



Animal Disease Diagnostic Laboratory



Miniature American Shepherd / Miniature Australian Shepherd / Toy Australian Shepherd Neuroaxonal Dystrophy (NAD)

Genetic Test Result Interpretation

We have designated the letter D to indicate the form of the NAD gene that contains this variant, and N to indicate the reference (normal) form of the gene. A dog's particular combination of N or D forms of the gene is known as its genotype.

Clear (NAD-N/N): A **clear** dog has no copies of the NAD variant (this is also referred to as being homozygous normal or free of the variant associated with this form of neuroaxonal dystrophy). A clear dog cannot produce NAD affected (D/D) offspring.

Carrier (NAD-D/N): A **carrier** dog has one copy of the NAD variant (this is also referred to as being heterozygous). Based on current data, a **carrier dog is not at risk of developing NAD**. NAD carriers will, on average, pass the NAD variant on to half of their offspring; they can produce **NAD-D/D** (affected/susceptible) offspring if mated to another carrier (**NAD-D/N**) or affected (**NAD-D/D**) dog.

Affected/Susceptible (NAD-D/D): An **affected/susceptible** dog has two copies of the NAD variant (this is also referred to as being homozygous affected). Based on current data, **all NAD-D/D dogs develop clinical signs within the first few years of life**; clinical signs are characterized by pelvic limb ataxia (abnormal gait) which progresses to eventually include thoracic limbs. These signs will slowly, but progressively worsen over the next several years. NAD-D/D dogs will pass one copy of this variant on to all of their offspring.

Further Information on NAD

Based on current data, NAD is most likely inherited in a **fully penetrant autosomal recessive** manner. Fully penetrant means that all genetically affected dogs (**NAD-D/D**) will show obvious clinical signs in their lifetime. Autosomal recessive means that two copies of the mutation are required to show signs of disease; the genotype of NAD affected / susceptible dogs is D/D. Both clear (NAD-N/N) and carrier (NAD-D/N) dogs do not develop the NAD disease but could still show clinical signs of other unrelated neurologic diseases (e.g., polyneuropathy, intervertebral disc disease, degenerative myelopathy, etc.).

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Below are the chances any given puppy in a litter from the indicated mating will have the genotype of N/N, D/N, or D/D. **Matings that produce an affected (NAD-D/D) dog are not recommended, and are shown in red.**

Matings that will not produce NAD affected dogs:

- Clear (N/N) x Clear (N/N) = 100% Clear (N/N)
- Clear (N/N) x Carrier (D/N) = 50% Clear (N/N), 50% Carrier (D/N)
(This is an average, individual litters may see anywhere from 100% Clear to 100% Carrier)
- Clear (N/N) x Affected (D/D) = 100% Carrier (D/N)

Matings that can produce NAD affected (D/D) dogs and are NOT recommended:

- Carrier (D/N) x Carrier (D/N) = 25% Clear (N/N), 50% Carrier (D/N), **25% Affected (D/D)**
(This is an average, individual litters may see more or less of any result)
- Carrier (D/N) x Affected (D/D) = 50% Carrier (D/N), **50% Affected (D/D)**
(This is an average, individual litters may see anywhere from 100% Carrier to 100% Affected)
- Affected (D/D) x Affected (D/D) = **100% Affected (D/D)**

We do not recommend exclusion of NAD carrier (D/N) dogs from the breeding population. We do recommend avoiding matings that have the potential to produce NAD affected (D/D) offspring as detailed above. As long as one of the two parents is NAD clear (N/N), NAD affected offspring will not be produced.

Immediately eliminating all NAD D/N (carrier) dogs from breeding may have negative consequences for the genetic diversity of the breed.

Test Limitations

While we have identified this NAD variant associated with neuroaxonal dystrophy in Miniature American Shepherds, other forms of genetic neurologic disease may exist in the breed. It is therefore important to remember that this NAD test is diagnostic for only one form of NAD and will not identify other forms. Thus, it is still possible that offspring could be affected with a different genetic form of NAD, even if both parents have tested NAD-N/N (clear). To that end, we recommend that both dogs in a breeding pair be free of any past or present signs of neurological disease, regardless of genotype. Nonetheless, this NAD test will help to prevent this form of neuroaxonal dystrophy and therefore significantly reduce the frequency of this disorder in the Miniature American Shepherd, Miniature Australian Shepherd, and Toy Australian Shepherd breeds.