# COMPARATIVE PERFORMANCE OF SIX HOLSTEIN-FRIESIAN × GUZERA GRADES IN BRAZIL

## 3. BURDENS OF *BOOPHILUS MICROPLUS* UNDER FIELD CONDITIONS

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ABSTRACT

Burdens of ticks (*Boophilus microplus*) on young and adult females (heifers and cows) of six red-and-white Holstein-Friesian (HF) × Guzera (G) grades were assessed by counting the number of semi-engorged tick females on the right side of the animals. The HF grades were: ¼, ½, ⅝, ¾, ⅞ and ≥ 31/32. Assessments of tick burdens of heifers were made on twelve occasions (357 observations on 193 animals). Cows were assessed six times (380 observations on 83 animals). Cows and heifers were in different pastures. Data were transformed to $\log_{10}$ (2 × count + 1) to normalize their distribution. Direct breed additive ($g^I$, HF-G) and heterosis ($h^I$) effects were estimated within dates of counting. Estimates of $h^I$ on the log scale were not significant ($P > 0{\cdot}05$) on 11 out of 12 dates for heifers and on five out of six dates for cows. Estimates of $g^I$ for heifers varied from 0·505 (s.e. 0·492) to 2·376 (s.e. 0·345) (mean $\hat{g}^I$ = 1·575 (s.e. 0·096)), and estimates for cows varied between 1·009 (s.e. 0·203) and 2·293 (s.e. 0·219) (mean $\hat{g}^I$ = 1·416 (s.e. 0·080)). These results indicate the presence of important genetic effects on tick burdens. The means of the untransformed number of ticks per animal were, for the six grades in the above order, respectively: 44, 71, 151, 223, 282 and 501, for heifers, and 7, 19, 31, 64, 62 and 97 for cows.

### INTRODUCTION

TICKS (*Boophilus microplus* Can.) are an important source of economic loss to the cattle industry in Brazil as well as in other tropical and subtropical regions (Lemos, 1983). Ticks may be controlled by chemicals, but there should also be other control methods, not only because of cost and the presence of residues in milk and meat (Lemos, 1983), but mainly because of the development by the tick of genetic resistance to chemicals. Thus, pasture spelling and the utilization of tick-resistant cattle types have been suggested together with strategic dipping (Wharton and Norris, 1980).

The fact that zebu and Criollo cattle are more resistant to ticks than cattle of European breeds has been known for a long time (Villares, 1941; Ulloa and Alba, 1957). In Australia, crosses between European and zebu cattle breeds are being developed for beef production in Queensland (Powell and Reid, 1982) and two dairy breeds, the Australian Milking Zebu (Hayman, 1974) and the Australian Friesian Sahiwal (Alexander, Reason and Clark, 1984), have been developed to exploit tick resistance.

Information on the performance of breeds and crosses and on the genetic parameters underlying any differences is needed to design breeding systems aiming at the economic utilization of genetic resources (Dickerson, 1973). In this article genetic effects on tick burdens are analysed, utilizing a sample of animals pertaining to a more comprehensive trial in the south-east region of Brazil, described by Madalena (1981).

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## MATERIAL AND METHODS

### *Animals and management*

Burdens of ticks (*B. microplus*) were assessed on young and adult females (heifers and cows) of six red-and-white Holstein-Friesian (HF) × Guzera (G) grades. Throughout this paper grade means the expected fraction of HF genes; the implicit complement adding up to one coming from the G breed. The six HF grades were: ¼, ½, ⅝, ¾, ⅞ and ⩾ 31/32 or HF. The halfbreds were $F_1$ out of G dams by HF sires. The ¼ and ¾ were first backcrosses of $F_1$ dams to, respectively, G and HF sires. The ⅞ were second backcrosses to HF sires, and the ⅝ were obtained by mating ⅝ dams to ⅝ sires. Numbers of animals, sires and observations for each grade are shown in Table 1. In total, 25 HF, 12 G and seven ⅝ sires were used. Further information on the genetic background of these animals was given by Lemos, Teodoro, Barbosa, Freitas and Madalena (1984).

The heifers were reared at Santa Mônica Experimental Station, Municipality of Valença, State of Rio de Janeiro. Climate and management were described by Lemos *et al.* (1984) and Teodoro, Lemos, Barbosa and Madalena (1984). Cows were on their first or second lactation. They were kept on a high plane of nutrition, as described by Madalena, Lemos, Teodoro and Barbosa (1982).

Tick burdens were assessed by counting semi-engorged female ticks 4·5 to 8·0 mm long on the right side of the animals (Wharton and Utech, 1970). Tick counts on heifers were made on 12 occasions. Ten of these were at Santa Mônica and two at another experimental farm (Unidade de Execução de Pesquisa de Âmbito Estadual, São Carlos, State of São Paulo) where some heifers had been transferred. Tick counts of cows were made at Santa Mônica twice, at two-week intervals, on each of three occasions. Dates of counting, number and age of animals and average tick burden at each occasion are shown in Table 2. Animals were routinely sprayed against ticks, at irregular intervals (on average 5·5 times per year for heifers and 4·0 times for cows), but tick counts were made after a minimum of 33 days had elapsed since the last spraying. On average, this interval was 66 days for heifers and 70 days for cows. Heifers and cows were in different pastures.

Except for minor deviations, five heifers were measured per grade at each of the first 10 assessments, eight at the 11th and two at

TABLE 1

*Number of animals, sires and observations per grade*

| | Holstein-Friesian grade | | | | | |
|---|---|---|---|---|---|---|
| | ¼ | ½ | ⅝ | ¾ | ⅞ | HF |
| Heifers | 35 | 35 | 28 | 30 | 32 | 33 |
| Sires | 12 | 14 | 7 | 13 | 14 | 16 |
| Observations | 60 | 58 | 60 | 66 | 54 | 59 |
| Cows | 21 | 16 | 8 | 10 | 19 | 9 |
| Sires | 5 | 7 | 1 | 5 | 5 | 4 |
| Observations | 72 | 88 | 30 | 52 | 94 | 44 |

TABLE 2

*Number of animals, average age, mean tick count† and days since last spraying for each counting date*

| | Date | No. | Age (months) | Ticks per animal | Days since last spraying |
|---|---|---|---|---|---|
| Heifers | | | | | |
| 1 | 25 July 1978 | 29 | 12 | 15 | 55 |
| 2 | 9 November 1978 | 30 | 16 | 18 | 62 |
| 3 | 6 March 1979 | 30 | 17 | 363 | 69 |
| 4 | 28 May 1979 | 30 | 22 | 880 | 42 |
| 5 | 10 August 1979 | 30 | 23 | 109 | 72 |
| 6 | 18 October 1979 | 28 | 24 | 83 | 65 |
| 7 | 6 February 1980 | 30 | 28 | 135 | 71 |
| 8 | 13 June 1980 | 30 | 18 | 92 | 98 |
| 9 | 25 March 1981 | 30 | 32 | 165 | 33 |
| 10 | 10 September 1981 | 30 | 21 | 357 | 46 |
| 11 | 26 January 1983 | 47 | 21 | 184 | 103 |
| 12 | 27 January 1983 | 13 | 16 | 98 | 76 |
| Total or mean | | 357 | 21 | 210 | 66 |
| Cows | | | | | |
| 1 | 22 December 1980 | 57 | 40 | 77 | 38 |
| 2 | 7 January 1981 | 57 | 40 | 63 | 54 |
| 3 | 5 August 1981 | 71 | 47 | 18 | 56 |
| 4 | 20 August 1981 | 71 | 47 | 41 | 71 |
| 5 | 14 January 1982 | 62 | 52 | 67 | 92 |
| 6 | 28 January 1982 | 62 | 52 | 10 | 106 |
| Total or mean | | 380 | 46 | 46 | 70 |

† Arithmetic mean of side count × 2.

the 12th. Some heifers were measured at more than one counting date. There was a total of 357 observations on 193 heifers (1·85 assessments per heifer). All milking cows at Santa Mônica were assessed at each counting date. There were 380 observations on 83 cows (4·58 assessments per cow). Animals included in any particular day of counting were contemporaries, running together at the same pastures. The maximum difference between grade means in age at any date of counting was 5 months for heifers and 3 months for cows.

*Statistical analysis*

Tick counts per side were doubled to obtain ticks per animal. Because of the association between mean and variance and skewness of the distribution of counts, the transformation $\log_{10}$ (2 × count + 1) was used (Wharton, Utech and Turner, 1970), which made the distribution more normal and resulted in homogeneous variances within classes of grade × date of counting (Madalena, Teodoro, Lemos and Oliveira, 1985). Henceforth, $\log_{10}$ (2 × count + 1) will be referred to as log score.

Cow and heifer data were analysed separately, by least-squares techniques, using the computer program of Harvey (1976) with all effects considered fixed. Separate analyses were made for each counting date because preliminary results indicated the presence of grade × counting date interactions.

Estimates were obtained of direct breed additive ($g^I$, HF − G) and heterosis ($h^I$) effects (Dickerson, 1973) utilizing multiple regression (Robison, McDaniel and Rincón, 1981) according to the following models:

$$Y_{ij} = \mu + g^I q_i + h^I z_i + e_{ij} \quad (1)$$

$$Y_{ij} = \mu + g^I q_i + e_{ij} \quad (2)$$

where $Y_{ij}$ represents the log score of the $j$th animal of the $i$th grade, $\mu$ represents the mean, $q_i$ represents the expected proportion of HF genes of an individual of the $i$th grade ($i$ = 1, . . . , 6), $z_i$ its expected heterozygosity and $e_{ij}$ represents the error term. The $z_i$ values for grades ¼, ½, ⅝, ¾, ⅞ and HF were respectively ½, 1, 30/64, ½ and 0 (Madalena, 1981). A third model was fitted:

$$Y_{ij} = \mu + G_i + e_{ij} \quad (3)$$

where $G_i$ represents the effect of the $i$th grade. Goodness of fit of model 2 was assessed by F tests of the extra m.s. due to fitting model 3 after model 2 against the model 3 residual m.s.

To test whether $g^I$ estimates were homogeneous over counting dates, pooled analyses of variance were made. In this case, significance levels are only approximate, because of the correlation among residuals due to repeated measurements on the same animals. Intraclass correlation repeatabilities were 0·159 for heifers and 0·695 for cows.

## RESULTS

Grade means for untransformed ticks per animal (2 × count) averaged over counting dates, were respectively for ¼, ½, ⅝, ¾, ⅞ and HF: 44, 71, 151, 223, 282 and 501, for heifers, and 7, 19, 31, 64, 62 and 97 for cows.

Estimates of $h^I$ were significantly different from zero only at the first date for heifers and the first date for cows ($P < 0·05$). Consequently, it was decided to consider $h^I$ effectively zero on the log scale, so model 2, the simple regression on $q_i$ was used. Variation among grades not explained by $g^I$ was not significant on any counting date, either for heifers or for cows ($P > 0·05$).

TABLE 3

*Analysis of variance for the log score† of ticks per animal pooled over counting dates*

| Source | Heifers d.f. | Heifers m.s. | Cows d.f. | Cows m.s. |
|---|---|---|---|---|
| Counting date | 11 | 7·140** | 5 | 6·364** |
| Common breed additive effect ($g^I$) | 1 | 53·256** | 1 | 51·900** |
| Deviation from $g^I$ due to counting date | 11 | 0·703** | 5 | 1·185** |
| Unexplained deviations from the within-date $g^I$ values | 48 | 0·193 | 24 | 0·143 |
| Animals within date × grade subclasses | 285 | 0·177 | 344 | 0·166 |

† log score = $\log_{10}$ (2 × count + 1).

TABLE 4
*Estimates of direct breed additive difference ($g^I$, HF-G) on ticks per animal (log score) at each assessment*

| Assessment | $\hat{g}^I$ | s.e. |
|---|---|---|
| Heifers | | |
| 1 | 1.286 | 0·280 |
| 2 | 0·505 | 0·492 |
| 3 | 2·300 | 0·371 |
| 4 | 2·132 | 0·460 |
| 5 | 1·491 | 0·267 |
| 6 | 2·376 | 0·345 |
| 7 | 1·367 | 0·257 |
| 8 | 1·378 | 0·267 |
| 9 | 1·159 | 0·305 |
| 10 | 1·304 | 0·159 |
| 11 | 2·231 | 0·209 |
| 12 | 1·604 | 0·283 |
| Mean | 1·575 | 0·096 |
| Cows | | |
| 1 | 2·293 | 0·219 |
| 2 | 1·982 | 0·262 |
| 3 | 1·009 | 0·203 |
| 4 | 1·046 | 0·155 |
| 5 | 1·575 | 0·191 |
| 6 | 1·208 | 0·192 |
| Mean | 1·416 | 0·080 |

Pooled analyses of variance are shown in Table 3. It may be seen that a better fit was obtained using date specific $g^I$ instead of a common value for all dates.

The $g^I$ estimates for each date are shown in Table 4. For heifers, these estimates ranged from 0·505 to 2·376 and averaged 1·575 (s.e. 0·096). For cows the estimates varied between 1·009 and 2·293, averaging 1·416 (s.e. 0·080).

## DISCUSSION

Present results agree with previous reports indicating higher tick resistance of zebus and their crosses than of cattle of European breeds (Villares, 1941; Ulloa and Alba, 1957; Francis and Ashton, 1967; Seifert, 1971; Utech, Wharton and Kerr, 1978). The latter authors ranked the Friesian as one of the least resistant cattle breeds.

In their literature review, Sutherst and Utech (1982) reported a seasonal effect on cattle tick resistance, which 'wanes in autumn and waxes in spring'. They presented average values of the percentage *B. microplus* larvae maturing on cattle of zebu and European breeds, which correspond, respectively, to 100 and 1000 ticks per animal in spring/summer and to 600 and 2600 in autumn/winter. On a log scale, these counts correspond to $g^I$ estimates of 1·00 and 0·64, respectively for both seasons, which are on the lower side of the $g^I$ estimates of Table 4. Seifert (1971) reported differences between halfbred British × zebu and zebu cattle of 0·463 on the log scale for one side counts, which would correspond to 0·764 (0·463 + $\log_{10}2$) for the two sides as used here. The latter figure estimates ½ $g^I$ and agrees with the mean $\hat{g}^I$ values for heifers and cows of Table 4.

Animals in this study grazed pastures in rotation with other cattle categories, and the latter were sprayed at irregular time intervals to keep tick numbers low. Some pastures caught fire accidentally during dry seasons, which would have reduced the number of tick larvae. Tick burdens of heifers at the first two dates of counting were probably low because of frequent spraying at Santa Mônica before this trial began. The tick burden of cows dropped at the sixth counting date probably because the herd had to be moved to a pasture which had supported no cattle for 60 days. Thus, the number of ticks at each counting date would depend on circumstancial factors and management decisions besides the seasonal effect on host resistance reported by Sutherst and Utech (1982). Nevertheless, seasonal effects on tick burdens were examined as a possible explanation for the variation in the $g^I$ estimates. Six of the counts on heifers were made in autumn/winter and six in summer/spring (Table 2). The six $\hat{g}^I$ values for each season were averaged, weighting them by the inverse of their variances. The two estimates were very similar (1·508 (s.e. 0·125) and 1·612 (s.e. 0·099)), indicating that the variation in $\hat{g}^I$ estimates was not due to seasonal differences. On the other hand, the two $g^I$ estimates for cows in winter were lower than the four summer estimates.

The association between mean tick burden and breed difference was explored by calculating the weighted regression of $\hat{g}^I$ on the mean $\hat{M}$ from model 3. These regressions were $b = 0{\cdot}133$ (s.e. 0·330) for heifers and 0·695 (s.e. 0·693) for cows, indicating that the variation in the $g^I$ estimates was not associated with the mean tick burden at each counting occasion.

Other analyses (Madalena *et al.*, 1985) failed to show significant effects of sires, age within dates of counting, days of pregnancy or days in milk on tick burdens ($P > 0{\cdot}05$). Thus, although grade × date of counting interactions were accounted for by the variation of $g^I$ estimates, no explanation was found for this variation itself.

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