctuation in Relative condition factor (Kn) for different sexes of *M. armatus* during 2014- 2015

Seasons	Male				Female			
	Min	Max	Average	S.D	Min	Max	Average	S.D
Winter (Dec, Jan, Feb)	0.687	1.250	1.013	±0.391	0.539	1.391	1.002	±0.411
Spring (Mar, Apr)	0.805	1.796	1.016	±0.181	0.722	1.417	1.009	±0.229
Summer (May, Jun)	0.842	1.305	1.003	±0.146	0.895	1.362	1.000	±0.102
Monsoon (Jul, Aug)	0.643	1.233	0.987	±0.215	0.731	1.738	0.980	±0.354
Autumn (Sep, Oct. Nov)	0.713	1.618	1.000	±0.288	0.770	1.237	0.991	±0.512

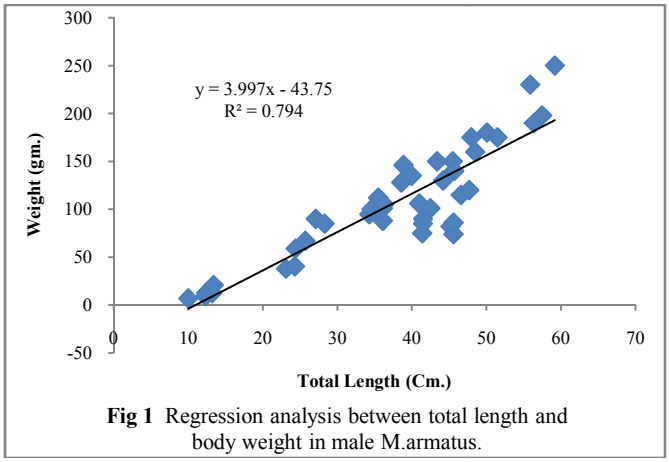

Fig 1 Regression analysis between total length and body weight in male M.armatus.

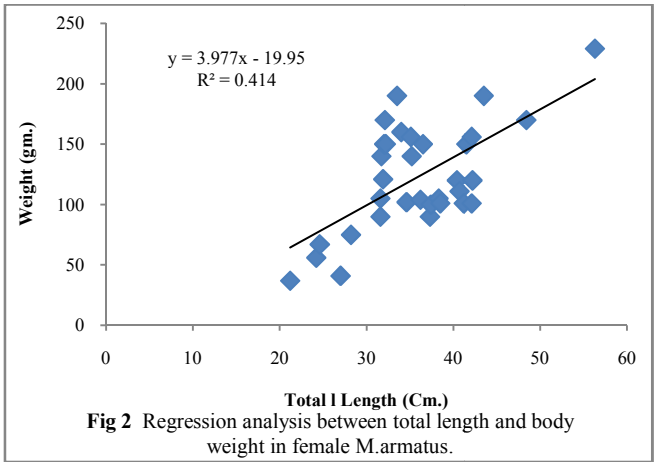

Fig 2 Regression analysis between total length and body weight in female M.armatus.

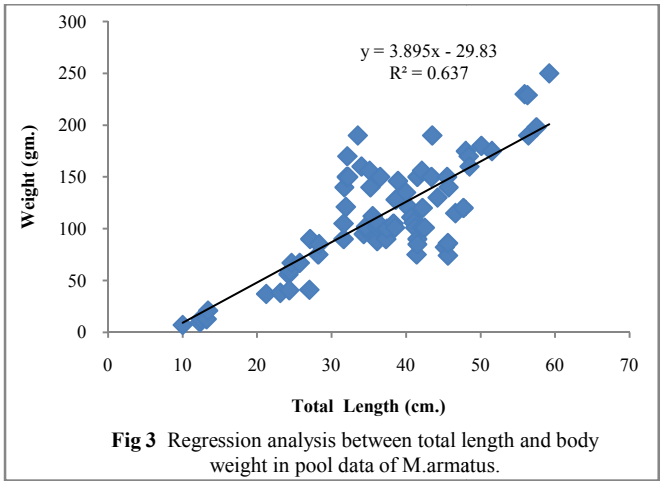

Fig 3 Regression analysis between total length and body weight in pool data of M.armatus.

Narasimha (1970) reported that the value of b was 3.4169 and 3.4369 for male and female of *Trichiurus lepturus*. Chondar (1972) observed the exponent value as 3.1586 in case of *Labeo gonius*. Soni and Kathal (1979) reported the higher value of b as 4.36 for *Cirrhina mrigala* and concluded that it was due to the presence of large quantities of sand and mud in the stomach that resulted in an increase in the total weight. Thakre and Bapat (1984) estimated length-weight relationship of the fish *Rasbora daniconius* and opined that the values of b were 3.1529 for females and 3.219 for the males. Zafar *et.al* (2003), worked on *Catla catla* and observed that weight of fish increases as the cube of length. The value of b=3.02 showed that the fish is growing isometrically in relation to length. Bahuguna *et.al*., (2010) observed that body mass- length relationship of *Garra lamta* was found significantly narrow but the value of "b" fluctuated from a minimum of 1.035 to 3.164 in summer in female and again it reaches its peak in autumn (2.545). The higher values may be due to maturation of gonads. The body mass-length relationship of the species from the Kalapani stream shows low growth rates due to ecological condition of the hill stream or feeding grounds

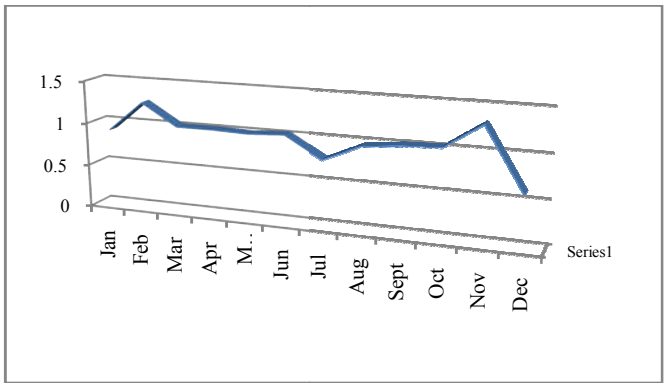

Fig 4 (A) Average values of Relative Condition Factor (Kn) of Male *M armatus* during 2014-15

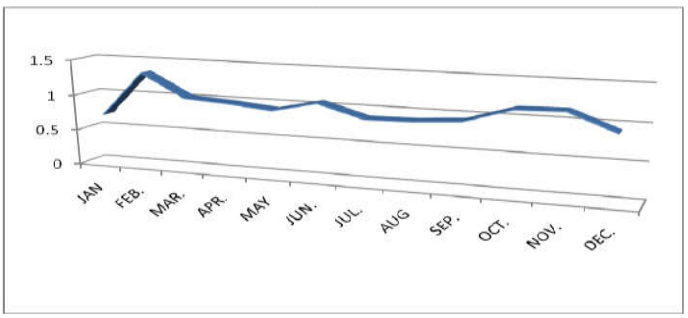

Fig 4 (B) Average values of Relative Condition Factor (Kn) of Female *M armatus* during 2014-15

Huxley (1932) and Frost (1945) reported that the changes in the value of "b" may be due to metamorphosis and onset of maturity. Le Cren (1951) divided *P. fluviatilis* into six groups on the basis of age, sex and maturity and found no significant difference in the length weight relationship. Our observation is supported by Hile (1936) and Martin (1949) who advocated that the value of the regression coefficient "b" usually lies between 2.5 and 4.0 and far ideal fish maintain that shape b=3.

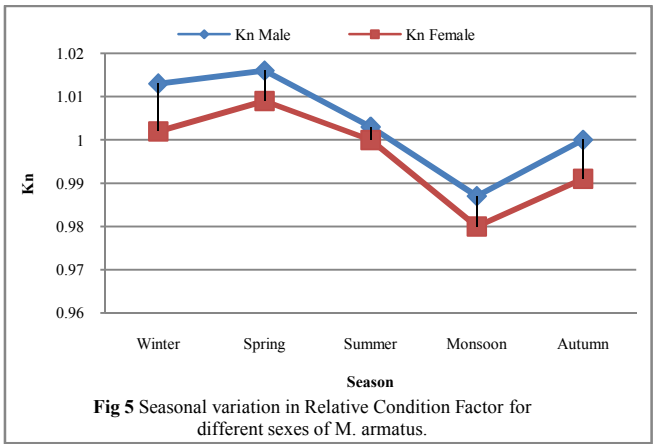

Fig 5 Seasonal variation in Relative Condition Factor for different sexes of M. armatus.

Dey (1987) has reported by a strong relationship between log of length and log of weight in Chocolate mahseer *Acrossocheilus hexagonolipis* from Assam region. The length-weight relationships in *Tor putitora,* was observed with low regression coefficient (2.5) in the male fishes by Bali and Sharma (2002) from Beas River. Kumar *et.al*, (2006) reported no significant difference in the length-weight relationship of *Botia dayi* Hora in different sex and in the different seasons, but observed good growth during spring-summer month which affected the value of "b" to go high. The values of regression coefficient for male (2.941), female (3.008) and combined sexes (2.984) was reported by Mortuza and Rahman (2006) in the fresh water fish *Rhinomugil corsula* (Ham.) from Rajshahi area Bangladesh. Verma (2015) studied the length-weight relationship and condition factor of *Labeo dyocheilus* from Western Ramganga River, Uttarakhand and showed that the results of length weight relationship were highly significant in all months during his period of observation.

Panda and Datta (2017) studied the relationship between total length (TL)-body weight (W), standard length (SL)-body weight (W) and total length (TL)-standard length (SL) for two *Barilius* species from Manu River, Tripura and reported that the value of regression coefficient "b" for *B. bendelisis* was found to be 2.99 which indicated isometric growth of the species and for *B. barna* to be 3.14 which indicated positive allometric growth of the species. The Length-Weight Relationship (LWR) of Mud eel (*Monopterus cuchia*) from three different areas of Meghalaya were studied by Kurbah and Bhuyan (2018) who also reported that the values of regression co-efficient 'b' showed a positive allometric growth pattern of the fish due to higher proficiency in feeding.

In present study, the value of correlation coefficient "r" was observed to be higher for male (0.794) than for females (0.414). Seasonal data showed that the value of "r" for males during spring season was quite high (0.972) and for females it was more during summer season (0.836) but less that the former one. Kalita, et. al., (2017) worked on length-weight relationship of *Mystus tengara* (Hamilton, 1822) of Lechia-Pavomari beel of Dhemaji District of Assam and reported that the correlation coefficient 'r' indicates strong positive correlation between the total length and the body weight, with coefficient correlation 'r' approaching almost towards 1.

The Relative Condition Factor (RCF) is calculated as an indicator of general well being of fish, relative robustness, plumpness or fatness in numerical terms. Hile (1936) pointed that the condition factor normally changed mainly due to maturation of gonads, amount of undigested food in the gut and amount of fat stored in the tissue. Le Cren (1951) stated that the condition factor is affected by length and other factors like environment, food supply and parasitism. He indicated that (Kn) was function of fatness and condition of gonads mentioned in his work on perch *P. fluviatilis*.

In the present study, the highest value of relative condition factor for male fish was 1.265 ± 0.354 for female 1.339 ± 0.074 in February (Fig 4A, 4B). Season wise the Kn value were observed high 1.016 ± 0.181 for males and 1.009 ± 0.229 for female fishes in spring (Fig 5). It is also observed that the second next peak values were found during winter for both sexes (For male: 1.003 ± 0.391 and female: 1.002 ± 0.411) which represent good condition of fish on the basis of active feeding and suitability of the environment. According to Hart (1946), the inflexion point on the Kn value curve is good indicator of size at first sexual maturity. It has been used by Pillay (1958) in *Hilsa ilisha* and Bahuguna (2007) in *Puntius conchonius.* The relative condition factors correlates with the more towards feeding rhythm than the sexual maturity reported by several workers.

Bhatt (1968) observed that in *Heteropneustis fossilis* the condition factor fluctuates more with the feeding rhythm than with the seasonal changes in gonad weight. Similar opinion was expressed by Pantulu (1963) in *Mugli gulio* and Raizada *et.al*,(1986) in *Labeo rohita.* Khan et. al (2001) reported high K_n value (1.0091) in *Hilsa ilisha*. Anibeze (1995) observed that females had higher mean K_n value than males (mean 1.29±0.19 and mean 1.07±0.18, respectively) in *Heterobranchus longifilis*. Nagesh *et.al* (2004) reported the average K_n values for *Rohu*, *Catla* and *Mrigal* to be 1.02, 1.022 and 1.03 respectively. The K_n values for three species indicated that they exhibit healthy and robust condition showing good compatibility with the environment. Raizada et al (2005) also stated that the condition factor (K) and relative condition factor (K_n) showed value around 0.9 to1.0 respectively in the milk fish.

The relative condition factor was calculated for *Garra lamta* by Bahuguna *et.al*.,(2010). The highest value for male fish was 1.0299 ± 0.316 in the month of April and 1.4772 ± 0.312 for the female in April. Season wise the Kn value were observed high 1.0590 ± 0.342 for males and 1.0195 ± 0.097for female fishes in spring. It is also observed that the second next peak values were found during summer for both sexes (For male: - 1.0083 ± 0.175 and female: - 1.0149 ± 0.285) which represent good condition of fish on the basis of active feeding and suitability of the environment. These months included due to the period of sexual maturity of fishes.

Panda and Datta (2017) calculated the mean relative condition factors (K_n) to be 1.014±0.023 and 1.043±0.025 for *Barilius bendelisis* and *Barilius barna* respectively which shows the good health and condition of the fishes. Kalita, et. al., (2017) expressed that the Kn value ranges from 0.74-1.39 with an average of 1.00±0.125 in *Mystus tengara* (Hamilton, 1822) of Lechia-Pavomari beel (wetland) of Dhemaji District of Assam, India. According to Kalita, et. al., (2017), the relative condition factor of *Mystus tengara* increases from lighter to heavier fish. They found the value of 'b' for *Mystus tengara* as 2.07.

The relative condition factor (Kn) of Mud eel (*Monopterus cuchia*) from three different areas of Meghalaya were studied by Kurbah and Bhuyan (2018). The values of relative condition factor 'Kn' indicated a good well-being of the fish. High relative condition factor (Kn) value proved that condition factor increased with increasing length and weight of the species. The results revealed a healthy habitat conditions.

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