MUSCULAR HYPERTROPHY OF GENETIC ORIGIN IN CATTLE

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SUMMARY

Muscular hypertrophy in cattle is reviewed in this paper with discussion on the potential as well as dangers of their use in Australia. Double muscling or muscular hypertrophy is an inherited condition found in many breeds of cattle. Double muscled cattle have higher lean meat yield and a higher proportion of 'expensive' cuts of meat. However the syndrome is associated with some characteristics, such as reduced fertility, which limits production. Certain trends in the Australian beef industry, such as the proliferation of feedlots, emphasis on meat yield, and current consumer demand for leaner meat could increase interest in such animals. While there could be a niche for the use of double muscled animals in the feedlot and dairy-beef production systems, the possible danger in reducing productivity of the breeding herd should be evaluated in planning potential breeding strategies with double muscled cattle.

INTRODUCTION

Muscular hypertrophy of genetic origin has been observed in many breeds and cattle exhibiting this syndrome are commonly referred to as double muscled cattle. Double muscled cattle excel in carcass characteristics. Compared to normal cattle, double muscled cattle have less bone, less fat, more muscle, a higher muscle to bone ratio and a higher proportion of 'expensive' cuts of meat (Menissier 1982a; Shahin and Berg 1985). Unfortunately the syndrome is associated with production problems such as reduced fertility, dystocia, low calf viability and increased stress susceptibility (Menissier 1982a; Arthur et al. 1988).

With consumer demand moving towards leaner meat, interest in double muscled cattle has increased. In Europe double muscled cattle are used to some extent and in North America semen from double muscled bulls are now available commercially. The proliferation of feedlots in Australia and the inclusion of meat yield in chiller assessment under AUS-MEAT will increase interest in double muscled cattle and heavily muscled breeds. This paper reviews various aspects of the double muscled syndrome in cattle and discusses the potential, limitations and dangers in the use of such animals for genetic improvement of cattle in Australia.

CHARACTERISTICS OF THE SYNDROME

The condition is a syndrome, implying that it is associated with many physical, physiological and histological characteristics other than muscular hypertrophy. The degree of expression of the syndrome however varies with genetic background, environment, nutrition, sex and stage of maturity.

Genetics

The double muscled syndrome in cattle was first documented by Cully in 1807 (cited by Oliver and Cartwright 1968). However its mode of inheritance is still not known with certainty. The variability in the expression of the double muscle character has been reported by many researchers, and this has contributed to the uncertainty in the mode of inheritance of the double muscle trait. Most researchers agree

that a pair of autosomal alleles at a single locus is involved in the inheritance of this character (Oliver and Cartwright 1968; Rollins et al. 1972; Menissier 1982b). There is, however, disagreement as to the mode of action of the gene. The different alternatives presented in the literature include partial dominance, incomplete recessiveness, incomplete penetrance and gene modifiers of some type.

Reproduction

Double muscled cattle show reduced fertility relative to normal cattle. Factors such as poor sexual behaviour, especially at young ages, delays in attaining puberty in both sexes, and a higher than normal incidence of genital infantilism have been attributed to this reduction in fertility (Oliver and Cartwright 1968). In mature double muscled cows reduced fertility has been attributed partially to the higher frequency of calving difficulty as well as to greater mortality in double muscled embryos (Rollins et al. 1972). There are indications in the literature that the sex ratio of double muscled calves born does not follow the expected 1:1 ratio, although the biological reason for this imbalance is not known (Rollins et al. 1972). Arthur et al. (1989a) reported that the imbalance was due solely to maternal effect, with more males than females being born to double muscled dams whether the sire was normal or double muscled. Double muscled cattle have a higher incidence of dystocia compared to normal cattle. Menissier (1982a) reported as high as 42 percent more caesarian sections in double muscled cows. The major cause of dystocia in double muscled cattle was aptly described by Vissac et al. (1973) as a "foeto-maternal morphological imbalance at calving", resulting from the conformation of the double muscled calf (increase in the width of the calf from the hypertrophy of the muscles) and the reduced area of the pelvic opening in double muscled cows (Arthur et al. 1988). Associated with, and partly as a result of the calving difficulty is the poor perinatal viability of double muscled calves (Arthur et al. 1988). Other reasons for the poor viability include poor maternal ability of double muscled dams plus the higher frequency of birth of calves with enlarged tongues and rachitism (Menissier 1982a).

Growth

Most studies have found that double muscled calves have a higher preweaning growth rate than normal calves. During the postweaning period however, most reports indicate that the growth rate of double muscled animals is inferior to that of normal cattle, resulting in a lower mature weight (Vissac et al. 1973; Geay et al. 1982). A number of studies have reported reduced appetite in double muscled cattle resulting in lower feed intake (Geay et al. 1982). It is suggested that the reduced feed intake is due to the reduction in the size of the digestive tract (Vissac 1968). Hence double muscled cattle express their growth potential better on concentrate diet. Double muscled cattle tend to adapt less easily to feed restriction and dietary changes (Menissier 1982a). Geay et al. (1982) found that double muscled cattle have better feed efficiency than normal cattle if the gain of muscles per unit energy intake is considered. However, restriction of feed up to 75% ad libitum reduced feed efficiency of double muscled bulls by 4.8% but improved that of their normal Charolais and Friesian contemporaries by 9% and 15.5%, respectively. Generally double muscled animals are more excitable or have a higher susceptibility to stress and hence a reduced ability to adapt to herd management conditions than normal cattle (Menissier 1982a).

Carcass characteristics

Double muscled cattle are known to have superior carcass characteristics compared to normal cattle. This is mainly due to the generalised muscular hypertrophy, fineness of bones, lower potential to accumulate fat and smaller digestive tract of the double muscled cattle. Modifications to the body composition are not uniform throughout the body. There are "highly hypertrophied", "hypertrophied" and even "hypotrophied" regions when comparisons with normal cattle are made at constant weight (Boccard and Dumont 1974; Shahin and Berg 1985). In the rachidial region, the muscular hypertrophy seems to follow an anteroposterior gradient (Vissac 1968) where the minimum hypertrophy will be located around the neck.

Muscular hypertrophy is more marked in hind limbs than in forelimbs (Vissac 1968; Boccard and Dumont 1974). The muscular hypertrophy is also seen to affect peripheral muscles and those exhibiting a large superficial face (Johnson 1981; Boccard and Dumont 1974). Bones of the limbs are subject to a reduction according to the same gradient (Vissac 1968; Menissier 1982a). Morphological differences in size and shape of long bones have been reported between double muscled and normal cattle. These modifications have resulted in double muscled carcasses having a higher dressing percentage, less fat, less bone, higher lean meat yield and a higher proportion of "expensive" cuts of meat compared to normal carcasses.

DOUBLE MUSCLED CATTLE IN PRODUCTION SYSTEMS

In spite of some limitations to production, the carcass characteristics of double muscled cattle are so superior that they are being used in production systems overseas. They are commonly used as sires in crossbreeding programs. Although there is great variability in the conformation of the progeny from crossing double muscled and normal cattle, overall, their carcasses yield more lean meat than normal carcasses (Menissier 1982a; Arthur et al. 1989b). Estimates of additive direct, additive maternal and heterosis effects of double muscled cattle have been provided by Arthur et al. (1989a).

Europe

Double muscled cattle are used in production systems in Europe more than anywhere else. A premium price is paid for double muscled carcasses due to their superior meat yield. This has resulted in the "infusion" of the double muscled gene(s) into some European breeds. In the Belgian Blue and White cattle, Hanset (1982) reported that from 1958 to 1970, A.I. bulls of the dual purpose type were progressively replaced by double muscled bulls and the proportion of double muscled calves born from A.I. in commercial farms increased from 2.3% to 11.3%. In 1980 it was reported that in the Piemontese breed in Italy, all breeding bulls were double muscled and the frequency of births of double muscled (hypertrophied) and double muscled "crossbred" (intermediate) calves were 50% and 25%, respectively (Masoero and Poujardieu 1982; Sartore and Chiappone 1982). In France double muscled sires have been used for a long time in A.I. centres, and a specialised double muscled sire line (called 'INRA 95') has been created for the production and selection of double muscled sires (Menissier 1982c).

North America

In Canada and the United States of America there have been numerous studies on double muscled cattle but their use in commercial operations has been limited to a few commercial herds. Interest in these animals has increased in recent years and double muscled semen is now available from commercial bull studs. One of the major limitations to their widespread use is that the beef carcass grading systems in both countries do not reward producers directly on the meat yield of their animals hence making the use of double muscled bulls as terminal sires not an attractive strategy (Arthur et al. 1989b). Great interest, however, is currently being shown by dairy farmers in using the double muscled gene(s) to improve muscling of dairy calves to be reared for veal (Makarechian and Price: personal communication).

POTENTIAL IN AUSTRALIAN BEEF PRODUCTION SYSTEMS

Double muscling has been reported in most breeds of cattle and exists in cattle populations in Australia, as evidenced by two Australian studies (Butterfield 1966; Johnson 1981). There have also been recent introductions of some European breeds, such as the Piemontese, which have relatively high frequencies of the gene(s). While there is great interest presently in heavily muscled breeds for beef production, the extent to which this will drive producers to utilise double muscled cattle will depend a great deal on whether meat yield will be reflected in prices paid for carcasses. The scenerio has however been set with the inclusion

of meat yield in chiller assessment under AUS-MEAT. Assuming that in the future the price paid for slaughter cattle will be based on meat yield, along with other carcass characteristics, what systems of production would double muscled cattle be suited to and what dangers should breeders be aware of?

There could be benefits in the use of double muscled cattle for both the beef as well as the dairy producer. Under both production systems however, their use will probably be restricted to temperate, rather than tropical, regions due to their high susceptibility to heat stress. They would also likely be grown for slaughter in feedlot, as opposed to pasture systems, due to the fact that double muscled cattle have smaller digestive tracts and are efficient only under concentrate feeding systems. The production problems associated with the double muscled syndrome are greatly reduced if the breeding females are normal cattle. Hence the use of double muscled bulls as terminal sires on normal cows would be the most logical approach. The "crossbred" progeny produced could yield about 9% more lean meat compared to normal cattle, based on 10-11-12th rib joint dissection of 300 kg yearling carcass with 7.5 mm fat thickness at the 12/13th rib (Arthur et al. 1989b). This difference is expected to be higher in leaner carcasses.

Weaned dairy calves are usually discounted in price due to their perceived lower beef value. The potential benefits in using double muscled sires on old and surplus dairy cows could be great. Careful planning is however required to develop strategies for their use on high producing dairy cows to minimise calving difficulty and hence reduce the potential for damaging the reproductive system of these cows.

There is certainly great potential in the use of double muscled cattle in genetic improvement, however potential dangers associated with massive "infusion" of double muscling in the female breeding herd cannot be overemphasised. The effects on most fitness traits, such as reproduction and survival, are well documented. Any breeding strategy adopted should thus address this problem.

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