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IMPACT OF ALTERNATING TEMPERATURE AND ELEVATED CO_2 ON HADDA BEETLE, *HENOSEPILACHNA VIGINTIOCTOPUNCTATA* (COLEOPTERA: COCCINELLIDAE)

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ABSTRACT

Increased temperature and carbon dioxide concentration on the development of Hadda beetle, *H. vigintioctopunctata* revealed that the longest incubation period (3.76±0.26 days) was at 30:20ºC and shortest (3.41±0.01 days) at 35:23ºC, and at the lowest (300 ppm) carbon dioxide level highest incubation period (3.65±0.09 days) was recorded while lowest (3.41±0.02 days) at 500 ppm CO_2 concentration. Total larval duration was maximum at 30:20ºC (19.43±0.15 days) and shortest at 35:23ºC (13.80±1.21 days). Longest larval duration of 17.37±1.18 days was observed at 300 pm, while the shortest 16.67±1.17 days at the elevated (500 ppm) CO_2 concentration. Mean pupal period was longest 5.00±0.09 and 4.50±0.24 days at 30:20ºC and 300 ppm CO_2 level respectively and shortest 3.72±0.14 and 4.25±0.27 days at 35:23ºC and 500 ppm CO_2. Longevity of males as well as females was longest (34.67±1.32, 38.17±1.02 days) at 30:20ºC and at the lowest 300 ppm CO_2 (34.08±1.33, 36.42±1.49 days) respectively. Highest fecundity of 47.89 eggs female{ ^{1} and 58.46 egg per female was recorded at 35:23ºC and at 400 ppm CO_2 level. The present study revealed that incubation, larval and pupal period decreases with rise in temperature and CO_2 concentration.

INTRODUCTION

Climate change is the most important global environmental challenges facing humanity with implications for food production, natural ecosystem, freshwater supply, health, *etc.* Due to anthropogenic activities, the atmospheric mean temperature is expected to rise from 1.1 to 6.4ºC by 2100 (IPCC, 2001) and CO_2 level from 405-460 ppm, 445-640 ppm and 540-970 ppm by 2025, 2050 and 2100, respectively (IPCC, 2007) so, much concern is there about changes in climate and direct or indirect effect on the biology of living organisms, insects as well as crop plants (Garg *et al.,* 2001; Krupa, 2003; IPCC, 2007). Higher temperature will result in faster development in insect while temperature above the specific optimum range may lead to decreased growth rates, reduced fecundity and increased rates of mortality for a multitude of species (Rounalt *et al.,* 2006). Elevated CO_2 and temperature may affect crop production by altering susceptibility to insect herbivores (O'Neill *et al*, 2008).

The spotted or Hadda beetle, *Henosepilachna vigintioctopunctata* (Fabricius) (Coleoptera: Coccinellidae) is a polyphagous pest mainly attacking the solanaceous crops like potato, brinjal and tomato. High temperature and low relative humidity coupled with scarcity of food plants had an adverse effect on fecundity, egg hatchability and neonate survival (Grewal, 1988). The eggs hatch in 5, 3.3 and 2.9 days at 25, 30 and 35ºC, respectively, and retain full-grown in 17.8, 8.7 and 7.1 days at 25, 30 and 35ºC, respectively. The pupal stage lasts 13.4, 6.7 and 5.1 days at 25, 30 and 35ºC, respectively (Atwal and Dhaliwal, 2005). The number of adult emergence was higher in females as compared to males and the longevity of females was longer than those of males (Jamwal *et al.*, 2013). A gradually declined in population due to lower temperature and humidity and also due to maturity of the crop was observed in Uttar Pradesh (Kumar and Singh, 2014). High temperature and humidity during July to September lowered down the duration of life cycle and increased fecundity leading to rapid multiplication of pest resulting in higher population level and thereby, increased crop loss during the period (Gosh and Senapati, 2001).

There are limited studies in which both insects and host plants were exposed to elevated CO_2 but these studies couldn't pinpoint the direct effects of elevated CO_2 on insects. Hence, there is a need to further examine how insects get affected when exposed directly to higher temperature as well as elevated CO_2 concentrations. The present study deals with the effect of rising minimum temperature and CO_2 level on *H. vigintioctopunctata*

MATERIALS AND METHODS

Maintenance of *H. vigintioctopunctata* cultures

Studies on *H. vigintioctopunctata* were carried out in a controlled environment chamber (PGW-40, M/s Percival Scientific, Inc., USA), at the Department of Entomology, Punjab Agricultural University, Ludhiana to observe the effects of temperature and carbon dioxide on the development and survival of the insect.

Field collected gurbs of *H. vigintioctopunctata* were reared in the laboratory in plastic jars (15 cm X 10 cm) on fresh and tender brinjal/eggplant leaves until they reached pupal stage. The jars were covered with muslin cloth and fastened with rubber band to prevent escape of adults and also provide aeration. Pupae were then separated and kept in jars with moistened foam disc (14mm thick). The emerged adults were collected, paired and kept for egg laying in jars (Saravanan and Chaudhary, 2012). Fresh eggplant leaves were offered daily to the insects. The leaves on which eggs were laid were wrapped with moistened cotton to prevent desiccation of the leaves and were placed inside the jars along with moistened foam disc. The insect culture was maintained at 30 ± 5ºC and 65 ± 5 % relative humidity and 14:10 L:D photoperiod.

Effect of temperature and CO_2 on development and survival of *H. vigintioctopunctata*

Freshly laid eggs taken from the culture were kept in plastic jars at the rate of 25 eggs at different temperature and concentrations of carbon dioxide. Four temperature regimes (30:20, 30:23, 35:20 and 35:23ºC) at 14:10 L:D photoperiod along with three CO_2 concentration maintained at 300, 400, 500 ppm were taken into consideration for the experiment. There were twelve treatments with three replications per treatment. The data on hatching was recorded at 12 hr interval (Mironidis and Savopoulou, 2008). Based on time of hatching of larvae at each alternating temperature and carbon dioxide levels the duration of egg stage was calculated. Larvae was transferred to separate jars with the help of soft camel's hair brush at the rate of 25 neonates larvae per replication and reared on fresh eggplant leaves until they reached adult stage. The larvae were monitered regularly until they reached adult stage. Molting was confirmed by examining exuviae and head capsules (Saravanan and Chaudhary, 2012). Male and female adults were identified and sorted out on the basis of morphological features and were released in the plastic jars (15x10cm) at the rate of two pair per jar for mating and laying eggs. Fresh brinjal leaves were provided as food for the adults. The jars were covered with muslin cloth and fastened with rubber band to prevent escape of adults and to provide aeration to adults. Data on eggs laid, larval survival, larval and pupal periods, pupal weight, adult emergence, adult longevity and fecundity were recorded at each temperature and concentrations of carbon dioxide.

Statistical analysis

The data were subjected to factorial completely randomized design (CRD) using CPCS1 software (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Incubation period

The incubation period of *H. vigintioctopunctata* was found

Table 1: Effect of different temperature and carbon dioxide regimes on the incubation period (days) of *H. vigintioctopunctata*

Carbon dioxide concentration (ppm)	Incubation period at temperature (ºC)-Max: Min (Mean)* 30:20º(25.83º)	30:23º (27.08º)	35:20º (28.75º)	35:23º (30.00º)	Mean
300	3.83 ± 0.17	3.79 ± 0.15	3.55 ± 0.01	3.43 ± 0.03	3.65 ± 0.09
400	3.98 ± 0.01	3.50 ± 0.03	3.45 ± 0.01	3.42 ± 0.01	3.58 ± 0.13
500	3.47 ± 0.03	3.45 ± 0.02	3.40 ± 0.01	3.38 ± 0.03	3.41 ± 0.02
Mean	3.76 ± 0.26	3.58 ± 0.10	3.46 ± 0.04	3.41 ± 0.01	
CD (p = 0.05)	CO_2 conc. (C) :	0.99			
	Temperature (T):	0.11			
	C X T :	0.20			

*These temperatures were maintained for 14:10 h along with L: D photoperiod

Table 2: Effect of different temperature and carbon dioxide regimes on the total larval duration (days) of *H. vigintioctopunctata*

Carbon dioxide concentration (ppm)	30:20º (25.83º)	Total larval duration at temperature (ºC)-Max: Min (Mean)* 30:23º (27.08º)	35:20º (28.75º)	35:23º (30.00º)	Mean
300	19.67 ± 0.07	18.54 ± 0.01	17.04 ± 0.04	14.23 ± 0.05	17.37 ± 1.18
400	19.46 ± 0.03	17.67 ± 0.17	16.33 ± 0.17	10.33 ± 3.17	16.74 ± 1.97
500	19.17 ± 0.17	17.67 ± 0.17	16.17 ± 0.17	13.67 ± 0.17	16.67 ± 1.17
Mean	19.43 ± 0.15	17.96 ± 0.30	16.51 ± 0.27	13.80 ± 1.21	
CD (p = 0.05)	CO_2 conc.(C) :	0.18			
	Temperature (T):	0.20C			
	X T:	NS			

*These temperatures were maintained for 14:10 h along with L: D photoperiod;NS-Non significant

Table 3: Effect of different temperature and carbon dioxide regimes on the larval weight (mg) of *H. vigintioctopunctata*

Carbon dioxide concentration (ppm)	30:20º (25.83º)	Larval weight (IV instar) at temperature (ºC)-Max: Min (Mean)* 30:23º (27.08º)	35:20º (28.75º)	35:23º (30.00º)	Mean
300	34.07 ± 0.29	34.44 ± 0.14	35.28 ± 0.29	36.82 ± 0.13	35.15 ± 0.60
400	34.64 ± 0.15	34.75 ± 0.13	36.74 ± 0.37	37.00 ± 0.12	35.78 ± 0.63
500	37.19 ± 0.22	37.49 ± 0.123	38.50 ± 0.22	38.66 ± 0.19	37.96 ± 0.36
Mean	35.30 ± 0.96	35.56 ± 0.97	36.84 ± 0.93	37.49 ± 0.58	
CD (p = 0.05)	CO_2 conc. (C):	0.32			
	Temperature (T):	0.36C			
	X T:	0.63			

*These temperatures were maintained for 14:10 h along with L: D photoperiod;NS-Non significant

Table 4: Effect of different temperature and carbon dioxide regimes on the pupal duration (days) of *H. vigintioctopunctata*

Carbon dioxide	Duration of Pupa at temperature (ºC)-Max: Min (Mean)*				
concentration (ppm)	30:20º (25.83º)	30:23º (27.08º)	35:20º (28.75º)	35:23º (30.00º)	Mean
300	5.17±0.16	4.50±0.01	4.33±0.17	4.00±0.01	4.50±0.24
400	5.00±0.01	4.50±0.01	4.33±0.16	3.67±0.06	4.38±0.28
500	4.83±0.17	4.33±0.17	4.33±0.17	3.50±0.01	4.25±0.27
Mean	5.00±0.09	4.44±0.05	4.33±0.01	3.72±0.14	
CD (p=0.05)	CO_2 conc. (C):	0.18			
	Temperature (T):	0.21			
	C X T:	NS			

*These temperatures were maintained for 14:10 h along with L: D photoperiod;NS-Non significant

Table 5:Effect of different temperature and carbon dioxide regimes on the pupal weight (mg per individual{ ^{1}) of *H. vigintioctopunctata*

Carbon dioxide	Pupae weight at temperature (ºC)-Max: Min (Mean)*				
concentration (ppm)	30:20º (25.83º)	30:23º (27.08º)	35:20º (28.75º)	35:23º (30.00º)	Mean
300	19.90±0.17	22.50±0.30	24.07±0.06	23.47±0.24	22.48±0.92
400	24.11±0.06	24.21±0.05	25.61±0.22	28.59±0.07	25.63±1.04
500	25.50±0.08	26.02±0.13	28.22±0.20	28.33±0.28	27.01±0.73
Mean	23.17±1.68	24.24±1.01	25.97±1.20	26.80±1.67	
CD (p=0.05)	CO_2 conc.(C) :	0.27			
	Temperature (T):	0.31C			
	X T:	0.53			

*These temperatures were maintained for 14:10 h along with L: D photoperiod;NS-Non significant

Table 6 : Effect of different temperature and carbon dioxide regimes on the adult longevity (days) of *H. vigintioctopunctata*

Carbon dioxide	Longevity at temperature (°C)-Max: Min (Mean)*				
concentration (ppm)	30:20° (25.83°)	30:23° (27.08°)	35:20° (28.75°)	35:23° (30.00°)	Mean
	Male				
300	37.17±0.16	35.00±0.01	33.33±0.16	30.83±0.44	34.08±1.33
400	34.17±0.44	32.00±0.58	30.67±0.33	28.67±0.67	31.37±1.15
500	32.67±0.17	29.33±0.17	28.00±0.17	22.67±0.01	28.17±2.07
Mean	34.67±1.32	32.11±1.63	30.67±1.54	27.39±2.44	
CD (p=0.05)	CO_2 conc. (C):	0.54			
	Temperature (T):	0.63			
	C X T:	1.09			
	Female				
300	39.83±0.44	37.50±0.76	35.50±0.76	32.83±0.44	36.42±1.49
400	38.33±0.33	36.50±0.29	35.33±0.33	31.33±0.33	35.37±1.48
500	36.33±0.33	32.33±0.33	31.00±0.01	27.17±0.17	31.70±1.89
Mean	38.17±1.02	35.44±1.58	33.94±1.47	30.44±1.69	
CD (p=0.05)	CO_2 conc.(C) :	0.63			
	Temperature (T):	0.72			
	C X T:	NS			

*These temperatures were maintained for 14:10 h along with L: D photoperiod; NS- Non significant

Table 7: Effect of different temperature and carbon dioxide regimes on the fecundity (eggs female{ ^{1}) of *H. vigintioctopunctata*

Carbon dioxide	Fecundity at temperature (ºC)-Max: Min (Mean)*				
concentration (ppm)	30:20º (25.83º)	30:23º (27.08º)	35:20º (28.75º)	35:23º (30.00º)	Mean
300	33.33±0.33 (5.85)	36.00±0.58 (6.08)	38.33±1.45 (6.27)	40.00±1.15 (6.40)	36.92±1.44 (6.15)
400	54.67±0.89 (7.46)	56.00±1.15 (7.55)	60.83±0.67 (7.86)	62.33±0.67 (7.95)	58.46±1.85 (7.70)
500	36.33±1.45 (6.10)	35.67±0.88 (6.05)	39.00±0.58 (6.32)	41.33±0.88 (6.50)	38.08±1.30 (6.24)
Mean	41.44±6.67 (6.47)	42.56±6.72 (6.56)	46.05±7.39 (6.82)	47.89±7.23 (6.95)	
CD (p=0.05)	CO_2 conc. (C):	0.10			
	Temperature (T):	0.12			
	C X T:	NS			

*These temperatures were maintained for 14:10 h along with L: D photoperiod;NS- Non significant
Figures in parentheses square root transformed values

to be significantly different at different temperatures (Table 1). Highest incubation period (3.76±0.26 days) was recorded at 30:20ºC followed by 3.58±0.10, 3.46±0.04, 3.41±0.01 days at 30:23ºC, 35:20ºC and 35:23ºC, respectively. Similar findings were provided by Kwon *et al.* (2010) who reported egg duration of 20.5±1.1, 9.8±1.0, 8.1±1.0, 5.8±0.7 and 3.2±0.7 days at 10ºC, 15ºC, 20ºC, 25ºC and 30ºC, respectively. Kang *et al.* (2014) also reported that the incubation period of eggs of *H. vigintioctopunctata* on *Lycium chinense* were 10.8, 7.7, 5.1 and 3.7 days at 15ºC, 20ºC, 25ºC and 30ºC, respectively. The incubation period of eggs of *H. vigintioctopunctata* has also been reported to vary with the host plant on which eggs were laid. For instance, incubation of 3.2 days on brinjal (Bindu and Pramanik, 2015), 3.25±0.97

days on *Solanum nigrum* (Jamwal *et al.,* 2013) and 3.79 ± 0.49 days on *Withania somnifera* (Venkatesha, 2006). Highest incubation period (3.65 ± 0.09 days) was recorded at the lowest carbon dioxide concentration. A reduction in the development of eggs of the flea beetle *Agasicles hygrophila* fed on alligator weed under elevated carbon dioxide (750 *micro litre*/ litre) as compared to ambient carbon dioxide (420 *micro litre*/ litre) concentration has been reported by Fu *et al.* (2016). The interaction effect of temperature and carbon dioxide levels on the incubation period of eggs revealed longest incubation period of 3.98 days at the lowest temperature (30:20ºC) and at the intermediate (400 ppm)carbon dioxide concentration, while the shortest period of 3.38 days was recorded at the highest temperature(35:23) and the highest(500 ppm) carbon dioxide concentration.

Larval duration and weight

The mean larval duration of *H. vigintioctopunctata* declined significantly with rise in temperature. The significantly longest larval duration of 19.43 ± 0.15 days was recorded at the lowest temperature (mean 25.83ºC) and the shortest (13.80 ± 1.21 days) at the highest temperature (Table 2).

Faster development and shorter larval duration with rise in temperature in *H. vigintioctopunctata* has been reported by Kwon *et al.* (2010). These authors recorded the total larval duration of 50.9 ± 6.3, 28.3 ± 2.8, 24.7 ± 2.5, 14.7 ± 1.1 and 11.3 ± 0.5 days at constant temperatures of 10, 15, 20, 25 and 30ºC, respectively. Similarly, Kang *et al.* (2014) observed the total developmental period of *H. vigintioctopunctata* from egg to adult stage on *Lycium chinense* to be 42.7, 26.3, 18.4 and 19.4 days at constant temperature of 15, 20, 25 and 30ºC, respectively. The total mean larval duration differed significantly at different carbon dioxide levels. The duration was found significantly longer (17.37 ± 1.18 days) at the lowest carbon dioxide concentration and shortest (16.67 ± 1.17 days) at the highest level. Similar results for developmental period of flea beetle, *A. hygrophila* reared on alligator weed at ambient (420 *micro* litre / litre) and elevated (750 *micro litre* / litre) carbon dioxide have recently been reported by Fu *et al.* (2016). The total developmental period for the pre-adult stage was 24.13 days and 22.22 days at the elevated and ambient carbon dioxide concentrations, respectively.

The larval weight of *H. vigintioctopunctata* was found to differ significant at different temperatures (Table 3). Maximum larval weight (37.49 ± 0.58 mg) was observed at the highest temperature. The carbon dioxide concentration also significantly affected the larval weight. At the highest concentration of carbon dioxide, the larval weight was maximum (37.96 ± 0.36 mg) while the same was minimum (35.15 ± 0.60 mg) at the lowest concentration of carbon dioxide.

The increased larval weight at elevated carbon dioxide concentration was probably due to increased food intake. An increase in food intake with rise in carbon dioxide level as been reported in a diverse group of insects including the flea beetles (Fu *et al.,* 2016).

Pupal duration and weight

Maximum pupal duration recorded was 5.00 ± 0.09 days at the lowest temperature and minimum 3.72 ± 0.14 days at the highest temperature (Table 4).

The duration of pupal *H. vigintioctopunctata* has been reported to decrease with a rise in temperature. Kwon *et al.* (2010) observed pupal period of 20.6 ± 1.9, 12.5 ± 1.57, 7.9 ± 1.1, 4.9 ± 1.2 and 4.1 ± 0.9 days at temperature of 10, 15, 20, 25 and 30ºC, respectively. A significant variation in pupal duration was also observed due to impact of carbon dioxide in the present study. At the highest regimes of carbon dioxide *i.e* 500 ppm the pupal duration was shortest 4.25 ± 0.27 days. Longest pupal duration (5.17 days) was recorded at the lowest temperature and carbon dioxide concentration and shortest (3.50 days) at the highest temperature and carbon dioxide concentration.

The pupal weight of *H. vigintioctopunctata* was significantly influenced by temperature regimes (Table 5). Maximum (26.80 ± 1.67 mg) pupal weight was observed at the highest temperature (35:23ºC). Maximum pupal weight (27.01 ± 0.73 mg) was recorded at the highest carbon dioxide concentration and minimum (22.48 ± 0.92 mg) at the lowest. The interactive effect of temperature and carbon dioxide was found to be significant in the present study. The pupal weight was significantly lowest (19.90 mg) at the lowest temperature (mean 25.83) and carbon dioxide concentration and highest (28.59 mg) at the highest (mean 30.00) temperature and 400 ppm carbon dioxide concentration.

Adult longevity

The adult male as well as female longevity was significantly different at different temperature and carbon dioxide regimes. In adult males, the maximum longevity (34.67 ± 1.32 days) was observed at the lowest temperature and minimum (27.39 ± 2.44 days) at the highest temperature (Table 6). Significant differences in male longevity were also observed at different carbon dioxide concentrations. The male longevity was maximum (34.08 ± 1.33 days) at the lowest (300 ppm) carbon dioxide concentration. The interactive effect of temperature and carbon dioxide was also found to be significant. Maximum (37.17 ± 0.16 days) male longevity was observed at the lowest temperature and carbon dioxide levels (30:20ºC, 300 ppm) and the minimum (22.67 ± 0.01 days) at the highest temperature and carbon dioxide level (35:23ºC, 500 ppm).

A decline in male longevity with increase in CO_2 concentration has been reported in *A. hygrophila* by Fu *et al.* (2016). The male longevity decreases with increased temperature and carbon dioxide concentration. Male longevity of 57.2 days on brinjal at 28ºC, 80% RH (Qamar *et al.,* 2009), 54.8, 50.9, 53.1, 45.5 days on ashwagangha, potato, makoi and tomato, respectively (Sharma and Chandel, 2009), 13.10 and 9.40 days on brinjal and bitter gourd, respectively at 29ºC, 60 ± 10% RH (Jamwal *et al.,* 2013) were reported.

Female adult longevity was maximum (38.17 ± 1.02 days) at the lowest temperature and minimum (30.44 ± 1.69 days) at the highest temperature (Table 6). Carbon dioxide was also found to have significant effect on the female adult longevity. The longevity of females was significantly more (36.42 days) at the lowest concentration than 31.70 days at the highest 500 ppm level.

Female longevity varied from 57.7 to 97.00 days at 26ºC on

Solanum (Shirai and Katakura, 1999), 60.8 days on brinjal at 28°C, 80% RH (Qamar *et al.,* 2009), 60.9, 54.1, 56.2, 48.1 days on ashwagangha, potato, maloi and tomato (Sharma and Chandel, 2009), 31.50 and 27.15 days on brinjal and bitter gourd, respectively at 29ºC, 60±10% RH (Jamwal *et al.,* 2013).

Fecundity

Highest fecundity of 47.89±7.23 eggs per female was recorded at the highest temperature (Table 7). In case of carbon dioxide regimes, highest fecundity (58.46±1.85 eggs per female) was recorded at the intermediate CO_2 and lowest (36.92±1.44 eggs female^{-1}) at the lowest CO_2 level. The findings revealed that higher fecundity (58.46) was observed at the 400 ppm concentration of carbon dioxide as compared to the other two different concentrations. In contrast to these findings an increase in fecundity of flea beetle females under elevated CO_2 was observed by Fu *et al.* (2016). The fecundity observed in our study was much lower than that observed by Shirai and Katakura (1999), Gosh and Senapati (2001), Venkatesha (2006) and Sharma and Chandel (2009) as 429.1 eggs per female on *S. nigrum*, 272.32 on brinjal, 90.89 on *W. sominifera* and 441.0 on tomato, respectively but in agreement with the findings of Bindu and Pramanik (2015) where 55.8 eggs per female was recorded. Lowest fecundity (33.33 eggs female^{-1}) was recorded at 30:20ºC temperature and 300 ppm concentration

Elevated temperature and carbon dioxide had a profound effect on the growth, development and survival of the insect. The larval and pupal period shortened with increasing temperature. The duration of pupal *H. vigintioctopunctata* has also been reported to decrease with rise in temperature. The larval weight increases under elevated temperature and carbon dioxide concentration due to increased food consumption. Higher infestation under elevated carbon dioxide and temperature by the pest may cause considerable economic loss, adversely affecting both quality and quantity of crop output. So, agricultural scientist need to orient their research on impact of climate change on various pests especially crop pests and various possibilities that can help in mitigating and adapting menace of anticipated climate change.

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APPLICATION FORM

NATIONAL ENVIRONMENTALISTS ASSOCIATION (N.E.A.)

To,
The Secretary,
National Environmentalists Association,
D-13, H.H.Colony,
Ranchi - 834 002, Jharkhand, India

Sir,
I wish to become an Annual / Life member and Fellow* of the association and will abide by the rules and regulations of the association

Name ____

Mailing Address ____

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E-mail ____________________ Ph. No. ____________ (R) ____________ (O)

Date of Birth ____________________ Mobile No. ____________________

Qualification ____

Field of specialization & research ____

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Please find enclosed a D/D of Rs.. No. .... Dated .... as an *Annual / Life membership fee*.

*Attach **Bio-data and some recent publications along with the application form when applying for the Fellowship of the association.**

Correspondance for membership and/ or Fellowship should be done on the following address :

SECRETARY,
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E-mails : m_psinha@yahoo.com Cell : 9431360645
dr.mp.sinha@gmail.com Ph. : 0651-2244071