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Brief Communication

Inheritance of Bovine Spinal Muscular Atrophy

Bovine spinal muscular atrophy (BSMA) is a disease, which primarily affects the motor neurons in the ventral horns of the spinal cord. Secondarily, denervation atrophy in the corresponding muscles is developed. The main clinical symptoms are a recumbent position with apparent normal sensorium. The disease is progressive. BSMA was first recognized in 1988 by *Hansen et al.* (1988) in Red Danish Dairy Breed (RDM) calves of American Brown Swiss origin. Later it has been described in the American Brown Swiss Breed (*El-Hamidi et al.* 1989).

All known cases of BSMA in the RDM can be traced back to imported American Brown Swiss bulls (*Hansen et al.* 1988, *Nielsen* 1990). The pedigree of known artificial insemination (AI) carrier bulls in the RDM is shown in Fig. 1. The identification is based on characteristic histopathological findings in progeny.

An autosomal recessive mode of inheritance has been proposed (*Hansen et al.* 1988). This study is the first to determine the inheritance of BSMA by testmatings.

From 38 different herds 152 cows of the RDM breed, which were daughters of known carrier bulls, were selected and inseminated with semen from known carriers. The bulls used as fathers or grandfathers are

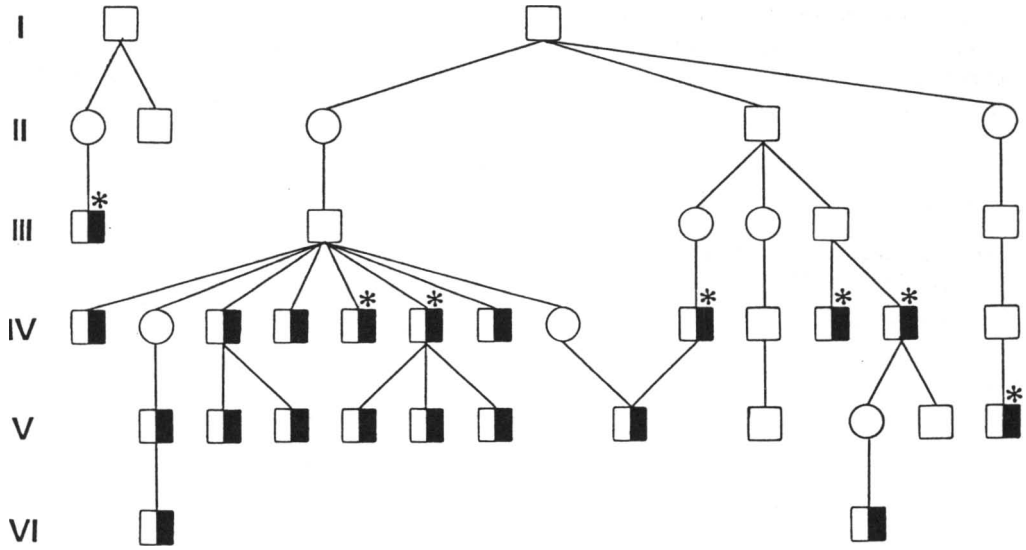

Figure 1. Pedigrees for AI-bulls of the Red Danish Dairy Breed known as carriers of bovine spinal muscular atrophy (BSMA).

◨ Bull diagnosed as carrier based on progeny necropsy. The remaining individuals indicated in the pedigree are possible or likely carriers. * Bull used in the investigation on inheritance of BSMA.

marked by an asterisk in Fig. 1. The calves were inspected by veterinary practitioners, until they were 3 months old. If they were free of clinical signs of BSMA at that age, they were regarded as normal. Calves, which died before the age of 3 months, were necropsied and histopathology was performed on the intumescentia cervicalis, int. lumbalis and muscular tissue after fixation in 10 % buffered neutral formalin, paraffin embedding and haematoxylin-eosin staining. Calves, which were recumbent, were tested for correct parentage by bloodtyping of both calf and alleged parents. These calves were euthanized and necropsied. A positive diagnosis was based on the findings described by *Hansen et al.* (1988). The results were tested using a chi-square test.

When the surviving calves were between 6 months and 2 years of age, the farmers were contacted to establish, if signs of BSMA had appeared after 3 months of age.

Twenty-one cows were excluded because of returning to service or slaughtering before calving. The remaining 131 cows gave birth to 137 calves. Eleven of these were stillborn and 13 died or were euthanized within the first 3 months. Not all dead calves were necropsied. Necropsy was performed on 4 stillborn and 9 older calves. None of the stillborn calves were diagnosed as having BSMA. Seven of the older calves had histopathological findings identical with BSMA. These calves had an age variation from 1 day to approximately 9 weeks, and a sex distribution of 2 males and 5 females. Two of the older calves not presented for necropsy had clinical signs of BSMA. 113 calves were alive and without clinical signs when 3 months old. These results are shown in Table 1.

None of the calves without clinical signs of BSMA at an age of 3 months developed BSMA later in life. When the farmers were contacted, 1 % of the calves were between 6 months and 1 year old, 7 % between 1 and 1 1/2 year old, 83 % between 1 1/2 and 2 years old and 9 % between 2 and 2 1/2 years old. Among the elder calves many of the bulls had been slaughtered for meat production. No clinical signs were observed before slaughtering.

Table 1. Results of testmating AI-bulls, carriers of bovine spinal muscular atrophy (BSMA), with progeny of known carrier bulls and statistical analysis to determine the mode of inheritance.

		Normal	BSMA
Necropsied	stillborn	4	0
	0–90 days old	2	7
Clinical signs; no necropsy		–	2
Examined alive 90 days old		113	0
Total		119	9
Expected (7:1 segregation)		112	16

$chi^2 = 3{,}50 \quad 0.05 < p < 0.1$

Because several bulls were used, a statistical test for homogeneity was performed. The material was homogeneous ($0.5 < p < 0.7$). The chi-square value for departure from the expected 7:1 segregation corresponds to a probability value of $0.05 < p < 0.10$ (Table 1).

The results indicate, that BSMA has autosomal recessive inheritance. The observed deficit of calves with BSMA, although not statistical significant, might be entirely fortuitous. However, it is possible, that BSMA can lower the birth survival rate because of congenital muscle weakness. In this study a 1 day old calf with BSMA was diagnosed, and in Denmark it is known (*Nielsen* 1990) that some calves with BSMA have a congenital recumbency and never become able to stand up after birth. This could explain the reduced number of calves with BSMA, because not all stillborn calves were necropsied.

In this study no cases of BSMA were detected after three months of age. This is in accordance with the knowledge obtained from the Danish programme to combat BSMA (*Nielsen* 1990). Therefore, it is likely, that BSMA is a disease among young calves, and that clinical signs appear before 3 months of age.

Even though not all dead calves were autopsied, it is evident, that BSMA is an autosomal recessive inherited disease. Some calves have a congenital form of BSMA with recumbency. These calves could have a reduced birth survival rate. Whether BSMA also has an influence on the prenatal mortality is unknown. It appears, that the first clinical signs of BSMA develop before three months of age.

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