Madras Agric. J., 98 (1-3): 95-98, March 2011
https://doi.org/10.29321/MAJ.10.100252

# Performance of Bivoltine Silkworm Germplasm under High Temperature and High Humidity of Jammu Region

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**Autumn silkworm crop is distinguished by high temperature and high humidity in Jammu and there is an urgent need to develop hardy bivoltine breeds/hybrids, which can withstand the autumn conditions of Jammu region to make sericulture activity profitable in the traditional sericultural state of Jammu and Kashmir. Though mulberry leaves are available in plenty during this season the silkworm crop during autumn season is generally a failure in Northern India. In order to identify suitable silkworm races, selected bivoltine silkworm germplasm were evaluated under abiotic stress conditions of high temperature and high humidity prevailing during autumn season in Northern India. Ten test accessions out of 230 bivoltine silkworm accessions were selected based on economically important rearing and post cocoon parameters and evaluated in the RSRS, Jammu conditions. The accessions were BBE-0173, BBE-0174, BBE-0178, BBE-0186, BBE-0189, BBE-0192, BBE-0198, BBE-0226, BBI-0239 and BBE-0266 with two control accessions (one local, *ie*., BBI-0116 for Jammu) and one common national control *ie*., BBI-0290). Six trials were conducted in the location in both the favourable (Spring) and unfavourable (Autumn) seasons. Test accessions BBE-0178 and BBE-0266 performed better during both spring and autumn seasons not only for rearing traits but also for post cocoon parameters. These accessions can be used to evolve suitable silk worm breeds or breed combinations through breeding programmes to stabilize autumn crop rearing.**

**Key words:** Germplasm, Abiotic stress, Bivoltine Accessions, Spring, Autumn

The Central Sericultural Germplasm Resources Centre (CSGRC), Hosur an assemblage of 443 silkworm genetic resources, which includes 350 Bivoltine, 73 multivoltine and 20 mutants stocks. The bivoltine collections are from 14 countries around the world and includes important races from Chinese, Japanese and European origin also. The main purpose of germplasm centre is to conserve these valuable collections without loss and thus preventing them from extinction. At the same time mere conservation will not sustain the existence of a germplasm resources centre, the invaluable genetic resources have to be evaluated for their potential on adaptability to different agro climatic conditions, disease resistance apart from important economic traits viz., high fecundity, higher cocoon weight, shell weight, shell ratio and cocoon yield (Chauhan *et al.*, 2003).

A collaborative project was undertaken by CSGRC, Hosur with Regional Sericultural Research Station (RSRS) Jammu to screen the promising bivoltine genetic stocks of CSGRC, Hosur under the abiotic stress conditions prevailing in Jammu region especially during autumn season (*ie.,* under high temperature and high humidity conditions). The purpose of taking up such a study is to evaluate the potential bivoltine silkworm genetic resources under Jammu conditions during autumn season, as autumn crop is usually a failure despite availability of sufficient mulberry leaves for taking up silkworm rearing. Autumn rearing constitutes only <15% of total seed intake in different years with <20% of total cocoon production for the respective years. Autumn crop is distinguished by high temperature and high humidity in Jammu division and there was an urgent need to develop hardy bivoltine breeds/hybrids, which can withstand the autumn conditions of Jammu region (Pankaj Tewary *et al.,* 2003) to make sericulture activity profitable in the traditional sericultural state of Jammu and Kashmir.

## Materials and Methods

Ten elite bivoltine accessions of CSGRC were selected for the study along with the local and national checks *ie.*, local control for Jammu was Jam-25 (BBI-0116) a popular race of Jammu region and the national check was CSR-2 (BBI-0290). The ten test accessions BBE-0173, BBE-0174, BBE-0178, BBE-0186, BBE-0189, BBE-0192, BBE-0198,

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BBE-0226, BBI-0239 and BBE-0266. These bivoltine accessions were short listed based on five important economic parameters for growth and reproductive traits *viz*., fecundity, larval duration, pupation rate, shell ratio, cocoon yield /100dfls and eight post cocoon traits namely total filament length, denier, renditta, raw silk recovery (%), neatness, boil-off loss, cleanness and evenness. Disease free layings (DFLs) of the selected bivoltine silkworm genotypes (10 test accessions with 2 controls) were sent to collaborating station (RSRS, Jammu) for conducting silkworm rearings in both the favourable season (Spring) and unfavourable seasons (Autumn). A total of six crops were undertaken three in spring season and three in autumn. Standard silkworm rearing techniques were adopted (Krishnaswami, 1978) and experiment was designed in completely randomized block design (CRBD) with three replications and three hundred larvae were maintained in each replication.

Evaluation data on important economic parameters *viz*., fecundity, hatching percentage, weight of 10 grown up larvae, total larval duration, fifth age larval duration, cocoon yield (No.) /10000 larvae and cocoon yield (weight) /10000 larvae, pupation percentage, single cocoon weight, single shell weight and shell ratio were recorded during all six crops, reeling tests for four reeling parameters like total filament length, non-broken filament length, renditta, and denier were also recorded and the

**Table 1. Performance of selected Bivoltine silkworm germplasm under High temperature and High humidity condition (Autumn) at Jammu**

| Acc.No | Fec | H% | 10 Lwt. | TLD | VLD | YLD No | YLD. wt. | P% | CWT | SWT | SR | Avg.f.l | A.Nbfl | Fil.den | Fla % | Gra % | Mus% |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BBE-0173 | 478 | 89.4 | 35.6 | 544 | 134 | 5909 | 7.3 | 49.8 | 1.36 | 0.24 | 17.5 | 631.6 | 273.3 | 2.35 | 1.37 | 21.90 | 0.00 |
| BBE-0174 | 464 | 86.9 | 34.9 | 544 | 131 | 5076 | 4.8 | 38.2 | 1.22 | 0.23 | 19.2 | 702.3 | 386.2 | 2.70 | 1.74 | 20.96 | 0.00 |
| BBE-0178 | 431 | 84.4 | 36.8 | 551 | 141 | 7563 | 9.2 | 69.5 | 1.28 | 0.24 | 18.8 | 746.8 | 260.3 | 2.28 | 2.19 | 7.95 | 0.19 |
| BBE-0186 | 460 | 80.7 | 35.5 | 561 | 143 | 6378 | 7.0 | 62.4 | 1.38 | 0.27 | 19.9 | 766.8 | 351.7 | 2.11 | 9.24 | 11.11 | 0.00 |
| BBE-0189 | 481 | 84.1 | 36.1 | 564 | 151 | 6169 | 7.4 | 58.9 | 1.29 | 0.20 | 15.3 | 650.0 | 537.3 | 2.07 | 5.61 | 13.79 | 0.15 |
| BBE-0192 | 449 | 83.3 | 34.1 | 558 | 145 | 6557 | 6.5 | 47.8 | 1.18 | 0.19 | 16.0 | 618.2 | 512.0 | 2.54 | 0.87 | 12.76 | 0.19 |
| BBE-0198 | 375 | 87.8 | 36.0 | 553 | 140 | 7806 | 9.3 | 68.1 | 1.28 | 0.23 | 18.2 | 791.8 | 476.0 | 2.41 | 2.94 | 4.61 | 0.00 |
| BBE-0226 | 370 | 83.8 | 32.2 | 564 | 140 | 7021 | 7.9 | 71.8 | 1.18 | 0.23 | 19.7 | 636.6 | 480.2 | 2.80 | 5.30 | 9.44 | 0.11 |
| BBI-0239 | 386 | 84.3 | 35.2 | 549 | 136 | 7019 | 7.7 | 56.7 | 1.09 | 0.20 | 18.3 | 612.1 | 436.5 | 2.88 | 1.70 | 10.37 | 0.33 |
| BBE-0266 | 424 | 89.5 | 37.8 | 548 | 135 | 7516 | 7.1 | 55.5 | 1.38 | 0.26 | 19.1 | 788.0 | 475.3 | 2.42 | 1.37 | 8.84 | 0.00 |
| BBI-0116 (Jam 25) | 481 | 95.2 | 39.9 | 582 | 147 | 8336 | 10.3 | 75.4 | 1.27 | 0.25 | 20.2 | 743.6 | 477.2 | 2.21 | 1.67 | 11.34 | 0.00 |
| BBI-0290 (CSR-2) | 408 | 96.1 | 40.4 | 581 | 143 | 7375 | 9.4 | 63.6 | 1.30 | 0.29 | 22.3 | 708.3 | 484.6 | 2.74 | 1.56 | 12.25 | 0.00 |
| Mean | 434 | 87.1 | 36.2 | 558 | 141 | 6894 | 7.8 | 59.8 | 1.27 | 0.24 | 18.7 | 699.7 | 429.2 | 2.46 | 2.96 | 12.11 | 0.08 |
| SD | 41 | 4.8 | 2.3 | 13 | 6 | 914 | 1.5 | 10.9 | 0.09 | 0.03 | 1.9 | 67.7 | 91.3 | 0.27 | 2.50 | 4.99 | 0.11 |
| SE | 12 | 1.4 | 0.7 | 4 | 2 | 276 | 0.5 | 3.3 | 0.03 | 0.01 | 0.6 | 20.4 | 27.5 | 0.08 | 0.75 | 1.50 | 0.03 |
| CV% | 10 | 5.5 | 6.4 | 2 | 4 | 13 | 19.4 | 18.3 | 6.97 | 13.02 | 10.1 | 9.7 | 21.3 | 11.02 | | | |

*Fec-Fecundity (No.),H%-Hatching%,10Lwt- Weight of 10 larvae (g.),TLD-Total Larval duration (Days), VLD-Fifth Larval duration YLDNo - Cocoon yield/10000 larvae by no , YLD.wt - Cocoon yield/10,000 Larvae by wt. (Kg),P%-Pupation percentage,CWT - Cocoon weight, SWT-Shell weight, SR- Cocoon Shell ratio (%),Avg.f.-AverageFilament length (m.), A.Nbfl- Average non broken Filament length (m.), Fil.den -Denier(d), Fla %-Flacherie%, Gra %-Grasserie% Mus%-Muscardine%

performance was statistically analysed for spring and autumn season separately( Table 1 and 2). Data recorded were also analyzed for identifying the best accessions performed under abiotic stress condition (Autumn season) in comparison with local control and national control. Biotic factors were also recorded during the experiment since diseases like flacherie, grasserie and muscardine are influenced / aggravated by prevailing climatic conditions. The data recorded under favourable rearing season (Spring season) were compared with that of unfavourable season (autumn season) after compilation and statistically analysed.

## Results and Discussion

The data recorded in RSRS, Jammu after analysis on important economic parameters for rearing, reeling and disease percentage for all accessions showed that few accessions were better than control. Based on the results a ranking of germplasm was also done for both the seasons (spring and autumn).

In RSRS, Jammu under abiotic stress condition (autumn season) test accession BBE-0266 performed well for 10 parameters and better than national control (CSR-2- BBI-0290) followed by BBI-0116, BBE-0198, BBE-186 and BBE-178 with 8 parameters. Similarly comparison of the test accessions with local control (Jam-25, BBI-0116), showed accession BBE-0266 in second position with 8 parameters followed by BBE-0186, BBE-198 (Table 3). During spring season also test accession BBE-0266 performed well for 8 parameters compared to national control followed by BBI-0116 with 7 parameters and BBE-0198, BBE-0178 with 6 parameters. National control CSR-2 performed better during favourable season with nine parameters followed by BBE-178 and BBE-0266, BBE-198 with 8 and 7 parameters respectively (Table 4).

**Table 2. Performance of selected Bivoltine silkworm germplasm under spring season at Jammu**

| Acc.No | Fec | H% | 10 Lwt. | TLD | VLD | YLDNo | YLD.wt. | P% | CWT | SWT | SR | Avg.f.l | A.Nbfl | Fil.den | Fla % | Gra % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BBE-0173 | 482 | 91.7 | 40.7 | 641 | 147 | 9037 | 13.0 | 75.8 | 1.3 | 0.2 | 18.5 | 822.8 | 694.7 | 2.5 | 3.01 | 2.73 |
| BBE-0174 | 483 | 86.9 | 39.7 | 641 | 148 | 8314 | 11.5 | 70.9 | 1.2 | 0.2 | 19.8 | 789.4 | 657.8 | 3.0 | 2.39 | 2.61 |
| BBE-0178 | 468 | 89.4 | 39.2 | 648 | 145 | 9313 | 13.1 | 81.4 | 1.3 | 0.2 | 18.9 | 1026.8 | 855.7 | 2.2 | 1.94 | 0.91 |
| BBE-0186 | 585 | 95.6 | 41.2 | 649 | 152 | 9253 | 13.0 | 78.5 | 1.4 | 0.3 | 20.2 | 849.3 | 707.8 | 2.7 | 2.89 | 1.61 |
| BBE-0189 | 511 | 93.4 | 40.4 | 652 | 158 | 9060 | 13.0 | 77.9 | 1.3 | 0.2 | 16.4 | 951.2 | 792.7 | 2.3 | 3.89 | 1.43 |
| BBE-0192 | 477 | 91.5 | 40.7 | 652 | 157 | 9105 | 13.0 | 81.4 | 1.3 | 0.3 | 18.8 | 823.9 | 626.0 | 2.6 | 3.39 | 0.69 |
| BBE-0198 | 436 | 90.4 | 40.2 | 644 | 150 | 9052 | 13.1 | 83.4 | 1.3 | 0.4 | 20.5 | 839.4 | 839.4 | 2.6 | 2.39 | 2.13 |
| BBE-0226 | 472 | 92.8 | 41.1 | 649 | 151 | 9318 | 12.5 | 79.5 | 1.3 | 0.3 | 19.9 | 914.0 | 733.3 | 3.1 | 3.39 | 0.90 |
| BBI-0239 | 411 | 92.6 | 40.9 | 643 | 146 | 9172 | 11.2 | 84.0 | 1.2 | 0.2 | 19.8 | 675.0 | 675.0 | 2.7 | 2.94 | 1.03 |
| BBE-0266 | 469 | 95.1 | 42.2 | 645 | 143 | 6824 | 13.3 | 72.7 | 1.4 | 0.3 | 19.3 | 851.0 | 851.0 | 2.4 | 3.06 | 2.70 |
| BBI-0116 (Jam-25) | 515 | 96.7 | 40.8 | 639 | 152 | 9149 | 12.9 | 86.3 | 1.4 | 0.3 | 20.5 | 833.7 | 833.6 | 2.3 | 3.33 | 2.56 |
| BBI-0290 (CSR-2) | 446 | 96.2 | 42.2 | 648 | 156 | 9316 | 13.2 | 89.4 | 1.4 | 0.3 | 23.1 | 1092.8 | 683.0 | 2.7 | 3.11 | 0.45 |
| Mean | 480 | 92.7 | 40.8 | 646 | 150 | 8909 | 12.7 | 80.1 | 1.3 | 0.3 | 18.5 | 872.4 | 745.8 | 2.6 | 2.98 | 1.64 |
| SD | 44 | 2.9 | 0.9 | 4.3 | 5.0 | 709.7 | 0.7 | 5.4 | 0.1 | 0.0 | 3.5 | 110.6 | 83.7 | 0.3 | 0.53 | 0.86 |
| SE | 13 | 0.9 | 0.3 | 1.3 | 1.5 | 214.0 | 0.2 | 1.6 | 0.0 | 0.0 | 1.1 | 33.4 | 25.2 | 0.1 | 0.16 | 0.26 |
| CV% | 9 | 3.2 | 2.2 | 0.7 | 3.4 | 8.0 | 5.3 | 6.7 | 5.5 | 18.1 | 17.1 | 12.7 | 11.2 | 10.7 | 17.80 | 52.40 |

*Fec-Fecundity (No.),H%-Hatching%,10Lwt- Weight of 10 larvae (g.),TLD-Total Larval duration (Days), VLD-Fifth Larval duration YLDNo - Cocoon yield/10000 larvae by no , YLD.wt - Cocoon yield/10,000 Larvae by wt. (Kg),P%-Pupation percentage,CWT - Cocoon weight, SWT-Shell weight, SR- Cocoon Shell ratio (%),Avg.f.-AverageFilament length (m.), A.Nbfl- Average non broken Filament length (m.), Fil.den -Denier(d), Fla %-Flacherie%, Gra %-Grasserie% Mus%-Muscardine%

The success of sericulture industry depends upon several factors, of which the impact of the environmental factors such as biotic and abiotic factors is of vital importance. Among the abiotic factors, temperature and humidity play important role on growth and productivity in silkworm, as the silkworm is a poikilothermic insect (Benchamin and Jolly, 1986). It is known that the late age silkworm prefers relatively lower temperature than young age (Krishnaswami, 1994) and fluctuation of

**Table 3. Top performing bivoltine silkworm accessions for multiple traits in comparison with CSR-2* and Jam -25 in autumn season at Jammu**

| Better than CSR-2* | | | Better than Jam -25 | | |
|---|---|---|---|---|---|
| Acc. No. | No. of Parameters | Trait number with actual values | Acc. No. | No. of Parameters | Trait number with actual values |
| BBE-0266 | 10 | 1(424), 4(548), 5(135), 6(7515), 9(1.37), 12(787), 14(2.42), 15(1.37), 16(8.83), 17(0) | BBI-0290 CSR-2 | 10 | 2(96.0), 3(40.4), 4(581), 5(143), 9(1.29), 10(0.28), 11(22.2), 13(484), 15(1.55), 17(0) |
| BBI-0116 Jam 25 | 8 | 1(480), 6(8335), 7(10.25), 8(75.3), 12(743), 14(2.21), 16(11.34), 17(0) | BBE-0266 | 8 | 4(548), 5(135), 9(1.37), 10(0.26), 12(787), 15(1.37), 16(8.83), 17(0) |
| BBE-0198 | 8 | 4(552), 5(139), 6(7805), 8(68.1), 12(791), 14(2.44), 16(4.61), 17(0) | BBE-0186 | 8 | 4(560), 5(142), 9(1.37), 10(0.27), 12(766), 14(2.10), 16(11.1), 17(0) |
| BBE-0186 | 8 | 1(459), 4(560.844), 5(142.556), 9(1.376), 12(766.818), 14(2.109), 16(11.114), 17(0) | BBE-0198 | 6 | 4(552), 5(139), 9(1.28), 12(791), 16(4.61), 17(0) |
| BBE-0178 | 8 | 1(431), 4(551), 5(140), 6(7563), 8(69.4, 12(746), 14(2.28), 16(7.94) | BBE-0189 | 5 | 1(481), 4(563), 9(1.28), 13(537), 14(2.07) |
| BBE-0173 | 7 | 1(478), 4(544), 5(133), 9(1.35), 14(2.34), 15(1.37), 17(0) | BBE-0178 | 5 | 4(551), 5(140), 9(1.27), 12(746), 16(7.94) |
| BBE-0192 | 5 | 1(448), 4(558), 13(512), 14(2.54), 15(0.87) | BBE-0173 | 5 | 4(544), 5(133), 9(1.35), 15(1.37), 17(0) |
| BBE-0174 | 5 | 1(463), 4(544), 5(131), 14(2.69), 17(0) | BBE-0226 | 4 | 4(563) 5(140) 13(480), 16(9.44) |
| BBE-0226 | 4 | 4(563), 5(140), 8(71.7), 16(9.44) | BBE-0192 | 4 | 4(558), 5(145), 13(512), 15(0.87), |
| BBE-0189 | 4 | 1(481), 4(563), 13(537), 14(2.07) | BBI-0239 | 3 | 4(549), 5(135), 16(10.36), |
| BBI-0239 | 3 | 4(549), 5(135), 16(10.36), | BBE-0174 | 3 | 4(544), 5(131), 17(0), |

* National Control ** Local Control

1-Fecundity (No.),2-Hatching%,3- Weight of 10 larvae (g.),4-Total Larval duration (Days), 5-Fifth Larval duration 6 - Cocoon yield/10000 larvae by no , 7 - Cocoon yield/10,000 Larvae by wt. (Kg),8-Pupation percentage,9 - Cocoon weight, 10-Shell weight, 11- Cocoon Shell ratio (%),12.-AverageFilament length (m.), 13- Average non broken Filament length (m.), 14 -Denier(d), 15-Flacherie%, 16 %-Grasserie% 17- Mus%-Muscardine% *Figures in parentheses are actual values*

temperature during different stages of larval development was found to be more favourable for growth and development of larvae than constant temperature. There is ample literature showing that good quality cocoons are produced with in temperature range of 22-27°C only and beyond this range the crop suffers (Krishnaswami *et al*., 1973). In a tropical country like India, it is very much essential to develop bivoltine breeds/hybrids that can withstand high temperature stress conditions. The silkworm breeds developed for tropical conditions in India should have the adaptive capabilities for the high temperature and high humidity and associated with the biotic and abiotic conditions. Based on the study the germplasm accessions BBE-0266, BBE-0178 and BBE-0198 performed better than local ruling breed (Jam-25) and national control (CSR-2) for rearing and reeling parameters at high temperature and high humidity which prevails during the autumn season in Jammu region. Accession number BBE-0198 and BBE-0266 recorded less disease incidence during the experimental rearings also. Hence, these germplasm can be exploited to evolve better parental breeds and suitable F1 hybrids for high temperature and high humidity condition. These races can also be utilized for assessing general combining ability (GCA) and specific combining ability (SCA) against popular F1 hybrids.

**Table 4. Top performing bivoltine silkworm accessions for multiple traits in comparison with CSR-2* and Jam-25 in spring season at Jammu**

| Better than CSR-2* | | | Better than Jam -25 | | |
|---|---|---|---|---|---|
| Acc. No. | No. of Parameters | Trait number with actual values | Acc. No. | No. of Parameters | Trait number with actual values |
| BBE-0266 | 8 | 1(468), 4(644), 5(142), 7(13.2), 9(1.43), 13(850), 14(2.43), 15(3.05) | BBI-0290 (CSR-2) | 9 | 3(42.2), 6(9315), 7(13.2), 8(89.4), 10(0.32), 11(23.0), 12(1092), 15(3.11), 16(0.45) |
| BBI-0116 (Jam 25) | 7 | 1(515), 2(96.7), 4(638), 5(151), 9(1.41), 13(833), 14(2.29) | BBE-0178 | 8 | 5(144), 6(9312), 7(13.1), 12(1026), 13(855), 14(2.2), 15(1.94), 16(0.90) |
| BBE-0198 | 6 | 4(644), 5(149), 10(0.40), 13(839), 14(2.58), 15(2.38) | BBE-0266 | 7 | 3(42.15), 5(142), 7(13.2), 9(1.43), 12(850), 13(850), 15(3.05) |
| BBE-0178 | 6 | 1(468), 4(648), 5(144), 13(855), 14(2.2), 15(1.94) | BBE-0198 | 7 | 5(149), 7(13.1), 10(0.40), 12(839), 13(839), 15(2.38), 16(2.13) |
| BBE-0173 | 6 | 1(482), 4(641), 5(146), 13(694), 14(2.48), 15(3.00) | BBE-0186 | 7 | 1(585), 3(41.1), 6(9253), 7(13.02), 12(849), 15(2.88), 16(1.61) |
| BBE-0226 | 4 | 1(471), 5(150), 6(9318), 13(733) | BBI-0239 | 5 | 3(40.8), 5(146), 6(9172), 15(2.94), 16(1.02), |
| BBE-0186 | 4 | 1(585), 5(151), 13(707), 15(2.88) | BBE-0226 | 5 | 3(41.13), 5(150), 6(9318), 12(913), 16(0.89), |
| BBE-0174 | 4 | 1(483), 4(641), 5(147), 15(2.38) | BBE-0189 | 3 | 7(12.98), 12(951), 16(1.42), |
| BBI-0239 | 3 | 4(642), 5(146), 15(2.94) | BBE-0173 | 3 | 5(146), 7(12.98), 15(3.00), |
| BBE-0189 | 3 | 1(510), 13(792), 14(2.32) | BBE-0192 | 2 | 7(12.98), 16(0.68), |
| BBE-0192 | 2 | 1(476, 14(2.63) | BBE-0174 | 2 | 5(147), 15(2.38), |

* National Control ** Local Control

1-Fecundity (No.),2-Hatching%,3- Weight of 10 larvae (g.),4-Total Larval duration (Days), 5-Fifth Larval duration 6 - Cocoon yield/10000 larvae by no , 7 - Cocoon yield/10,000 Larvae by wt. (Kg),8-Pupation percentage,9 - Cocoon weight, 10-Shell weight, 11- Cocoon Shell ratio (%),12.-AverageFilament length (m.), 13- Average non broken Filament length (m.), 14 -Denier(d), 15-Flacherie%, 16 %-Grasserie% 17- Mus%-Muscardine% Figures in parentheses are actual values

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Received: January 3, 2011; Accepted: March 5, 2011