INTRODUCTION

In India, there are currently 26 and 8 recognized breeds of indigenous cattle and riverine buffaloes, respectively. The total population of cattle and buffaloes was estimated to be 185.18 and 97.92 million in 2003 (Livestock Census, 2003), of which the indigenous and crossbred cattle represented 160.49 and 24.68 million animals respectively. It has been found that the annual growth rate of indigenous crossbred cattle and buffaloes had increased marginally, however, the growth rate for buffaloes was found to be the highest. India has achieved the distinction of being the world’s top milk producing country, with an estimated output of 97.1 MT in 2005-2006 with a per-capita availability of milk of 241 gm/d. Milk production was estimated as 19.34 MT, 20.41 MT and 52.07 MT, respectively, in crossbred cows, non-descript cows and buffaloes in 2005-2006. Average milk yield in kg per year has been reported to be 1800, 900 and 1200 for crossbred and indigenous cattle and buffalo, respectively. Average per animal productivity has been observed to be 987 kg per lactation in India compared to 2038 kg per lactation in the world (Livestock Census, 2003).

Artificial insemination was adopted on the organized farm because it was thought initially that “sire is half of the herd” in the progeny testing program. However, considering the importance of sire selection in the herd, research has shown that the total genetic gain obtained through sire-to-sire path and sire to dam path is about 64 percent, equating to more than a 50 percent contribution (Basu, 1985). The...
increased genetic gain through sire over dam is due to the
greater intensity of selection that can be applied amongst
male parents, thus the greater accuracy for estimating the
breeding value of sires and the production of a larger num-
der of daughters which make contributions as replacement stock for the next generation (Basu, 1985; Jain, 1992).

The importance of male animals in selection emphasizes
a set of existing criteria for selection of young male animals
under the breeding program. The young males initially are
screened based on their expected predicted difference (EPD), percent superiority over the herd average, breed
characteristics and their dam’s best lactation 305-day yield.
Breeding values should be more than the target values and
the young males should be the sons of proven sires (Anonymous, 2009).

After attaining maturity, young bulls are screened based
on their growth and physical conformity, sexual behaviour,
semen characteristics including semen freezability and mi-
Crobial load of the semen, and the test bulls should be free
from deadly diseases as tuberculosis, Jones disease and in-
crobes and foot and mouth disease (Anonymous, 2009).

For any improvement in a herd, selection is a major tool
for a breeder. The selection used conventionally that is
based on the phenotypic traits is time consuming and also
lacks accuracy. Multitrait selection can be employed for
overall improvement and improved economic returns. It
becomes a tedious job to select the traits under considera-
tion. In this connection phenotypic correlation among the
various traits such as growth, reproduction and production
is to be taken into consideration for the overall improve-
ment, which can give us maximum economic return.

The greater the number of traits considered, the more the
selection process becomes difficult. After studying the phe-
notypic correlation of the traits, a number of traits can be
minimized by excluding one trait when more than one trait
has a high phenotypic correlation. Hence the present study
was conducted to examine the economically important traits
of dairy cattle and buffalo and the phenotypic correlation among various growth, production and reproduction traits.

MATERIALS AND METHODS

Animals: The present study was conducted with 52 cross-
bred cattle (Holstein Friesian crossed with Tharparkar) and
50 Murrah buffalo bulls maintained at the Artificial Breeding
Complex of the National Dairy Research Institute, Kar-
nal, Haryana, India.

Sample and data: Data on various economic traits includ-
ing growth, production and reproduction on dairy bulls
were generated as well as collected. The duration of the
study was 4 months. The study of semen characteristics and
behavioural characteristics for various bulls studied were
conducted in a particular season.

The male animals were selected randomly and were kept
individually under a loose housing system. The semen was
collected 8.30 to 9.30 a.m. from February to March and
7.30 to 8.30 a.m. from April to May. The ejaculates were
collected twice weekly and behavioral traits including li-
bido score, reaction time, Flehmen’s response and require-
ment of mounting stimulus were noted during daily semen
collection and evaluation.

Various semen traits (semen volume, sperm mass activ-
ity, semen consistency and individual fresh sperm motility
and post thaw sperm motility) were estimated immediately
after daily semen collection. For all practical purposes se-
men was frozen when the mass activity was more than 3.5
and the lower standard for sperm concentration remained
(2×10^6 motile sperm per semen dose).

libido is the willingness and eagerness of a male animal
to mount and to attempt service on the female and mating
ability is the ability to complete a service when an opportu-
nity is provided (Chenoweth, 1981; Sharma et al. 2003). A
Libido score card was prepared and libido was scored on a
10-point scale (Chenoweth, 1981) (Table 1).

Reaction time was measured as the time taken by a bull
from its introduction to female (or a trained bull i.e. dummy
in case of the present study) until first ejaculation Fleh-
men’s response was characterized as when the bull stands
rigidly and holds his head in horizontal position, which the
bull may move slowly from side to side with his neck ex-
tended and upper lip raised.

Flehmen’s response facilitates olfactory and vomero-
nasal organ access to body secretions, which allow the male
to identify female reproductive status. The passive partner
does not object to this procedure. Flehmen’s response gen-
erally lasts for 10 to 30 sec. The bulls exhibiting Flehmen’s
response were coded as 1 and when no response was ob-
tained 2.

Bulls will usually mount a female or a dummy with no
encouragement, however some bulls are reluctant to mount
and an external stimulus (e.g. whistling sound) is needed.
When an external stimulus was required for mounting by a
bull, the code was 1 and when no stimulus was needed this
was coded as 2.

Statistical analysis: Mean and standard error of the traits
were calculated using standard statistical procedure
(Snedecor and Cochran, 1967).

The expected predicted differences (EPD) of the bulls
were collected from the records maintained. EPD is calcu-
lated based on the record of the average milk yield of dam
and paternal grand dam, and is calculated (Jain, 1992) as
follows:
EPD = \frac{1}{2} h^2 M_1 (M-\mu) + \frac{1}{4} h^2 P_1 (P-\mu)

Where,
M_1 = \frac{n}{1 + (n-1) r}

n = no of lactation
r = repeatability
M = average lactation yield of dams
\mu = population average

P_1 = \frac{p}{1 + (p-1) r}
p = number of lactations of paternal grand dam
P = average lactation yield of paternal grand dam

Percent superiority is estimated based on genetic superiority above the herd average in percent.

To compare the economic traits a series of t-tests were used. The phenotypic correlations (r_p) between the records of two traits were estimated by using the following formula:

r_p(xy) = \frac{\sigma_s(xy) + \sigma_e(xy)}{\sqrt{\sigma^2_s(x) + \sigma^2_e(x)} \times \sqrt{\sigma^2_s(y) + \sigma^2_e(y)}}

The standard errors of phenotypic correlation were obtained by using the following formula:

SE(r_p) = \sqrt{1 - r_p^2 / (n-2)}

t = r_p \sqrt{(n-2) / (1-r_p^2)}

RESULTS AND DISCUSSION

I. Various phenotypic traits

A. Growth traits

The mean with standard error of various growth characteristics under investigation for crossbred bulls and Murrah bulls is presented in (Table 2).

Body weight

The mean birth weight of crossbred bulls was observed as 28.83±0.56 kg (Table 2). Biswas et al. (2003) also found lower birth weight in male crossbred Holstein, Jersey and the Sahiwal bulls.

Birth weight of buffalo calves (33.83±0.45 kg) was significantly (P<0.01) higher than the birth weight of crossbred bulls which is also supported in Banik (2001) work on birth weight for Murrah bulls. The average three months body weight of crossbred bulls was estimated as 59.38±1.33 kg which was significantly (P<0.01) lower than that of Murrah bulls (62.53±1.05 kg).

The present observations for three months body weight for Murrah bulls was similar to all Murrah animals maintained in NDRI, Karnal and PAU, Ludhiana (Anon, 2002). The average six months body weight of the crossbred bulls was found to be 106.20±1.95 kg. crossbred bulls have significantly (P<0.01) higher six months body weight compared to Murrah bulls (100.88±1.71 kg). Since the phenotypic association between body weights at three months and six months was not significant in Murrah buffaloes, these discrepancies between body weight at six months for cattle and buffalo may have arisen. Studies conducted by Pal et al. (2004a) have also reported similar findings at all body weight comparisons as reported in this study.

B. Sexual behavioral traits

The observations in respect of various behavioral characteristics under study for crossbred bulls and Murrah bulls are presented in Table 3 and 4.

Libido score

The present study depicted a positive trend of better libido score in crossbred bulls (5.41±0.19) than Murrah buffalo bulls (5.07±0.21). Earlier work has reported libido score ranges from 4.44 to 5.67 in KF bulls (Panwar and Nagpaul, 1989; Adwani et al. 1992), whilst similar observations were also reported by studies conducted by Pal et al. (2004b), and Pal and Chakravarty, (2004).

Reaction time

Murrah bulls were found to have better reaction time (43.13±5.36) than the crossbred bulls (48.71±6.75). Panwar and Nagpaul (1989) reported the reaction time of KF bulls as 20.8±2.23 sec which was lower than that obtained in present study. This might be due to genotype environmental interaction as the experiments were conducted in two different seasons. Since our present study was conducted during the winter season, libido was expected to be less, hence reaction time was enhanced. Our present study was conducted on randomly allotted bulls, so average reaction time may be a more appropriate measure for comparison. Similar observations to our present study were reported by Pal et al. (2004b).

Flehmen’s response

Approximately 14.29% of crossbred bulls exhibited the Flehmen’s response, whereas in Murrah bulls about 65 percent of the bulls had a similar response. Murrah bulls reported a higher Flehmen’s response (1.33±0.04) compared to crossbred bulls (1.83±0.39). Panwar and Nagpaul (1989) earlier observed this response in only six percent of the Karan Fries bulls in a small population of KF bulls. Studies conducted by Pal et al. (2004b) have also reported similar findings.
In the present study, crossbred bulls were found to be better as they require less mounting stimuli (score as 1.62±0.04) and only 33.33% of the individuals investigated required any kind of external stimulus for mounting. However, in Murrah bulls about 72.22% (score as 1.25±0.04) of bulls required an external stimulus for mounting, indicating that crossbred bulls were significantly (P<0.01) better than Murrah bulls in terms of mounting stimulus required under the present study (Tables 3 and 4). Panwar and Nagpaul (1989) also observed for the requirement mounting stimulus in KF bulls.

Similar observations as in present study were reported by Pal et al. (2006).

### Semen traits

The observations regarding the semen characteristics under study for crossbred bulls and Murrah are presented in Table 5 and 6.

#### Semen volume

Lowered semen volume (2.70±0.22 mL) was observed in Murrah bulls compared to crossbred bulls (3.86±0.11 mL). The reason for differences in semen volume in both Murrah and crossbred bulls need to be explored in future research. Studies conducted by Pal et al. (2006) have also reported similar findings.

#### Semen consistency

Approximately 22.73%, 40.91%, 31.82% and 4.55% of the crossbred bulls donated creamy, lemon, milky and watery semen. However in Murrah bulls a different trend was observed as 50.00%, 40.00% and 10.00% of the individuals donated creamy, milk and watery types, respectively. Ninety percent of the Murrah bulls donated better semen in terms of semen consistency and none of the bulls donated watery semen (Table 6). Panwar and Nagpaul (1989) found that KF bulls donated semen of 41%, 54% and 6% as creamy, milk and watery type, respectively. Similar observations to the present study were reported by Pal et al. (2006).

#### Sperm mass activity

Higher semen mass activity (2.10±0.06) was obtained in Murrah bulls as compared to crossbred bulls (1.99±0.07) in the present study (Table 5). Similar observations were reported by Pal et al. (2006).

#### Individual motility of fresh sperm

Individual motility of fresh sperm in crossbred bulls was estimated as 40.73±2.3% and estimated in score as 2.41±0.14 (Table 5). Murrah bulls individual motility of sperm was found to be significantly (P<0.01) higher (58.40±4.15% or 2.41±0.30 in scores) than that of crossbred bulls, which might be due to the variability observed.

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### Tables

#### Table 1: Libido score card

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Description of libido</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bull showed no sexual interest or no mounting</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>One mount or mounting attempt, no service</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>Two mounts or mounting attempts, no service</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>More than two mounts or mounting attempts, no service</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>Two mounts one service, followed by sexual interest including mounts and mounting attempts</td>
<td>4</td>
</tr>
<tr>
<td>6</td>
<td>More than two mounts or mounting attempts and one service followed by sexual interest</td>
<td>5</td>
</tr>
<tr>
<td>7</td>
<td>Two mount one service no further sexual interest</td>
<td>6</td>
</tr>
<tr>
<td>8</td>
<td>One mount one service no further sexual interest</td>
<td>7</td>
</tr>
<tr>
<td>9</td>
<td>One mount one service followed by sexual interest including mounts or mounting attempts</td>
<td>8</td>
</tr>
<tr>
<td>10</td>
<td>More than two mounts and one service, no further sexual interest</td>
<td>9</td>
</tr>
</tbody>
</table>

#### Table 2: Mean±SE of growth traits of crossbred bulls and Murrah bulls

<table>
<thead>
<tr>
<th>Species</th>
<th>Birth weight (kg)</th>
<th>3 M Body weight (kg)</th>
<th>6 M Body weight (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cattle (crossbred bulls)</td>
<td>28.83±0.56</td>
<td>59.38±1.33</td>
<td>106.20±1.95</td>
</tr>
<tr>
<td>Buffalo (Murrah)</td>
<td>33.83±0.45</td>
<td>62.53±1.05</td>
<td>100.88±1.71</td>
</tr>
</tbody>
</table>

The means within the same column with at least one common letter, do not have significant difference (P>0.01).

#### Table 3: Behavioural characteristics of crossbred bulls and Murrah bulls (Mean±SE)

<table>
<thead>
<tr>
<th>Species</th>
<th>Libido score (Score)</th>
<th>Reaction time (Second)</th>
<th>Flehmen’s response (Score)</th>
<th>Mounting stimulus (Score)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cattle (crossbred bulls)</td>
<td>5.41±0.19</td>
<td>48.71±6.75</td>
<td>1.83±0.39</td>
<td>1.62±0.04</td>
</tr>
<tr>
<td>Buffalo (Murrah)</td>
<td>5.07±0.21</td>
<td>43.13±5.36</td>
<td>1.33±0.04</td>
<td>1.25±0.04</td>
</tr>
</tbody>
</table>

The means within the same column with at least one common letter, do not have significant difference (P>0.01).

#### Table 4: Percent of behavioural characteristics shown by crossbred bulls and Murrah bulls

<table>
<thead>
<tr>
<th>Species</th>
<th>Flehmen’s response (%)</th>
<th>Mounting stimulus (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cattle (crossbred bulls)</td>
<td>14.29</td>
<td>33.33</td>
</tr>
<tr>
<td>Buffalo (Murrah)</td>
<td>65.00</td>
<td>72.22</td>
</tr>
</tbody>
</table>
Studies conducted by Pal et al. (2006) have also reported similar findings. Post-thaw sperm motility
Significantly \( P<0.01 \) higher post-thaw motility (44.98\% ±0.77\%) was observed (Table 5) in Murrah bulls compared to crossbred bulls (35.43\% ±1.08\%) which might be due to the species specificity of the buffaloes or due to the different expression of the trait as a result of genotype-environmental interactions. Similar observations as in present study were reported by Pal et al. (2006).

D. Averages of milk production traits
In the present study, a tendency was observed for the crossbred bulls to have higher EPD (250.00\% ±21.81 kg) compared to Murrah bulls (242.52\% ±12.35 kg). Crossbred bulls having higher superiority (7.72\% ±0.67\%) over the herd average whereas Murrah bulls were reported to have 11.03\% ± 0.56\% over herd average (Table 7). Anonymous (1999) reported the genetic superiority of bulls, where 17.5 percent of the crossbred bulls showed genetic superiority of 10 percent of the herd average. Studies conducted by Pal et al. (2005) have also reported similar findings.

II. Phenotypic associations among various economic traits: The phenotypic association of various phenotypic traits in crossbred bulls and Murrah bulls is presented in Tables 8 and 9, respectively.

Association among growth traits
Association studies of Growth Traits in crossbred bulls revealed that the association of birth weight with three months and six months body weights were high at a significant level \( P<0.05 \) and three months with six weight was also found to be highly associated \( P<0.01 \). The present observation was found to be similar to that of Demeke et al. (2003), where high genetic correlation was observed between birth weight and weaning weight, pre-weaning average daily gain and yearling weight as well as among weaning weight, pre-weaning average daily gain and yearling weight.

For the Murrah bulls, the birth weight was significantly associated with three months body weight, and the three months and six months body weight was although highly associated but not found to be significant (Table 9).

Association among various growth and behavioural traits
Association among various growth and behavioural traits depicted that for crossbred bulls, the association of growth traits with libido score and reaction time was found to be low to medium, whereas the trend was low in Murrah bulls. Meyer et al. (1991) also reported that serving capacity and weights were phenotypically unrelated for Australian Zebu cattle.

Association of the growth characters with various semen characteristics
For crossbred bulls, the association of the growth characters with various semen characteristics were estimated and observed as mostly low to medium, and high for some characteristics.

However, a high association of the traits was not found to be significant. Susan et al. (1984) observed that semen traits were lowly correlated phenotypically with growth traits (–0.08 to 0.08) and genetic correlation estimates were variable.
A similar trend was observed for the association of growth traits with semen characteristics of Murrah bulls.

**Association of growth traits with milk production traits**

Association of Growth Traits with Expected Predicted Difference for crossbred bulls had shown that three months body weight was significantly associated with their expected predicted difference ($P<0.05$) (Table 8). For Murrah bulls, although the association between growth traits with three and six months body weight was found to be medium to high, the associations were not found to be significant.

**Association among reproductive traits**

The association of libido score with reaction time was found to be negative, but low to high for both crossbred bulls and Murrah bulls, which indicates that libido of the bulls is high because it is negatively related with the reaction time.

---

**Table 8** Phenotypic correlation of various traits of Murrah bulls

<table>
<thead>
<tr>
<th></th>
<th>BWT</th>
<th>EPD</th>
<th>LS</th>
<th>RT</th>
<th>SVOL</th>
<th>SCONS</th>
<th>MACT</th>
<th>IMOTF</th>
<th>IMOTPT</th>
<th>SDOSE</th>
<th>X3</th>
<th>X6</th>
</tr>
</thead>
<tbody>
<tr>
<td>BWT</td>
<td>1.00</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<td>-</td>
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</tr>
<tr>
<td>LS</td>
<td>-0.06</td>
<td>0.14</td>
<td>1.00</td>
<td>-</td>
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<td>-</td>
<td>-</td>
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<td>-</td>
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</tr>
<tr>
<td>RT</td>
<td>-0.01</td>
<td>0.15</td>
<td>0.15</td>
<td>1.00</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
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</tr>
<tr>
<td>SVOL</td>
<td>0.03</td>
<td>0.27</td>
<td>0.17</td>
<td>0.04</td>
<td>1.00</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>SCONS</td>
<td>-0.01</td>
<td>0.14</td>
<td>0.14</td>
<td>0.13</td>
<td>0.15</td>
<td>1.00</td>
<td>-</td>
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<td>-</td>
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<tr>
<td>MACT</td>
<td>-0.08</td>
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<td>0.15</td>
<td>0.14</td>
<td>0.14</td>
<td>0.13</td>
<td>1.00</td>
<td>-</td>
<td>-</td>
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<tr>
<td>IMOTF</td>
<td>0.16</td>
<td>0.14</td>
<td>0.14</td>
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<td>0.53</td>
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<td>1.00</td>
<td>-</td>
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<tr>
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<td>0.15</td>
<td>0.13</td>
<td>0.13</td>
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<td>0.14</td>
<td>1.00</td>
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</tr>
<tr>
<td>SDOSE</td>
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<td>0.14</td>
<td>1.00</td>
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<tr>
<td>X3</td>
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<td>0.14</td>
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<td>0.15</td>
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<tr>
<td>X6</td>
<td>0.46</td>
<td>0.13</td>
<td>0.15</td>
<td>0.15</td>
<td>0.15</td>
<td>0.15</td>
<td>0.15</td>
<td>0.15</td>
<td>0.15</td>
<td>0.08</td>
<td>1.00</td>
<td>1.00</td>
</tr>
</tbody>
</table>

BWT: body weight; EPD: expected predicted difference; LS: libido score; RT: reaction time; SVOL: semen volume; SCONS: semen consistency; MACT: mass activity; IMOTF: individual motility (Fresh); IMOTPT: post-thaw motility; SDOSE: semen dose; X3: three months body weight; X6: six months body weight.

* $P<0.05$; ** $P<0.01$.
The association of behavioural characteristics (libido score and reaction time) with semen characteristics were mostly low to medium but high for some characteristics, both for crossbred bulls and Murrah bulls with LL genotype. The association of individual motility with member of semen doses per collection reported a strong positive and significant (P<0.05) correlation for crossbred bulls. However, the trend was found low for Murrah bulls. Most of the association among the semen characteristics in both the species was found to be low to medium. Susan et al. (1984) reported that genetic and phenotypic correlations among semen traits were high and favorable with absolute values ranging between 0.49 and 1.11 in Angus cattle. This difference could be due to breed difference.

**Association of reproductive traits with milk production traits**

The association of behavioural characteristics with expected predicted difference was reported as low to medium for both crossbred bulls and Murrah bulls. The association of various semen characteristics with expected predicted difference for crossbred bulls and Murrah bulls were mostly medium to high (Tables 8 and 9).

**ACKNOWLEDGEMENT**

The authors are thankful to Director, NDRI, Karnal for carrying out the work.

**REFERENCES**


