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DEVELOPMENT OF A NEW BIVOLTINE BREED OF SILKWORM *BOMBYX MORI* MU_{51} WITH SHORT LARVAL DURATION

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ABSTRACT
An exotic bivoltine race of silkworm *Bombyx mori* namely C_{108}, and an exotic multivoltine race pre, with known genetic background were utilized in different combinations in the cross breeding programme including test crossing and backcrossing at appropriate stages by following suitable selection procedure for the ten economic traits considers at every generation, a hardy new bivoltine breed MU_{51} is evolved, which is characterized by plain larvae spinning white oval cocoons with shorter larval duration (20-22 days) was isolated in the selected breeding experiment.

INTRODUCTION

The attempts were made to import, rear and breed new bivoltine races in the tropical climates with an appropriate rearing technology that resulted in the evolving of few bivoltine races. However these races were mostly used for producing commercial crossbreed cocoons with that of multivoltine Pure Mysore females, but are not fully utilized for the production of pure bivoltine silk, in view of their poor adaptability to the fluctuating environmental conditions of the tropics (Nagaraju, 2002). Despite a quantum jump in mulberry silk production since the last three decades in India, the quality of silk remained inferior and can not meet the international standards as well the domestic needs of the power loom sector since the bulk of silk production comes from multivoltine x bivoltine hybrids (Kumaresan *et al*., 2003). Hence, there is a need to formulate need based breeding strategies to evolve robust bivoltine races to improve the productivity and viability traits and to investigate the genetic worth of the new silkworm races evolved regarding their performance and the influence of the environment on the expression of economic characters. Although the possibility and potentiality of bivoltine silk production exists in the country, India has her lion's share of raw silk produce from polyvotine x bivoltine hybrids; attempts were made by different breeders adopting appropriate breeding strategies to develop bivoltine breeds for qualitative and quantitative improvement. Realizing the need for high cocoon shell percentage and high raw silk percentage as thrust areas in silkworm breeding, many viable single hybrids were evolved and authorized for commercial exploitation (Datta *et al*., 2000). These hybrids although being more productive and robust, in their parental breeds, negative correlation exists between other quantitative characters (Pallavi and Basavaraja, 2007). Keeping this in view an attempt has been made to evolve a bivoltine x polyvotine breed using exotic pure races, since the improvement of indigenous races could be achieved through hybridization utilizing exotic races (Kovalov, 1970), which has not been utilized to its potential in Indian sericulture that suits the tropical climatic condition.

MATERIALS AND METHODS

A female of an exotic bivoltine race of silkworm *Bombyx mori*, namely C_{108} characterized by plain larvae, white oval cocoons known for high cocoon weight, shell weight, shell ratio etc., and a male of an exotic multivoltine race pre, with larval body marking and spinning white oval cocoon, known for high survival rate and shorter larval duration (19-20 days) were used in different breeding programmes designed to isolate promising silkworm races. The data pertaining to rearing performances of these races were recorded, evaluated and critically analyzed for ten economic traits (Table 1, 2 and 3), before utilizing them in hybridization programme by conducting cellular rearings in replicates of three each by following standard rearing techniques suggested by and Krishnaswami and Narasimhanna (1974), by feeding M_5 variety of mulberry leaves.

Based on their performance they were used in different combinations followed by selection made at every generation for the desirable traits with regard to egg, larva, pupa/cocoon and moth stages, coupled with testcrossing/backcrossing to the initial parents at appropriate stages in the breeding programme (Fig. 1).

The Duncan system of statistical model for one-way classification was employed for the data obtained during of course of inbreeding. In addition the student 't' test was employed following the method of Snedecor and Cochran (1967) in order to understand the difference between new isolated lines and the control multivoltine and bivoltine races based on the means of F_{12} generations for ten economic traits. Further, after a significant F obtained through ANOVA (Scheffe, 1959), more specific comparisons are required to be made away the number of means, for such comparisons the most widely used test the Duncan's multiple range test (DMRT), (1955) is applied.

RESULTS AND DISCUSSION

By following the breeding plan (Fig. 1) a bivoltine breed was isolated. The results for ten quantitative traits analyzed during the course of breeding of the cross until the fixation of the desired traits in the isolated breed (Table 3 and Fig. 2) and control parental races are presented in Table 1 and 2 for pre, and C_{108} respectively.

In the present hybridization programme, utilization of locally adopted exotic mulivoltine and bivoltine races which are known for their distinct phenotypes and genotypes, as parent material produced wide variability in the hybrid progenies offering large scope for selection of desirable gene combinations. Further during the course of breeding it is of major importance to have optimum population (mass rearing) size since the desired alleles in a crossbreed population at early generations will be at low frequency for selection of desirable gene combinations (Kobayashi, 1962).

Data on the fecundity of the breed compared to multivoltine control pre, and bivoltine control $C_{108,}$ revealed significant increase in the isolated breed. The observed fecundity (573) thus exhibited by the isolated breed attributed to the selection of layings with optimum number of eggs at every generation and allowing a mating of three hours for the moths as suggested by Petkov *et al.,* (1979). The significant improvement ($p<0.000$) in hatching percentage (95%) exhibited by the isolated breed over the bivoltine control race can be attributed to favourable environmental condition provided during incubation period as pointed out by Tazima (1988), optimum duration of mating allowed enabling the female moths to lay more number of fertilized eggs, and selection of layings for high hatchability followed during the course of breeding experiment. Further, Chandrashekaraiah (1992) pointed out that hatchability as a viability parameters and increase in hatching is ascribed to viability. The isolated breed exhibited significant ($p<0.000$) decrease in larval duration (20-22 days) due to the prematurity genes that present in multivoltine pre race (Murakami and Yoshiki Ohtsuki, 1989), than the control bivoltine race (24-26 days) is an important feature.

Cocoon yield by number and pupation rate are the two important characters reflecting the viability of a breed. Comparison of the data over multivoltine (9522 and 93%) and bivoltine (9209 and 90%) revealed significant ($p<0.000$) differences in the isolated breed (9440 and 93%). Though their mean values were recorded less than multivoltine control marginally when compared to bivoltine control thus, establishing their merit for viability. Cocoon yield by weight is an important parameter from the point of view of cocoon

Table 1 : Mean value of the Ten economic characters of the control multivoltine parent pre

Generations	Fecundity	Hatching percentage	Larval duration (hrs)	Cocoon yield by No./10,000 larvae	Cocoon yield by wt/10,000 larvae	Single cocoon weight (g)	Single shell weight (g)	Shell percentage	Pupation rate (%)	Filament length (m)
F_1	362.00 ^{a}	93.930 ^{cd}	458.66 ^{abc}	9355.33 ^{ab}	8.793 ^{bc}	0.940 ^{bc}	0.121 ^{b}	12.870 ^{c}	92.330 ^{abcd}	312.66 ^{a}
F_2	380.66 ^{a}	94.660 ^{cde}	502.33 ^{abcd}	9644.33 ^{cd}	10.366 ^{e}	1.074 ^{d}	0.134 ^{c}	12.503 ^{bc}	95.106 ^{de}	330.00 ^{b}
F_3	382.66 ^{ab}	94.950 ^{de}	488.00 ^{abcd}	9666.33 ^{d}	10.630 ^{e}	1.100 ^{d}	0.137 ^{c}	12.453 ^{bc}	95.330 ^{e}	331.00 ^{bc}
F_4	394.00 ^{b}	92.220 ^{a}	508.00 ^{bcd}	9489.00 ^{abcd}	9.163 ^{d}	0.965 ^{c}	0.118 ^{ab}	12.220 ^{ab}	93.330 ^{abcde}	331.00 ^{bc}
F_5	420.00 ^{c}	92.300 ^{a}	530.66 ^{cd}	9522.00 ^{abcd}	9.033 ^{cd}	0.948 ^{bc}	0.116 ^{ab}	12.263 ^{ab}	93.443 ^{abcde}	333.00 ^{bc}
F_6	373.66 ^{a}	93.846 ^{c}	440.00 ^{ab}	9388.66 ^{abc}	8.800 ^{bc}	0.937 ^{bc}	0.121 ^{b}	12.910 ^{c}	91.663 ^{ab}	310.00 ^{a}
F_7	421.66 ^{cd}	95.726 ^{e}	488.33 ^{abcd}	9622.00 ^{bcd}	10.470 ^{e}	1.080 ^{d}	0.136 ^{c}	12.533 ^{bc}	94.553 ^{cde}	314.66 ^{a}
F_8	412.33 ^{c}	94.743 ^{cde}	508.00 ^{bcd}	9666.33 ^{d}	10.606 ^{e}	1.097 ^{d}	0.138 ^{c}	12.606 ^{bc}	94.220 ^{bcde}	314.00 ^{a}
F_9	376.00 ^{a}	92.403 ^{a}	488.33 ^{abcd}	9599.66 ^{abcd}	9.290 ^{d}	0.967 ^{c}	0.117 ^{ab}	12.126 ^{ab}	93.440 ^{abcde}	331.33 ^{bc}
F_{10}	399.33 ^{b}	92.736 ^{ab}	538.33 ^{d}	9544.33 ^{abcd}	9.033 ^{cd}	0.946 ^{bc}	0.112 ^{a}	11.906 ^{a}	93.663 ^{abcde}	327.33 ^{b}
F_{11}	371.33 ^{a}	93.716 ^{bc}	458.66 ^{abc}	9433.00 ^{abcd}	8.410 ^{a}	0.891 ^{a}	0.114 ^{a}	12.790 ^{c}	91.110 ^{a}	312.00 ^{a}
F_{12}	369.00 ^{a}	92.230 ^{a}	434.33 ^{a}	9333.00 ^{a}	8.640 ^{ab}	0.926 ^{b}	0.118 ^{ab}	12.780 ^{c}	91.886 ^{abc}	320.00 ^{b}
Mean value	388.55	93.621	486.72	9522.00	9.436	0.990	0.123	12.496	93.339	322.25
F value	4.051	60.723	10.396	9.732	269.10	305.99	130.51	21.274	11.272	3.318
Significance	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.007
SE	4.130	0.2024	5.941	21.826	0.135	0.012	0.001	0.053	0.240	1.900
T test for mean of F_1 to F_{12} generation (pre vs isolated line MU_{51})										
t value	-27.041	-5.412	-4.702	2.411	-46.498	-61.338	-91.537	-92.600	0.367	-84.378
$p<0.00$	0.000	0.000	0.000	0.019	0.000	0.000	0.000	0.000	0.000	0.000

Mean with same letter are not significantly different from each other

Table 2 : Mean value of the Ten economic characters of the control bivoltine parent C_1

Generations	Fecundity	Hatching percentage	Larval duration(hrs)	Cocoon yield by No./10,000 larvae	Cocoon yield by wt/10,000 larvae	Single cocoon weight (g)	Single shell weight (g)	Shell percentage	Pupation rate (%)	Filament length (m)
F_1	494.33 ^{a}	92.753 ^{bc}	553.66 ^{ab}	8933.00 ^{a}	15.190 ^{a}	1.700 ^{a}	0.352 ^{a}	20.726 ^{e}	88.116 ^{a}	1055.33 ^{a}
F_2	540.33 ^{bc}	89.203 ^{a}	552.33 ^{ab}	9311.00 ^{ab}	17.833 ^{b}	1.915 ^{cdef}	0.396 ^{c}	20.696 ^{e}	91.440 ^{c}	1143.66 ^{b}
F_3	546.00 ^{bc}	89.986 ^{a}	582.00 ^{c}	9310.66 ^{ab}	17.886 ^{b}	1.921 ^{def}	0.392 ^{c}	20.440 ^{de}	91.330 ^{c}	1168.00 ^{b}
F_4	560.33 ^{bc}	91.436 ^{ab}	578.00 ^{c}	9255.33 ^{ab}	17.630 ^{b}	1.904 ^{cde}	0.370 ^{b}	19.443 ^{a}	90.996 ^{b}	1170.33 ^{b}
F_5	571.66 ^{c}	91.600 ^{a}	603.00 ^{d}	9255.00 ^{ab}	17.640 ^{b}	1.906 ^{cde}	0.377 ^{b}	19.800 ^{abc}	90.666 ^{bc}	1163.33 ^{b}
F_6	521.66 ^{ab}	90.353 ^{a}	540.33 ^{a}	9100.00 ^{ab}	15.770 ^{a}	1.732 ^{b}	0.348 ^{a}	20.103 ^{bcd}	88.776 ^{a}	1042.00 ^{a}
F_7	574.00 ^{c}	88.390 ^{a}	560.33 ^{b}	9355.33 ^{b}	18.066 ^{b}	1.931 ^{ef}	0.396 ^{c}	20.506 ^{de}	91.330 ^{c}	1159.33 ^{b}
F_8	571.00 ^{c}	88.860 ^{a}	584.33 ^{c}	9321.66 ^{ab}	18.033 ^{b}	1.934 ^{f}	0.396 ^{c}	20.490 ^{de}	90.330 ^{b}	1171.66 ^{b}
F_9	577.33 ^{c}	91.110 ^{ab}	578.33 ^{c}	9222.00 ^{ab}	17.540 ^{b}	1.902 ^{cd}	0.373 ^{b}	19.646 ^{ab}	90.550 ^{bc}	1176.00 ^{b}
F_{10}	571.00 ^{c}	91.013 ^{ab}	608.33 ^{d}	9277.33 ^{ab}	17.556 ^{b}	1.892 ^{c}	0.370 ^{b}	19.563 ^{a}	90.000 ^{b}	1131.33 ^{b}
F_{11}	488.33 ^{a}	90.860 ^{a}	554.66 ^{ab}	9088.66 ^{ab}	15.743 ^{a}	1.732 ^{b}	0.350 a	20.203 ^{cd}	88.000 ^{a}	1036.66 ^{a}
F_{12}	842.00 ^{a}	90.810 ^{a}	556.00 ^{b}	9088.66 ^{ab}	15.776 ^{a}	1.736 ^{b}	0.352 a	20.313 ^{de}	88.886 ^{a}	1032.33 ^{a}
Mean value	541.50	90.531	570.94	9209.88	17.055	1.850	0.373	20.161	90.035	1120.83
F value	35.984	3.725	95.593	4.968	85.497	599.66	225.3	45.647	4.909	33.664
Significance	0.000	0.003	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000
SE	6.0203	0.254	3.944	24.900	0.177	0.015	0.003	0.074	0.246	10.025
T Test for the mean of F_1 to F_{12} generations (C_{108} v/s isolated line MU_{51})										
t value	-3.937	-13.941	9.467	-6.428	-6.008	-5.464	-6.166	-2.500	-8.994	-3.409
$p < 0.000$	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.015	0.000	0.001

Mean with same letter are not significantly different from each other

Table 3 : Mean value of the Ten economic characters of the isolated new bivoltine breed MU_{51}

Generations	Fecundity	Hatching percentage	Larval duration (hrs)	Cocoon yield by No./10,000 larvae	Cocoon yield by wt/10,000 larvae	Single cocoon weight (g)	Single shell weight (g)	Shell percentage	Pupation rate (%)	Filament length (m)
F_1	541.00 ^{a}	96.310 ^{c}	475.33 ^{a}	9144.33 ^{a}	16.759 ^{a}	1.832 ^{a}	0.379 ^{a}	20.699 ^{cd}	90.773 ^{a}	1072.66 ^{a}
F_2	565.00 ^{a}	96.345 ^{c}	549.33 ^{f}	9500.00 ^{cde}	18.873 ^{c}	1.986 ^{cd}	0.414 ^{d}	20.872 ^{d}	94.330 ^{c}	1150.00 ^{bc}
F_3	560.00 ^{a}	96.010 ^{bc}	533.00 ^{def}	9566.33 ^{de}	19.002 ^{cd}	1.986 ^{cd}	0.415 ^{d}	20.893 ^{d}	95.330 ^{c}	1175.00 ^{cd}
F_4	614.00 ^{b}	96.457 ^{c}	532.33 ^{def}	9455.33 ^{bcd}	18.516 ^{c}	1.958 ^{c}	0.396 ^{c}	20.238 ^{ab}	93.331 ^{bc}	1194.66 ^{cde}
F_5	645.00 ^{b}	96.391 ^{c}	548.33 ^{f}	9444.33 ^{bcd}	18.530 ^{c}	1.962 ^{c}	0.390 ^{bc}	19.911 ^{a}	93.106 ^{bc}	1219.66 ^{def}
F_6	541.66 ^{a}	92.381 ^{a}	495.66 ^{abc}	9255.33 ^{ab}	17.499 ^{b}	1.890 ^{b}	0.379 ^{a}	20.046 ^{ab}	91.997 ^{bc}	1095.66 ^{a}
F_7	567.00 ^{a}	94.965 ^{abc}	484.66 ^{ab}	9666.33 ^{e}	19.419 ^{de}	2.009 ^{de}	0.420 ^{d}	20.906 ^{d}	94.785 ^{c}	1197.33 ^{cde}
F_8	561.66 ^{a}	94.816 ^{abc}	530.66 ^{def}	9633.00 ^{de}	19.577 ^{e}	2.032 ^{e}	0.420 ^{d}	20.682 ^{cd}	94.997 ^{c}	1212.66 ^{def}
F_9	566.00 ^{a}	95.776 ^{bc}	532.00 ^{def}	9499.66 ^{cde}	18.721 ^{c}	1.970 ^{c}	0.392 ^{bc}	19.891 ^{a}	93.109 ^{bc}	1247.00 ^{f}
F_{10}	612.33 ^{b}	95.431 ^{bc}	537.00 ^{ef}	9466.33 ^{cde}	18.617 ^{c}	1.966 ^{c}	0.392 ^{bc}	19.966 ^{a}	93.553 ^{bc}	1241.33 ^{ef}
F_{11}	561.00 ^{a}	93.615 ^{ab}	519.00 ^{cde}	9333.00 ^{abc}	17.661 ^{b}	1.892 ^{b}	0.385 ^{ab}	20.362 ^{abc}	91.666 ^{ab}	1104.33 ^{ab}
F_{12}	547.00 ^{a}	94.571 ^{abc}	508.33 ^{bcd}	9321.66 ^{abc}	17.670 ^{b}	1.895 ^{b}	0.387 ^{abc}	20.450 ^{bcd}	91.555 ^{ab}	1114.66 ^{ab}
Mean value	573.47	95.256	520.47	9440.47	18.403	1.948	0.397	20.409	93.211	1168
F value	32.127	11.009	45.987	27.541	131.495	169.147	115.998	33.042	19.763	65.421
Significance	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SE	5.450	0.2241	4.026	25.823	0.137	0.009	0.002	0.066	0.2525	9.850

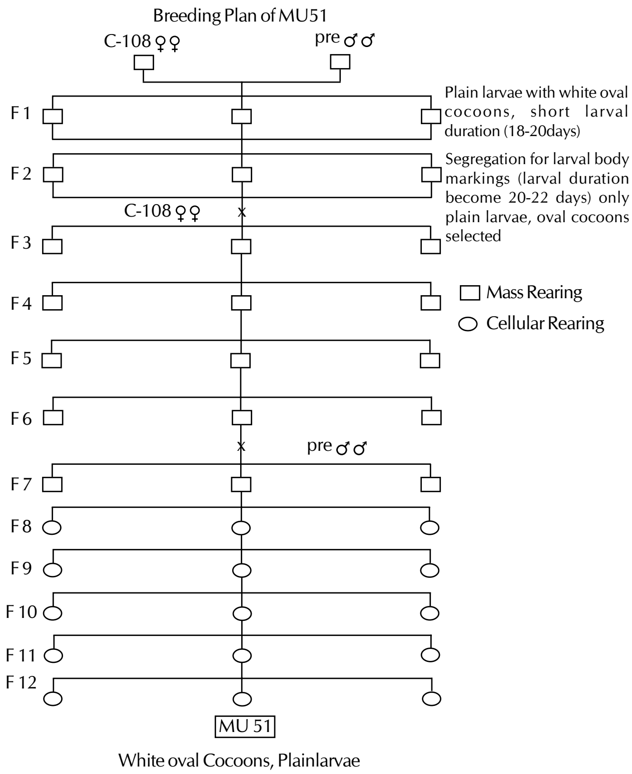

Figure 1: Flowchart diagram of Breeding plan of isolated new Bivoltine Breed MU 51

growers contributing to the cocoon production. The isolated breed recorded 18.40 kg, which is more than control multivoltine (9.43kg) and bivoltine (17.05kg), revealed significant ($p<0.000$) improvement for the trait. Indicated the increased cocoon yield by weight is depends upon the cocoon weight achieved in the isolated lines that is higher the cocoon weight better will be the yield. Productivity traits such as single cocoon weight, shell weight, shell percentage and filament length revealed significant ($p<0.000$) increase for the said four traits in the isolated breed over controls. It is well documented that the shell weight (0.397gms in MU_{51}, 0.373gms in C_{108} and 0.123gms in pre) an important productivity trait is positively correlated to other productivity traits such as cocoon weight, shell percentage and filament length (Ohi *et al.,* 1970). Contrary to the Hybrids beings robust and higher productivity in their parental breeds, have negative correlation for shell percentage and pupation rate (Datta *et al*., 2000), the newly evolved robust and productive breed MU51 has positive correlations for shell percentage and pupation rate as stated in the Table 3.

Further, as pointed out by Nagalakshmamma *et al*., (1994) a positive correlation is observed between cocoon weight and fecundity of the subsequent generation that might be the weight of the female pupae in previous generation. Venkatesh *et al*., (2007) also reported positive correlation between pupal weight and fecundity, mature larval weight and cocoon weight, cocoon weight and pupal weight, female cocoon weight and egg number and weight. In the present study also higher cocoon weight and effective rate of rearing has produced higher fecundity, confirming the positive influence of cocoon

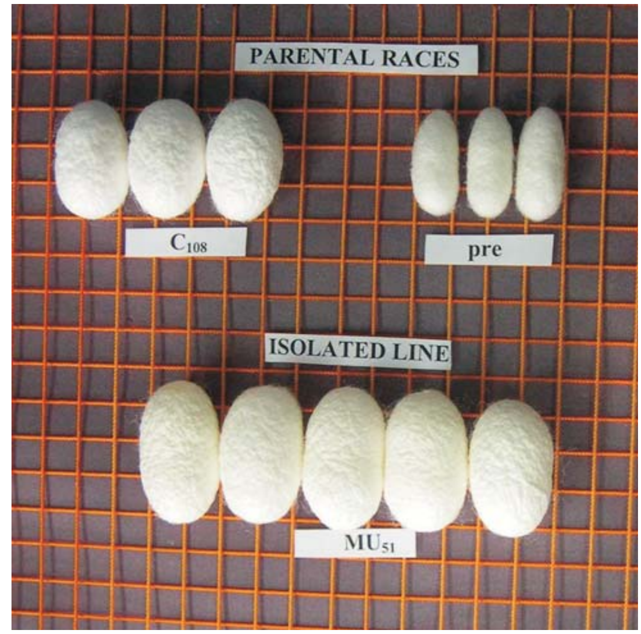

Figure 2: Cocoons of parental races and the isolated new Bivoltine Breed MU51

weight on fecundity. It is apparent that cocoon weight is more critical than survival. Further, (Narayanaswamy and Visweswara Gowda, 1989) they also reported that the rearing parameters such as larval weight, ERR, pupal weight, cocoon weight and shell weight also decrease with increased pupal weight and hence in this breeding experiment, middle order female and male larvae were used as explained by Narasimhanna (1986) in each inbredding generations to get optimum result. Thus in the present investigation application of appropriate selection procedures during the course of breeding has resulted in the fixation of desired alleles ultimately leading to the expression of statistically significant ($p<0.000$) difference for the various economic characters indicating the fixation of the characters in the isolated breed (Louis Ollivier, 2004).

The present studies on the performances of newly evolved bivoltine breed MU_{51}, characterised by plain larvae, spinning white oval cocoon, exhibiting superiority for the viability traits such as cocoon yield by number and pupation rate in addition to shorter larval duration, higher hatching percentage and moderate productivity establishes unique combination of genotypes which make the evolved breed could be suitable for commercial exploitation under prevailing environmental conditions of tropical climates as in India where viability is a highly concerned parameter in the practical utilization of bivoltine races.

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APPLICATION FORM

NATIONAL ENVIRONMENTALISTS ASSOCIATION (N.E.A.)

To,
The Secretary,
National Environmentalists Association,
D-13, H.H.Colony,
Ranchi-834002, 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 ____________________

____

Official Address ____________________

____

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

Date of Birth ____________________ Mobile No. ____________________

Qualification ____________________

Field of specialization & research ____________________

Extension work (if done) ____________________

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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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