

Genetic Disorders and the Arabian Horse

**AHA Task Force on Genetic Diseases Forum
November 2009, AHA Convention**

Forum Program

- Overview of basic genetics and equine genetic disorders
 - Emphasis on disorders of particular concern for Arabians
 - Research updates
- Review of Task Force activity
 - Including a review of the 2 resolutions submitted by the Task Force
- Arabian Horse Foundation (Larry Kinneer)
- FOAL (Fight Off Arabian Lethals) (Ray Cerniga)
- Q/A and Discussion

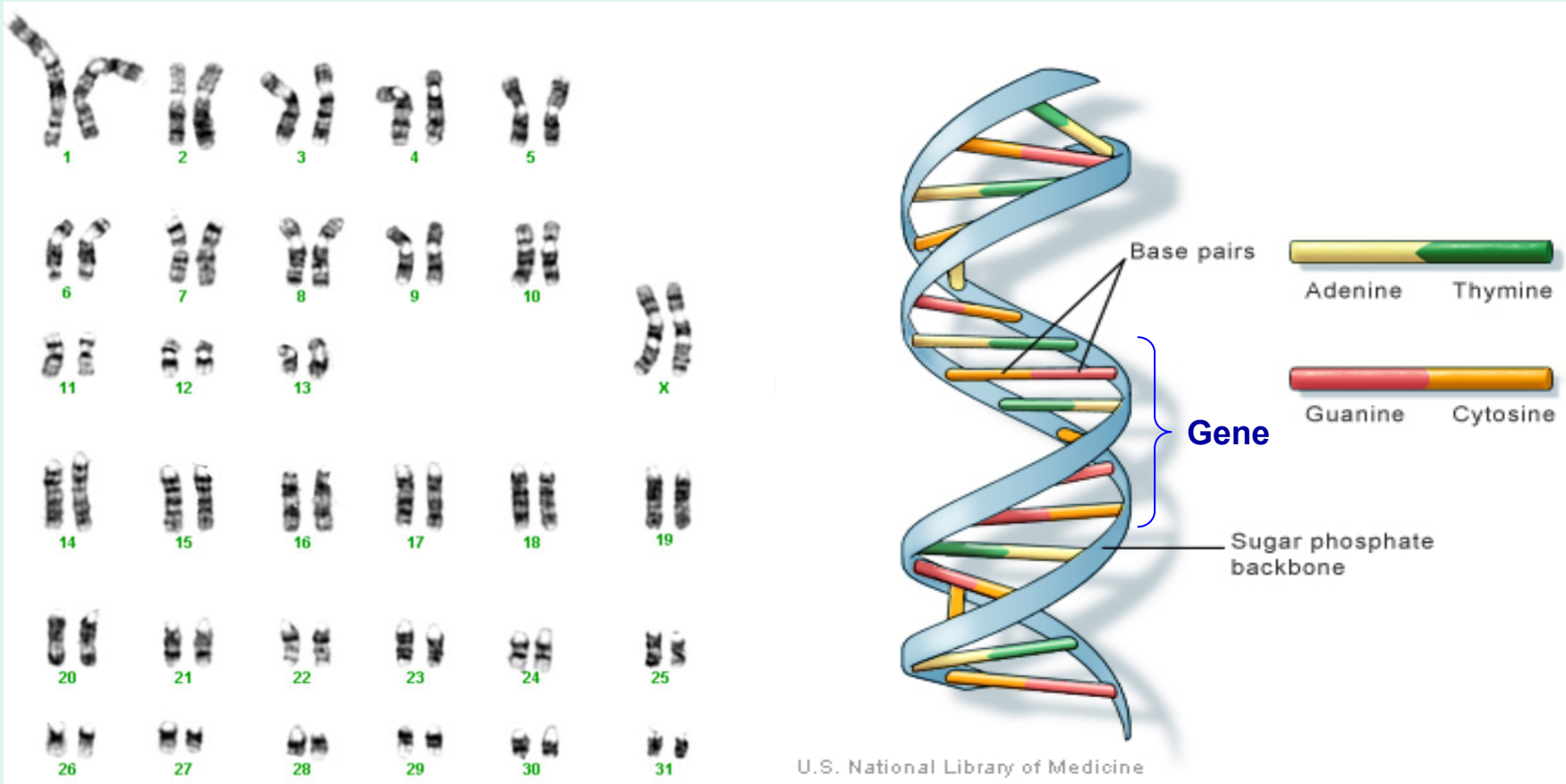
What are Genetic Disorders?

- Genetic disorders are pathologic conditions that result from a genetic origin (mutation of the normal genetic code).
 - Basically, a spelling mistake that has resulted in some type of operation malfunction in the body.
 - Not just an “Arabian thing”, occur in other horse breeds and also in other species (including humans).

Gene Basics

- **DNA (deoxyribonucleic acid) is the hereditary material passed from generation to generation.**
- **The information in DNA is stored as a code made up of packages of information referred to as “genes”. A gene is the basic physical and functional unit of heredity.**
- **Horse have about ~20,000 genes that are stored on 32 chromosomes.**
- **Most genes code for some type of protein.**
- **Variations in DNA coding (gene sequences) can result in production of different types of proteins.**
- **These differences in genetic coding and the resulting variation in the proteins produced → differences between individuals, breeds and species; it is what makes an individual “unique”.**

A Picture is Worth a Thousand Words



Courtesy of U of KY – Gluck Equine Research Center

Courtesy of the US National Library of Medicine

Equine Genome Project

- In February 2007, the first draft of the equine genome sequence was completed.
- Researchers went base pair by base pair and put together a map so they could see what the equine code is.
- Having this sequence available has dramatically decreased the amount of time, money and samples needed to develop DNA tests.
 - What used to take 15 years now can take 2-3 years.
 - What used to take hundreds of thousands of dollars can now be done in a fraction of that.



More Gene Basics

- Individuals have two copies of each gene – one copy inherited from each parent.
- Alleles are differing forms of the same gene that affect individual traits (in some cases, diseases). Alleles have small differences in their DNA base sequence that result in expression of the different versions of the trait:
 - **grey vs. non-grey**
 - **SCID affected vs. normal**

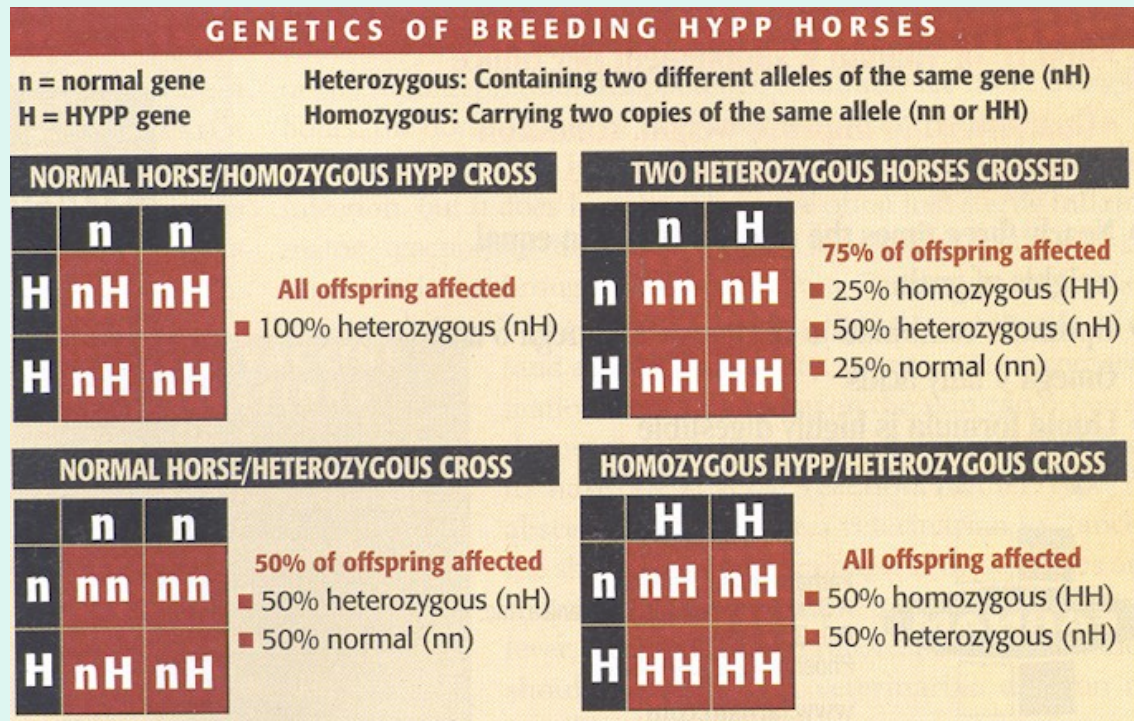
What Causes These Mutations?

- Mutations are permanent changes in an individual's DNA sequence – a spelling mistake...our focus is random changes.
 - Mutations occur fairly frequently; but the body has a DNA repair system that usually recognizes a mutation and fixes it. Or, if the mutation has occurred in a section of the junk DNA it usually isn't an issue.
 - However, if a mutation occurs within a gene and isn't repaired, then the function of the gene can be in some way altered.
 - Mutations can vary from something like greying (gene on chromosome 25) or a disorder such as SCID (gene on chromosome 9).
 - Mutations aren't necessarily bad, but in the case of genetic disorders – mutations are the source of the problem.

Review on Modes of Inheritance (single gene traits)

- Dominant – only one copy of the mutated allele is needed for expression of the trait.
 - Only one parent needs to pass along the mutated allele in order to produced an affected foal.
 - Affected individuals can be either homozygous or heterozygous for the mutation – both will show clinical signs and be affected.

(Probability at each mating)



Credit: unknown creator of chart

Review on Modes of Inheritance

(single gene traits)

- Recessive – two copies of the mutated allele are needed for expression of the trait.
 - Trait can skip generations.
 - An individual can be a carrier, but is physically normal.
 - Both parents must be carriers and pass along a copy of the mutated allele, in order to produce an affected foal.

	CLEAR Stallion	CARRIER Stallion
CLEAR Mare	100% Clear	50% Clear 50% Carrier
CARRIER Mare	50% Clear 50% Carrier	25% Clear 50% Carrier 25% Affected

(Probability at each mating)

Review on Modes of Inheritance

(single gene traits)

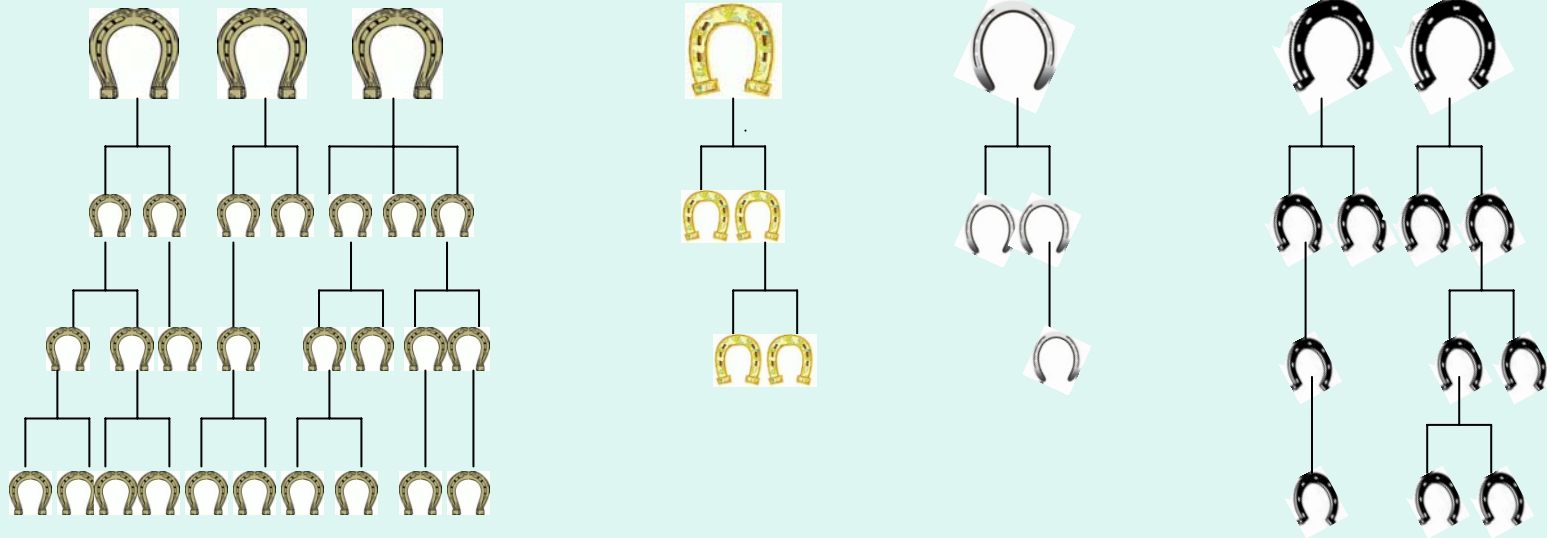
	<u>AFFECTED</u>	<u>CARRIER</u>	<u>CLEAR</u>
<u>AFFECTED</u>	100% AFFECTED	50% AFFECTED 50% CARRIER	100% CARRIER

Probability at each mating

Popular Sire Syndrome and Concern of Genetic Diversity

- There is a tendency for breeders to breed to the male who is the top-winner. When a large portion are breeding to a single animal, or the *Popular-Sire Syndrome*, the gene pool will drift and there will be a loss of genetic diversity.
- Too much breeding to one animal will give the gene pool an extraordinary dose of his genes, and this will include whatever detrimental recessives he may carry, to be uncovered in later generations. This can cause future *breed-related genetic disease* through what is known as the *Founder's Effect*.

Genetic Drift



- Random changes in a few individuals can be subsequently repeated throughout successive generations; this affects the frequency of the allele in the population.
- Effects of genetic drift in small populations can be quite dramatic.

Frequency of genetic diseases in AQHA subgroups

Tryon, et al. 2008 JAVMA

	Affected %		Carriers%		
	HYPP	PSSM	GBED	HERDA	LWF
AQHA	1.5	11.3	11.0	3.5	No
Paint	4.5	4.5	3.9	1.7	21.3
Halter	56.4	28.2	5.1	0.8	No
W pl	1.1	8.6	26.3	12.8	No
Cut	No	6.7	13.6	28.3	No
Rein	No	4.3	3.1	9.3	No
W cow	No	5.7	9.5	11.5	No
Barrel	1.2	1.4	1.2	1.2	No
Race	No	2.0	No	No	No

Courtesy of Dr. Sharon Spier, UC Davis

Equine Genetic Disorders (Testable)

(listed with general breed association)

Autosomal Dominant Disorders:

- Hyperkalemic Periodic Paralysis (HYPP) (*QH and related breeds*)
- Type 1 Polysaccharide Storage Myopathy (PSSM) (*~20 breeds*)
- Malignant Hyperthermia (MH) (*QH and related breeds*)

Autosomal Recessive Disorders:

- Glycogen Branching Enzyme Deficiency (GBED) (*QH and related breeds*)
- Hereditary Equine Regional Dermal Asthenia (HERDA) (*QH and related breeds*)
- Overo Lethal White Syndrome (OLWS) (*Paints*)
- Cerebellar Abiotrophy (*Arabians*)
- Severe Combined immunodeficiency (SCID) (*Arabians*)
- Lavender Foal Syndrome (*Arabians*)
- Junctional Epidermolysis Bullosa (JEB) (*Belgians and Saddlebreds – 2 different mutations*)

Some Other Equine Genetic Disorders

(under investigation)

- Guttural Pouch Tympany (GPT)
(includes Arabians and Warmbloods)
- Congenital Stationary Night Blindness (CSNB)
(Appaloosa)
- Recurrent Exertional Rhabdomyolysis (RER)
(Thoroughbred study)
- Type 2 Polysaccharide Storage Myopathy (PSSM)
(numerous breeds)

Genetic Disorders of Particular Interest for Arabian Horse Owners and Breeders

- **Severe Combined Immunodeficiency (SCID)**
- **Cerebellar Abiotrophy (CA)**
- **Lavender Foal Syndrome (LFS)**

- **Occipito-atlantoaxial Malformation (OAAM)**
- **Juvenile Epilepsy Syndrome (JES)**
- **Guttural Pouch Tympany (GPT)**

More information available on the AHA website:

<http://www.arabianhorses.org/education/genetic/default.asp>

Severe Combined Immunodeficiency (SCID)

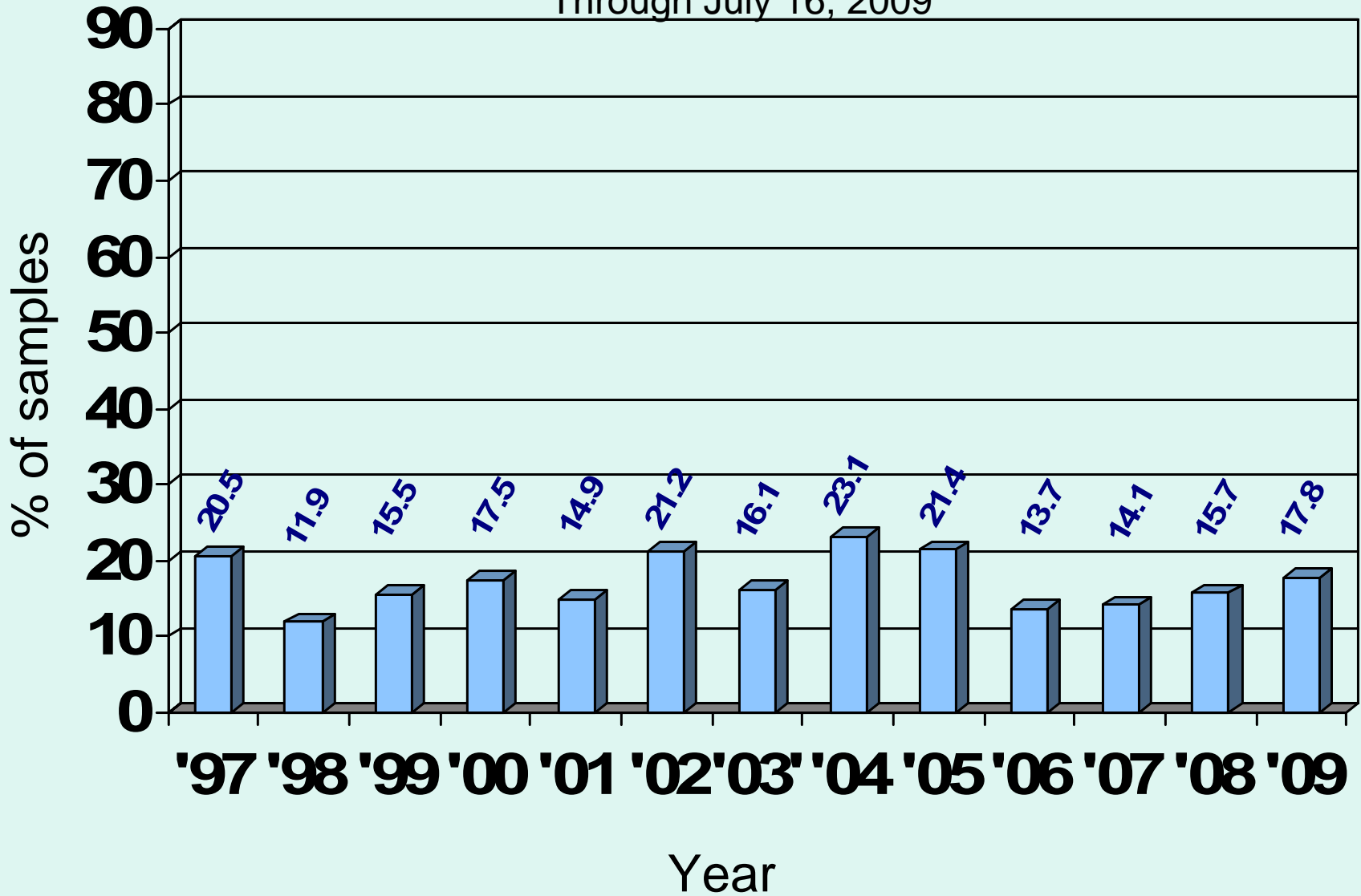
- Lethal autosomal recessive disorder.
- First described in veterinary literature in 1973.
- 1997 – University of TX developed a SCID test, available through VetGen (test kits can be ordered from FOAL).
- Through the efforts of the FOAL Commission, IAHA and the Morris Animal Foundation, >\$100,000 raised for SCID research.

Overview of SCID Clinical Signs

- Affected foals born with a severely weakened immune system.
- Generally die of an opportunistic infection (such as pneumonia) before the age of 5 months; lethal short of attempting a bone marrow transplant.
- Underdeveloped thymus and lymph nodes; lacking T- and B-lymphocytes of a normal immune system.
- Greatly decreased white blood cell count and lack of immunoglobulin M (IgM).

VetGen Tested SCID Carrier

Through July 16, 2009



SCID Testing Information

- Through January 2010 special pricing
 - \$70/test for 1st 100 tests ordered
 - \$84/test thereafter
- Can also combine special pricing for coat color testing done with the same sample.
- Contact FOAL to place orders: www.foal.org

Cerebellar Abiotrophy (CA)

- Equine cerebellar abiotrophy (CA) is a genetic, neurological condition found almost exclusively in Arabian horses.
- Results from breeding experiments carried out at UC Davis during the 1980's by the late Dr. Ann Bowling indicate a recessive mode of inheritance for this condition.
 - This means that a horse can "carry" a copy of the mutated allele (gene) but not be affected by it.
 - However, when two carrier horses are bred together, they have a 25% probability of producing an AFFECTED foal.
- The incidence of CA in Arabians is unknown, but evidence from affected foals pedigrees indicates that the disease gene is present in popular bloodlines.

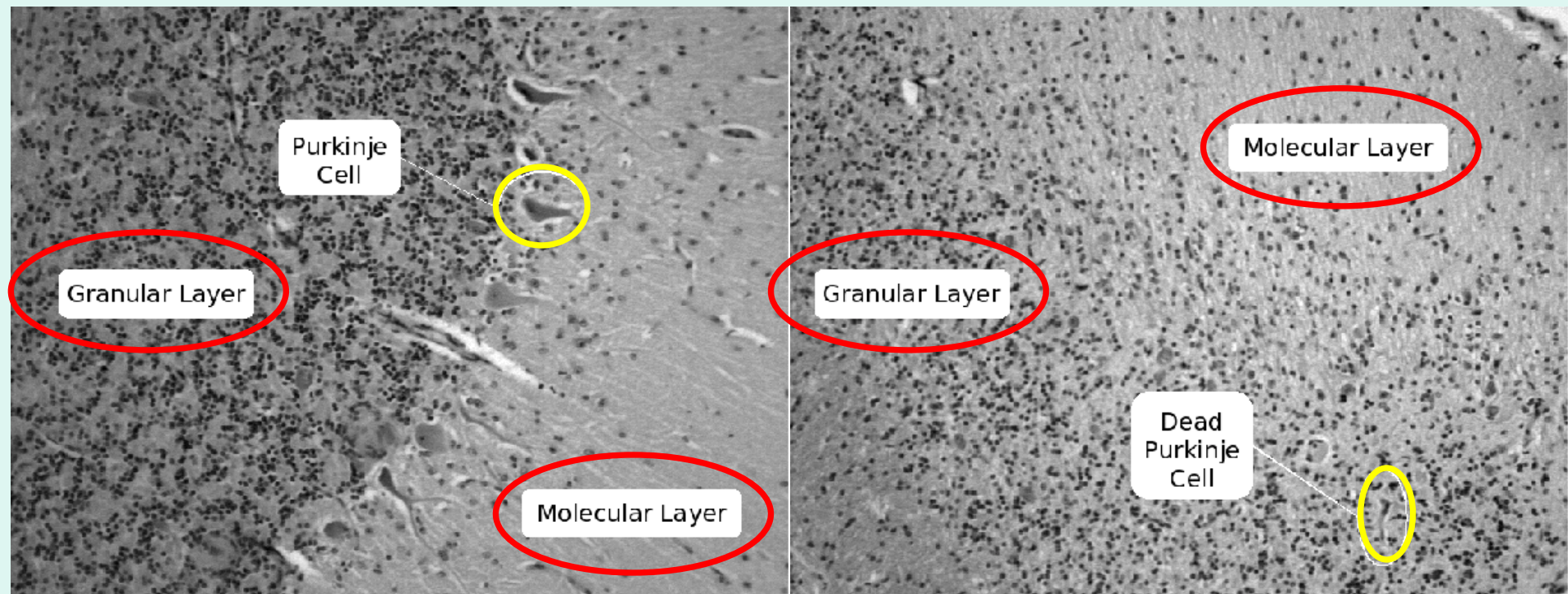
Overview of CA Clinical Signs

- Affected foals begin to show symptoms within 6 weeks - 4 months of age.
- Ataxia, intention head tremor, exaggerated action of the forelegs, wide-based stance, unable to rise, lack of menace response.
- May startle easily, fall, injure themselves or handlers.
- If not euthanized, they are usually restricted to life as pasture pets.



What Causes CA?

- Due to a post-natal degeneration of the Purkinje cells and associated granular neurons of the cerebellum
- Cerebellum becomes disorganized
- May be caused by a failure of the Purkinje cells to migrate correctly during development



Courtesy of the UC Davis Veterinary Genetics Lab, Dr. Cecilia Penedo and Leah Brault

CA or Wobbler's Syndrome?

CA Testing Statistics – UC Davis VGL

(as of 11/4/09)

Status	# animals	% of total
CA/CA	26	3.5
N/CA	158	21.2
N/N	561	75.3
Total	745 - (plus >50 in process)	

Allele frequency: Estimate from raw data (based on test results, not random sampling) $f(\text{CA})= 0.14$ and $F(\text{N})=0.86$.

CA has appeared in virtually all major Arabian bloodline groups

CA Testing Information

- **Indirect DNA test available from UC Davis:**
 - \$50/test
 - Hair sample
 - To order: <http://www.vgl.ucdavis.edu/services/horse.php> or call (530) 752-2211
- **Results are reported as:**
 - **N/N:** Normal. Horse does not possess markers associated with CA.
 - **N/CA:** Carrier (1 copy of gene). Horse has markers associated with CA and is considered to be phenotypically normal and a carrier of the disease gene.
 - **CA/CA:** Affected (2 copies of gene). Horse has markers associated with CA and is considered to have the disease.
- **Marker based test:**
 - A group of genetic markers on chromosome 2 adjacent to the CA gene have been identified and are used as an indirect test for CA. When markers lie close to a gene of interest, they are often inherited along with the trait.
 - The CA test looks for a specific set of alleles (genes) that are co-inherited with CA which can be used as a diagnostic tool to identify affected foals and also animals that are potential carriers of the disease.

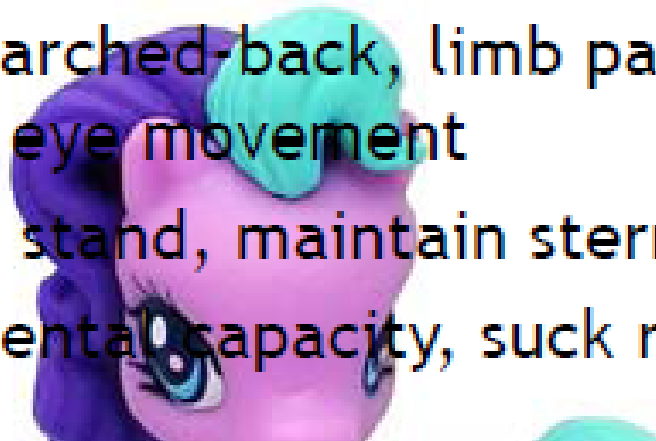
Research continues (partially funded by the Arabian Horse Foundation) to find the specific mutation so that a direct DNA test can be developed.

Lavender Foal Syndrome (LFS)

- Also known as Coat Color Dilution Lethal (CCDL).
- Neurologic disorder.
- Foals often very large at birth and have a difficult delivery (dystocia).
- Foals often born with a telltale diluted coat color; can appear lavender, pale pink or silvery; eye color often described as grayish-brown or having a bluish tint.
- If the coat coloration isn't present or is overlooked, foals may be diagnosed as having neonatal maladjustment syndrome ("dummy" foal).

WHAT IS LAVENDER FOAL SYNDROME (LFS)?

- ⦿ Seizures, arched-back, limb paddling, abnormal eye movement
- ⦿ Unable to stand, maintain sternal position
- ⦿ Normal mental capacity, suck reflex

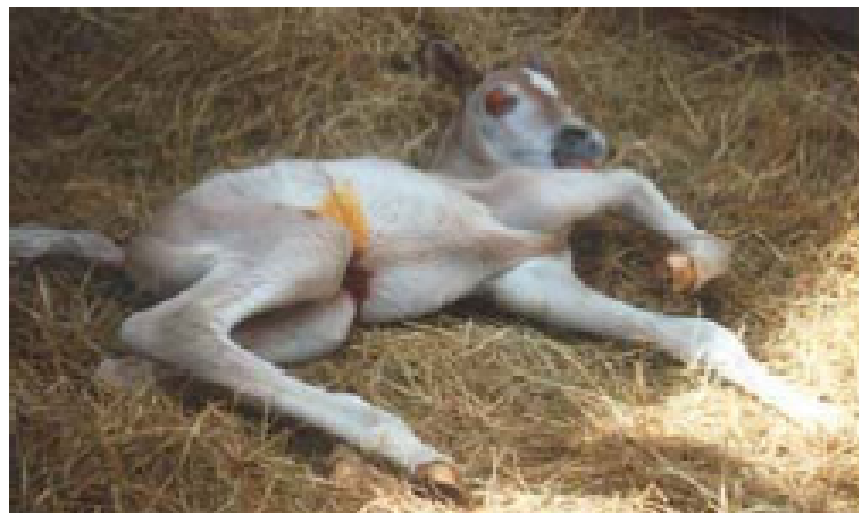


Case studies in:
Fanelli, 2005,
Page et al. 2008

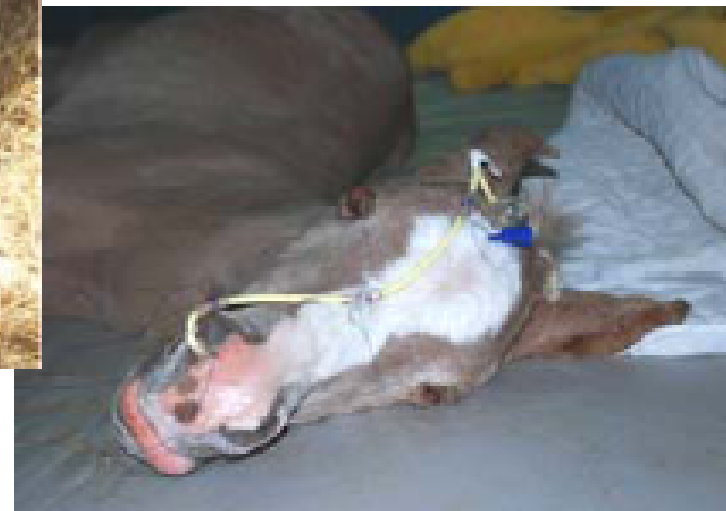


LFS...

- ⊙ Lethal, from complications or euthanasia
- ⊙ Predicted to be a single gene
 - autosomal recessive
- ⊙ Historically found in Arabians, particularly Egyptian Arabians



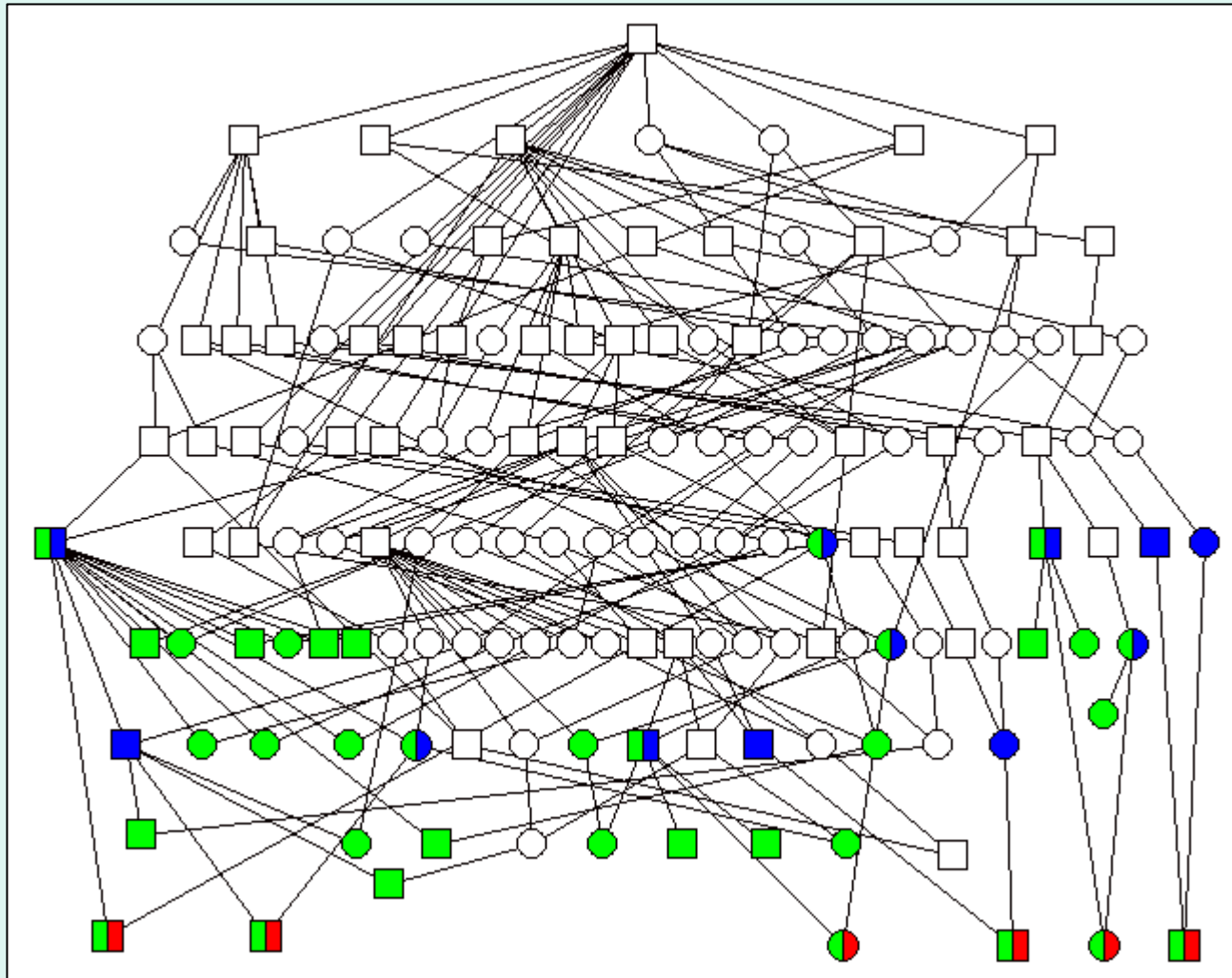
Fanelli, 2005



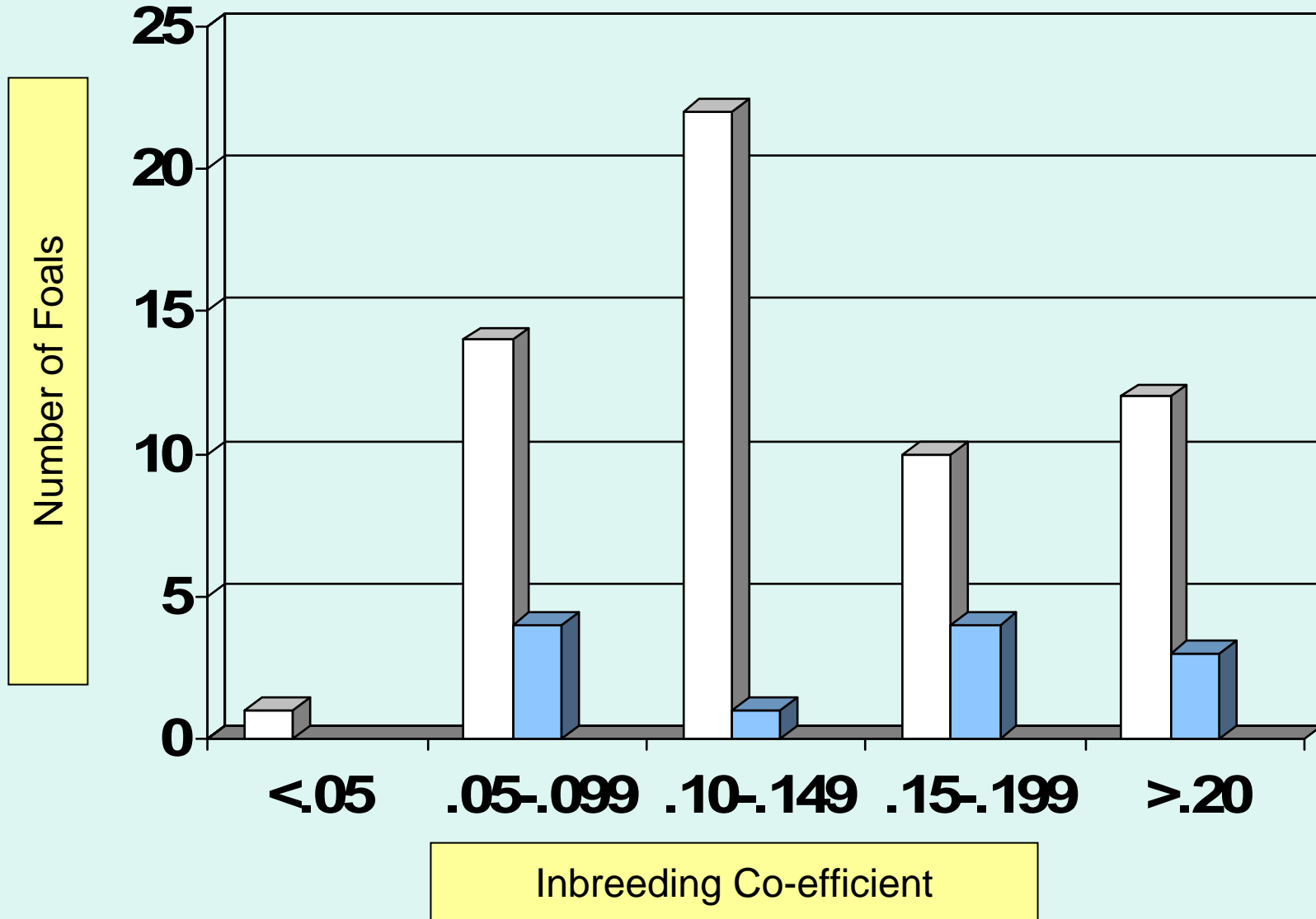
LFS Test

- Cornell University (lab of Dr. Samantha Brooks) has recently developed a test for LFS.
- Direct DNA test (tests for the mutation).
- Will be commercially available in the near future.
- More details to come as final arrangements for publication of the scientific paper are made and licensing arrangements are completed.

LFS Research Project at Cornell

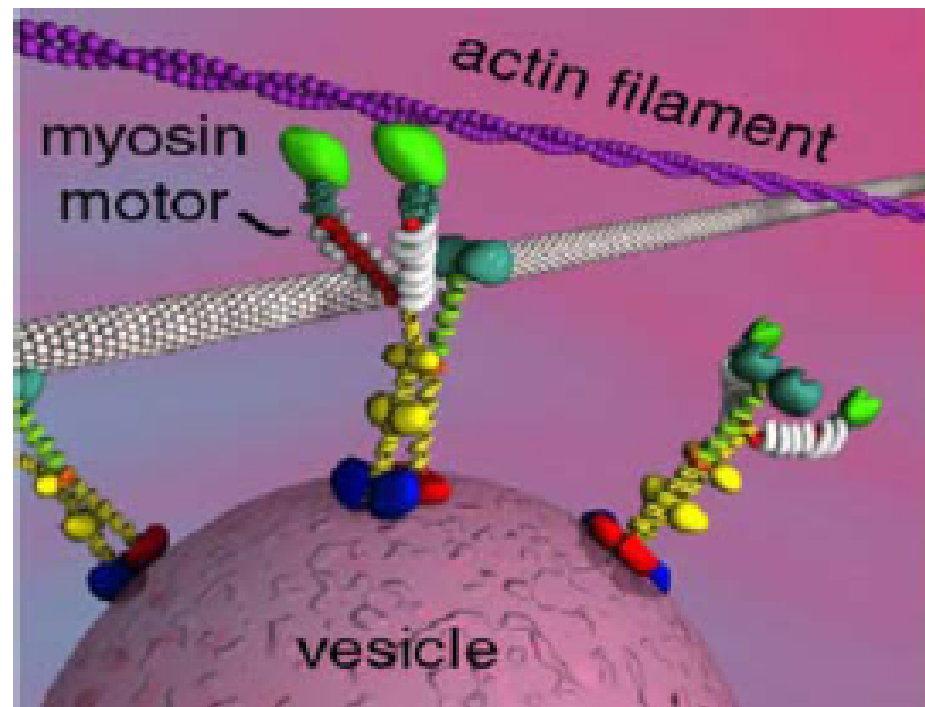


Inbreeding Co-efficients of LFS Affected Foals in Database (partial listing)



FUTURE WORK

- ⊙ Connection to Juvenile Epilepsy?
- ⊙ Is LFS in other breeds?



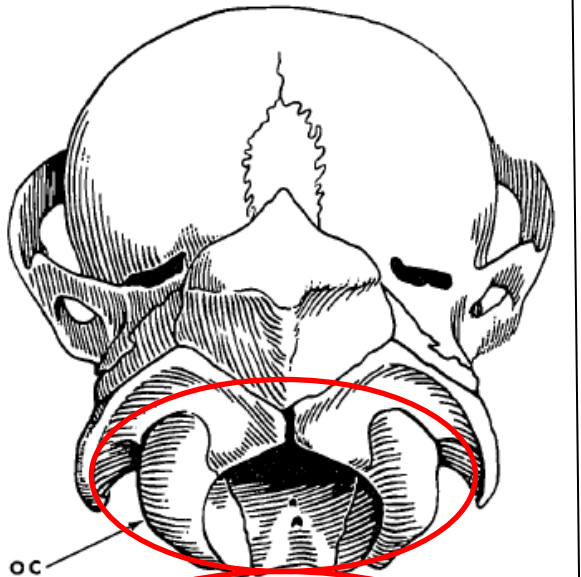
Occipitoatlantoaxial Malformation (OAAM)

- Neurologic disorder.
- Cervical vertebrae fuse together in the neck and base of the skull; causes compression and injury to the spinal cord.
- Limited research to date; no genetic test yet available, thought to be an autosomal recessive.
- Doesn't appear to be as commonly reported as SCID or CA. Please report affected foals to FOAL.

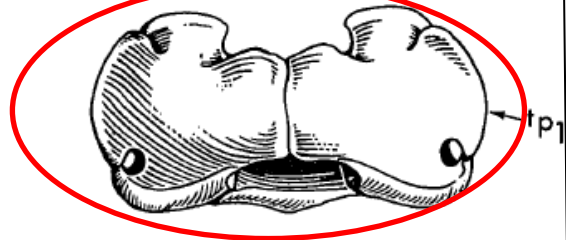
Overview of OAAM Clinical Signs

- Affected foals are often unable to stand and nurse, but some cases may not become noticeable for several weeks.
- Clinical signs range from mild incoordination to paralysis of both the front and rear legs.
- Radiographs can assist in diagnosing the condition.
- Generally the only cervical spinal cord disorder seen in horses less than 1 month of age.

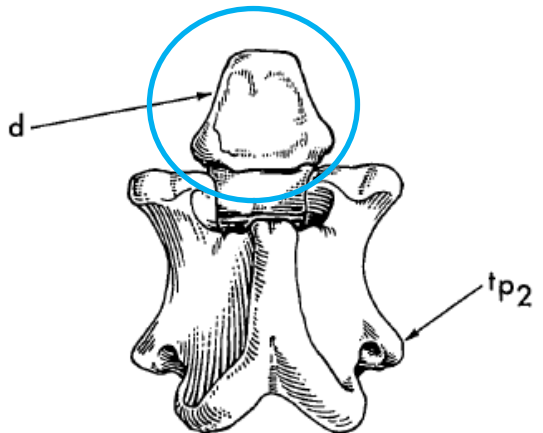
Normal Foal



oc



tp1

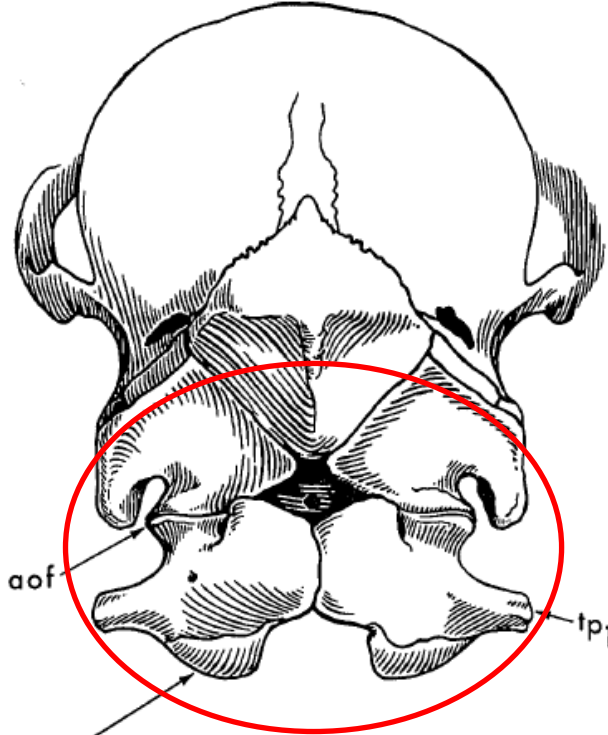


d

tp2

A

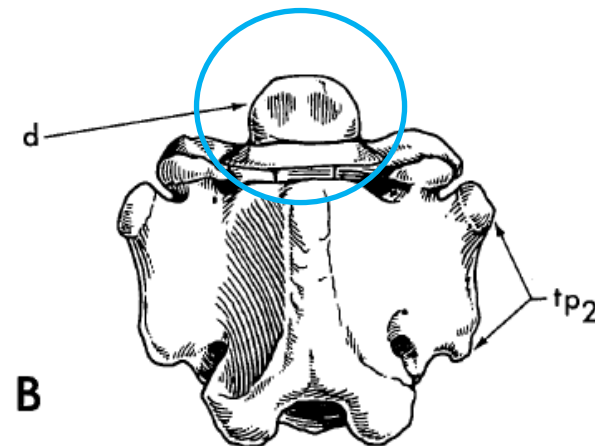
Stillborn OAAM Foal



aof

tp1

ac



d

tp2

B

Juvenile Epilepsy Syndrome (JES)

- Also known as Idiopathic Epilepsy (IE).
- Self limiting disorder, not usually fatal.
- Foals are born normal and are normal between epileptic seizures.
- Can be treated with traditional anti-seizure medications which may reduce the severity of the seizures.
- Research indicates JES is a dominant trait; also a proposed link to LFS that is being further investigated.

Overview of JES/IE Clinical Signs

- Affected foals may show signs anywhere from a couple of days of age to six months or so of age; generally outgrow the condition between 1 and 1-1/2 years of age.
- Foals will often have “cluster seizures”; multiple seizures over a several day period showing signs of confusion, blindness, head rubbing, depression and/or inability to eat, nurse or drink.
- Grand Mal seizures may cause the foal to lose consciousness.
- Foals may suffer injury as a result of falling to the ground or against hard objects.

JES Research

- Dr. Monica Aleman at the University of Davis is looking for samples from JES/IE affected horses for their ongoing research project.

Contact information:

mr Aleman@ucdavis.edu

Neuromuscular Disease Laboratory

UC Davis

One Shields Avenue

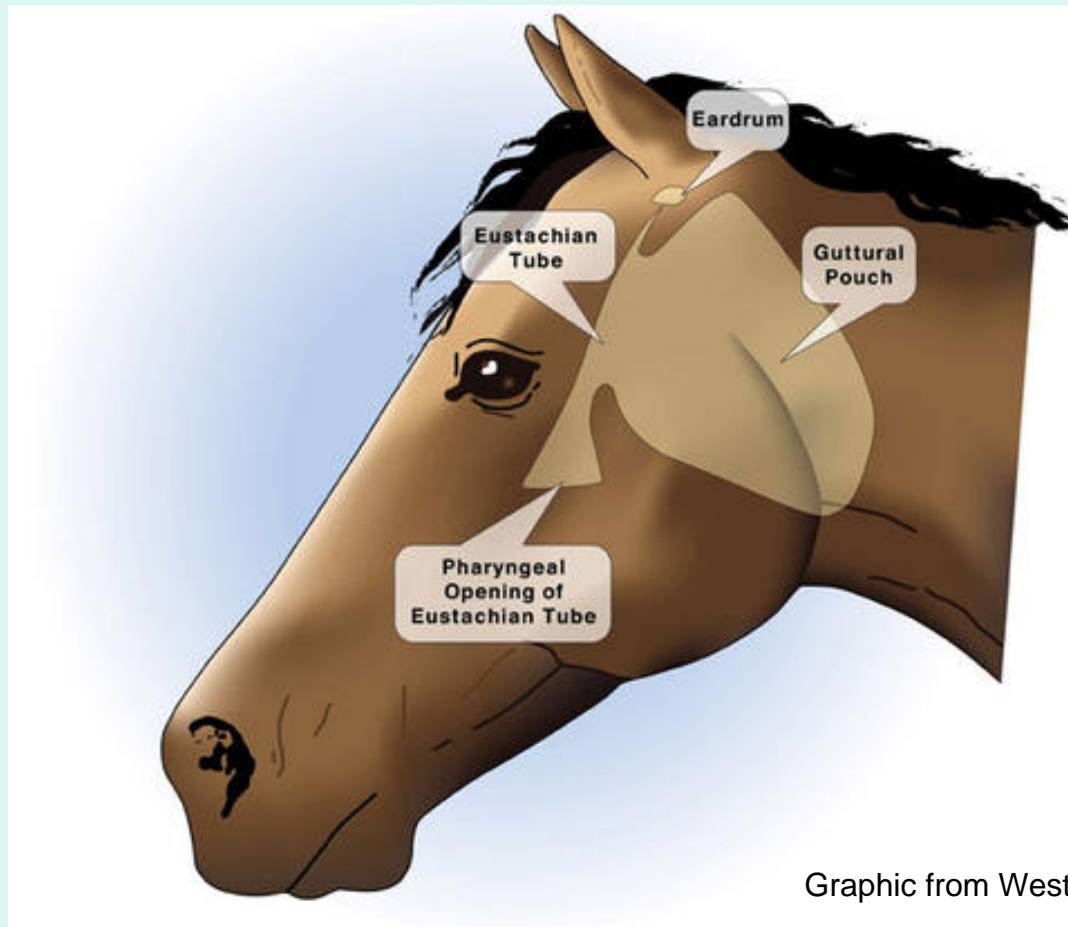
Davis, CA 95616-8744

Phone (530) 752-1170

Fax (530) 752-7267

Guttural Pouch Tympany (GPT)

- Malformation of the pharyngeal opening of the Eustachian tube; acts like a one way valve where air can get in, but it can't get out.



Graphic from Western Horseman Magazine

Guttural Pouch Tympany (GPT)

- The guttural pouch gets distended with air and forms the characteristic non painful swelling; breathing can be noisy in severe cases.



Credit:
Knottenbelt DC, Pascoe RR
Diseases and Disorders of the Horse



photo: Clinic for Horses of University of Veterinary Medicine Hannover

Guttural Pouch Tympany (GPT)

- Occurs in horses ranging from birth to a year of age; more common in fillies than colts.
- Diagnosed with clinical signs and radiographs.
- NSAIDs and antimicrobial therapy can treat resulting upper respiratory tract problems.
- Surgery is required to correct the malformation; foals who undergo successful treatment can have fully useful lives.

GPT Research

- Recent study indicates some sex linkage – females 4x more likely to be affected than males.
- Research indicates a polygenic trait (multiple genes involved).

Contact info:

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Alexandra.zeitz@tiho-hannover.de

AHA Task Force on Genetic Diseases

Take Force on Genetic Diseases

- Why?
 - With the equine genome now mapped, research related to genetic disorders has been tremendously boosted and horse owners are becoming more interested and more educated about equine genetic disorders.
 - With the Arabian Horse Foundation active in funding research projects directed at developing tests for some of these genetic disorders, we will be getting new tools that we, as the Arabian horse community, need to figure out how to best use.

Task Force Members

- Beth Minnich, Chair
- Dr. Ray Cerniga (EPRB)
- Lori Conway (Equine Stress, Research and Education)
- Debbie Fuentes (AHA staff liaison)
- Frank Galovic (AHA)
- Dale Harvill (Legal)
- Larry Kinneer (Arabian Horse Foundation)
- Denni Mack (Registration Commission)
- Fred Metcalf (FOAL)
- Glenn Petty (AHA EVP)
- Brenda Wahler (Affected horse owners)

Acknowledgements

- Dr. Monica Aleman, UC Davis
- Dr. Ernie Bailey, UKY
- Michael Bowling
- Dr. Samantha Brooks, Cornell University
- Lisa Goodwin-Campiglio
- Dr. Molly McCue, UMN
- Dr. Cecilia Penedo and Leah Brault, UC Davis, VGL
- Dr. Sharon Spier, UC Davis
- Dr. Stephanie Valberg, UMN
- Ladonna Wilkinson and Tammy Canida, AQHA
- VetGen
- The thousands of people who have responded with their input and experiences

AHA Task Force on Genetic Diseases

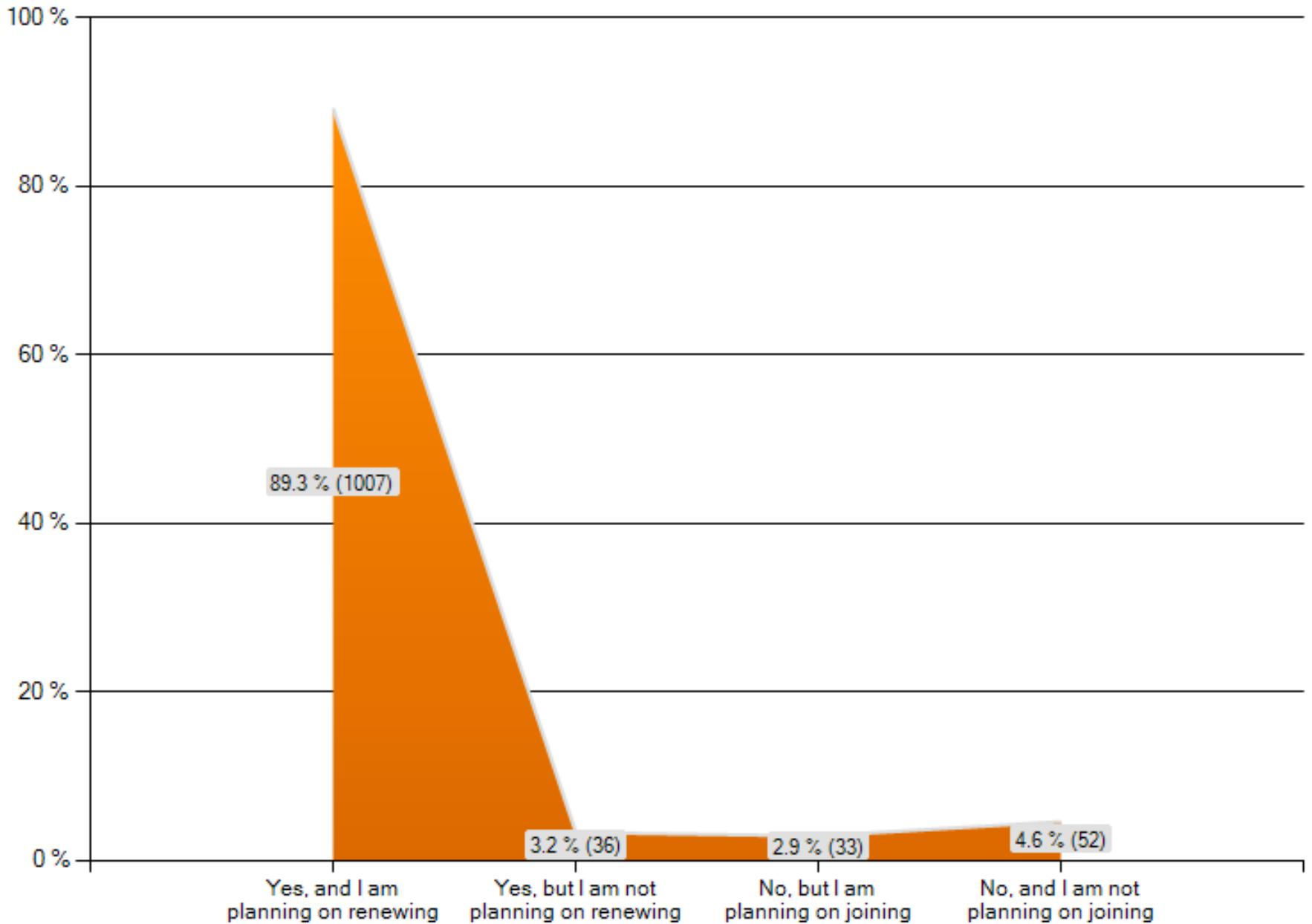
Major areas of focus:

- 1) Testing for genetic disorders
- 2) Reporting and disclosure of test results
- 3) Education

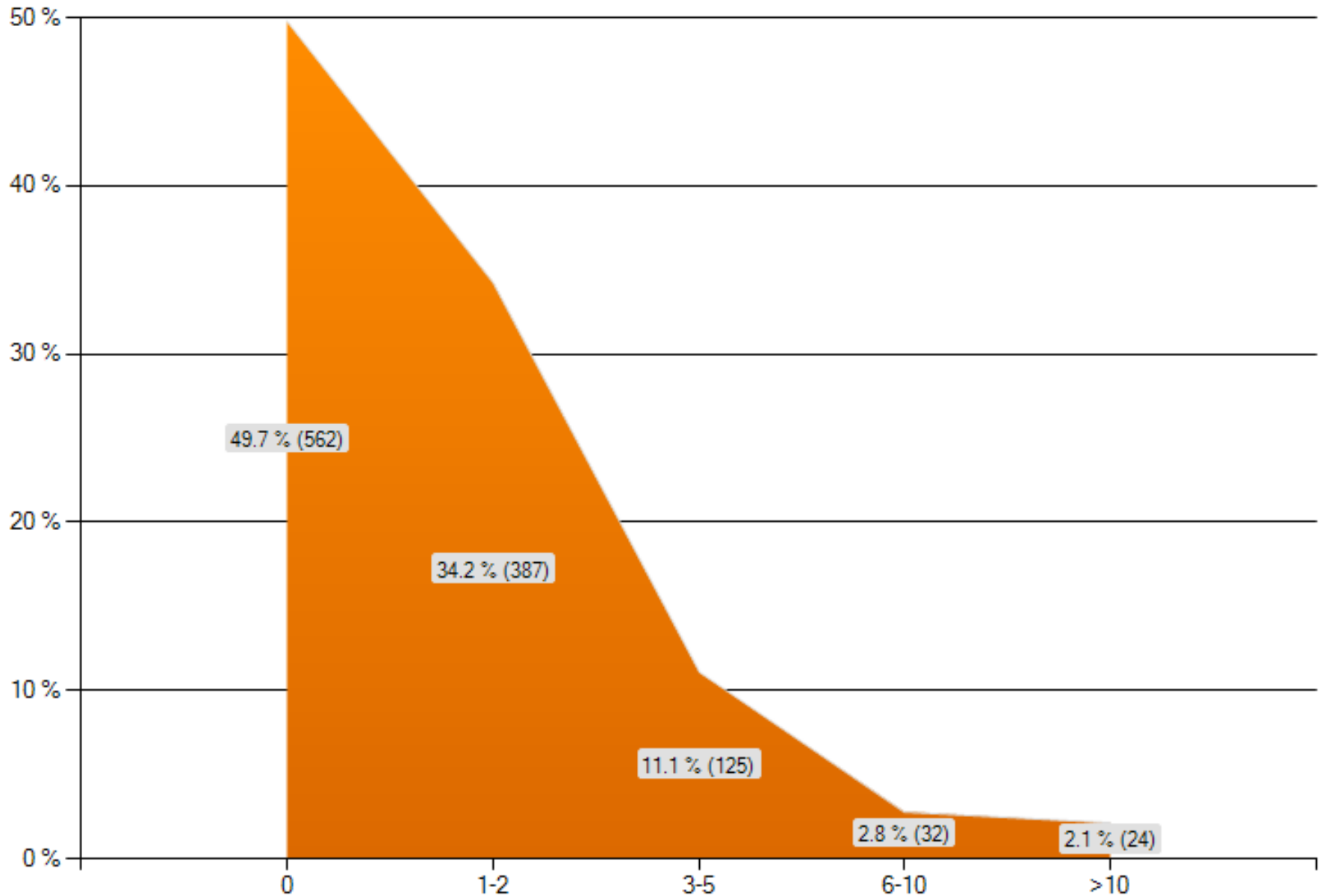
Task Force Survey Results

- Over 1,100 responses.
- LOTS of comments – ranging from the very cryptic to the very insightful; and from extreme (AHA should do nothing) to the other extreme (AHA should cull all carriers and ban all members who breed carriers).
- Some differences between breeders and non-breeders about voluntary vs. mandatory testing.
- A lot of feedback to consider in how to approach education of owners/breeders.

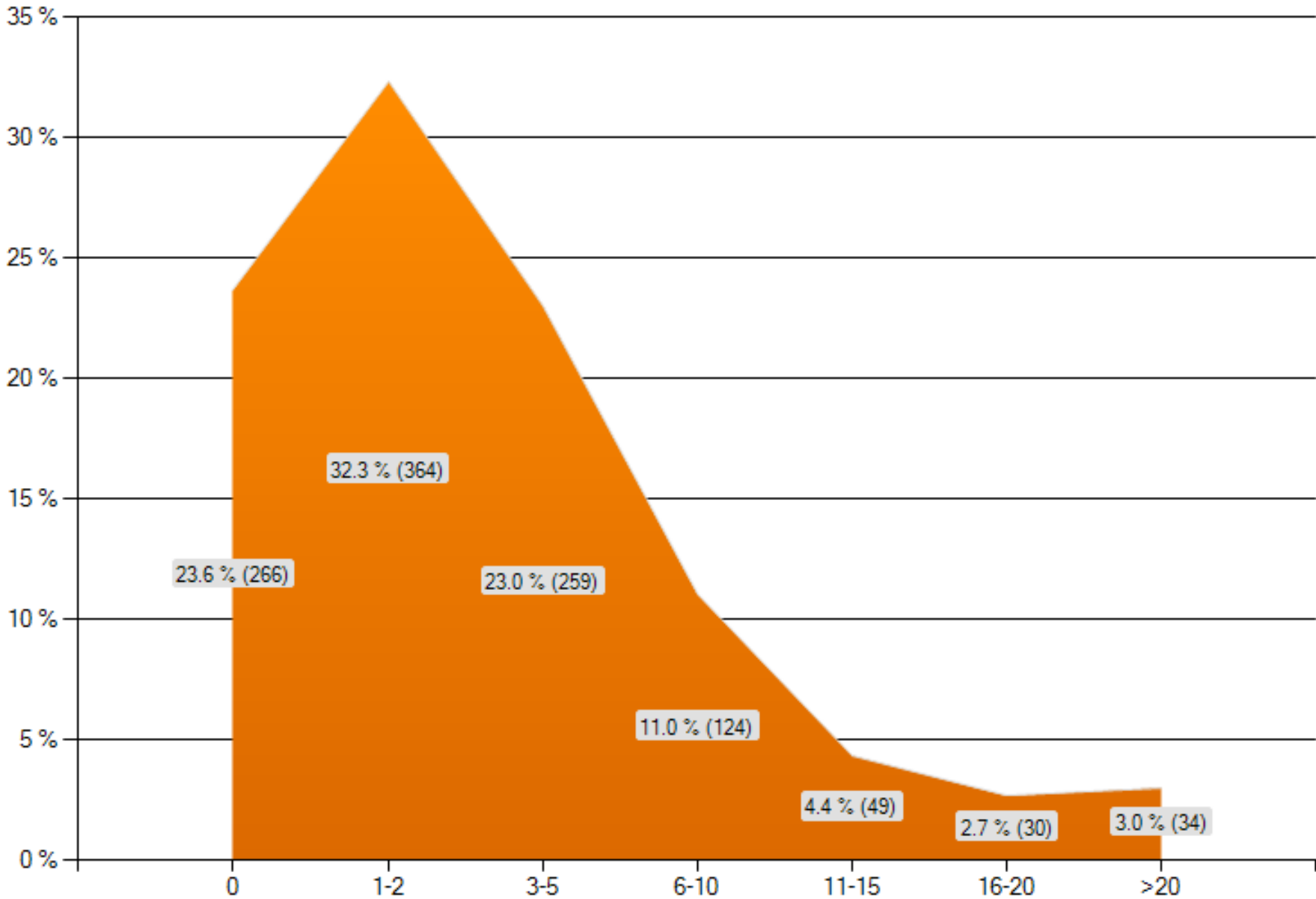
Are you currently an AHA member?



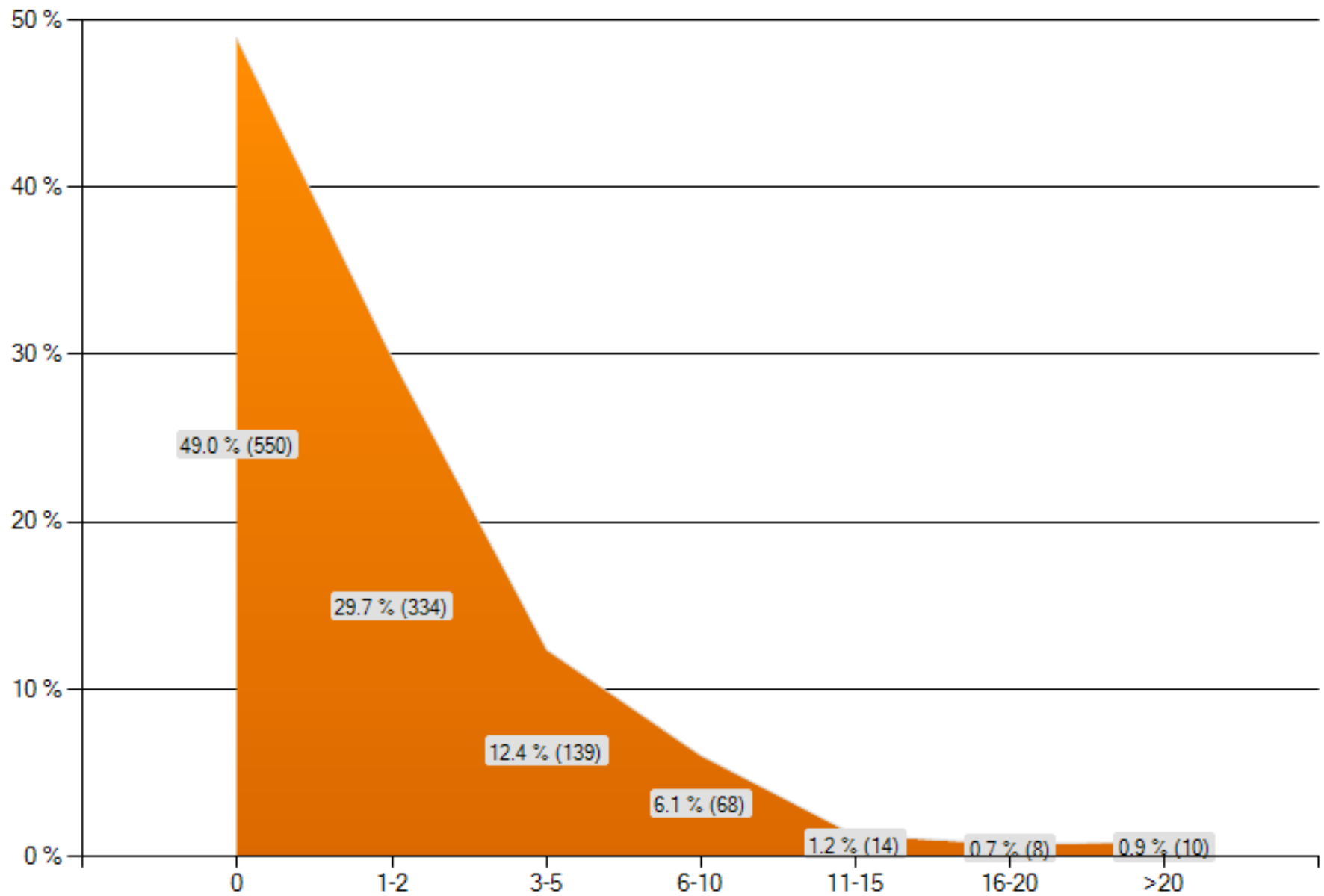
How many purebred Arabian colts/stallions being used for breeding (or are intended to be used for breeding in the future) do you own and/or manage?



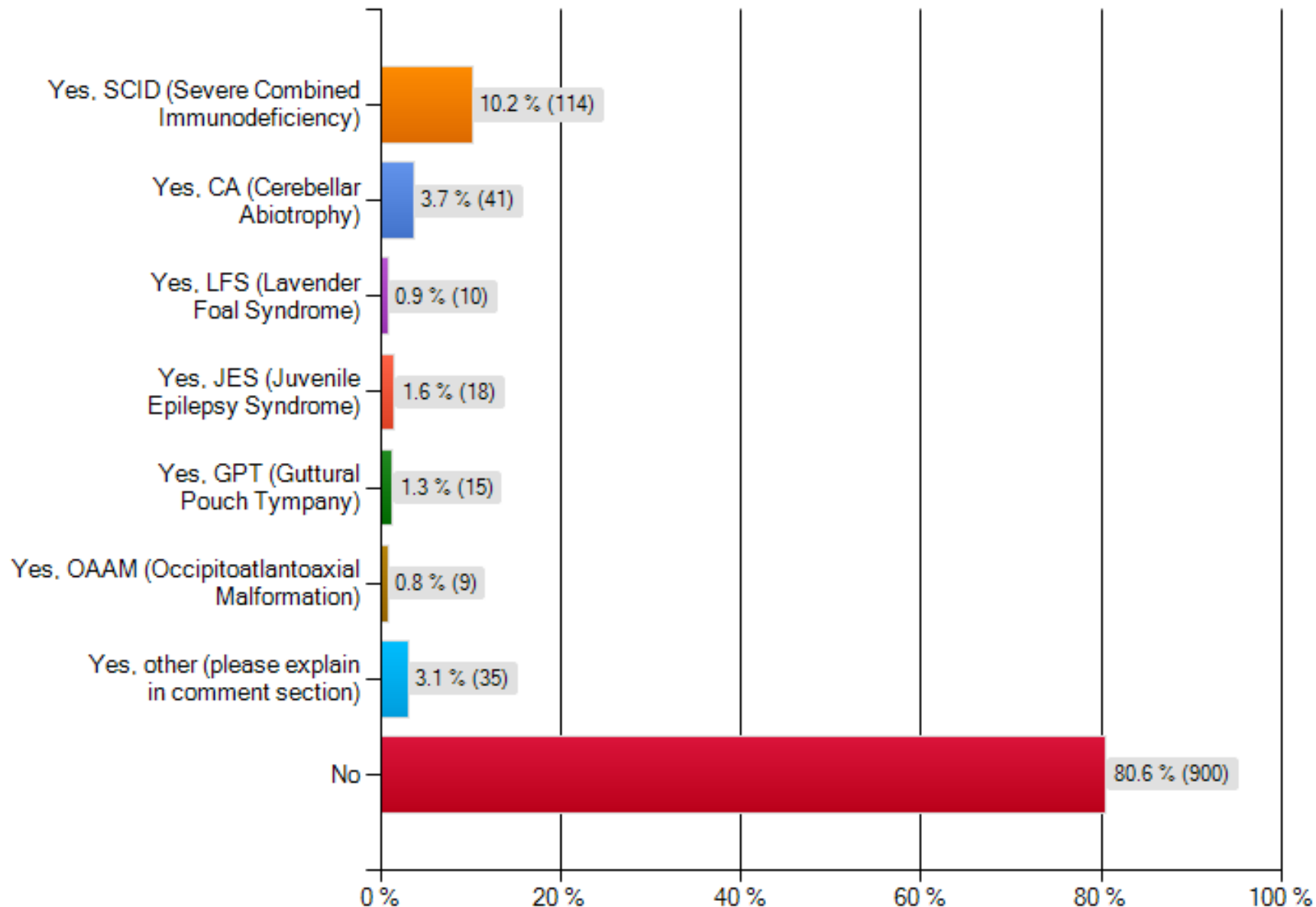
How many purebred Arabian fillies/mares being used for breeding (or are intended to be used for breeding in the future) do you own and/or manage?



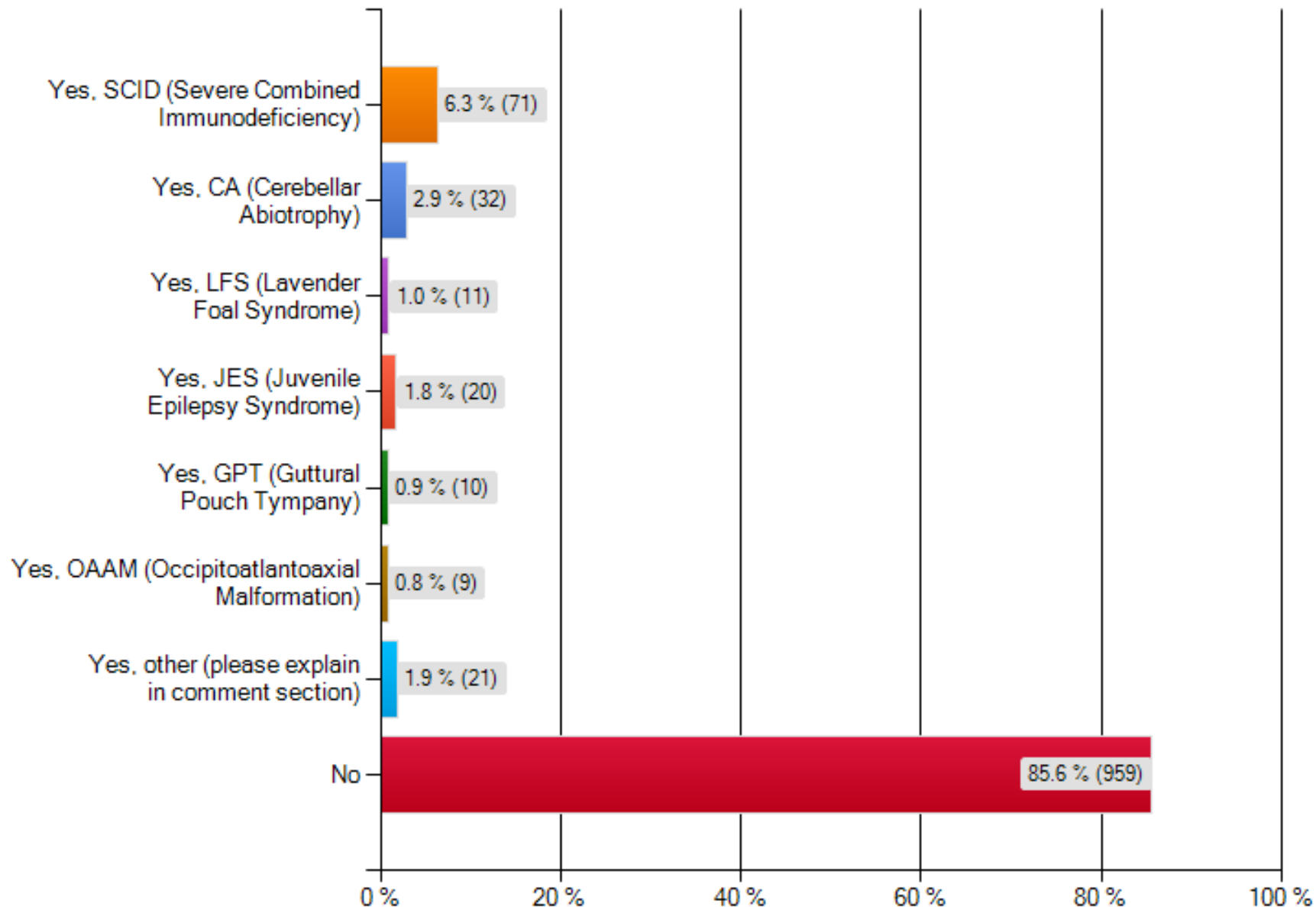
How many total purebred Arabian foals will you have/are planning to have in 2009 and 2010 combined?



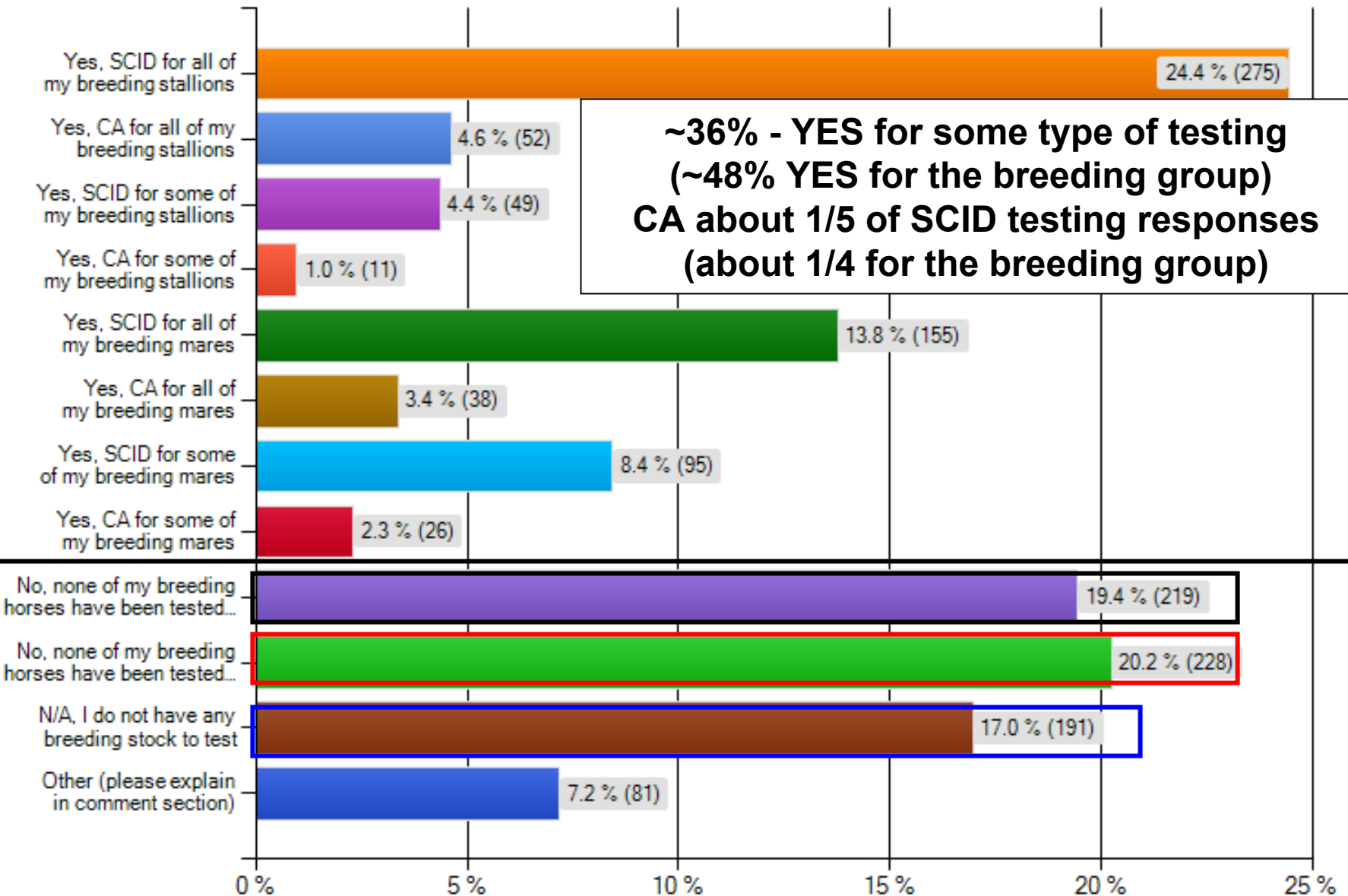
Have you ever bred or owned a horse who was diagnosed as having or was strongly suspected of having a genetic disorder? Choose all that apply.



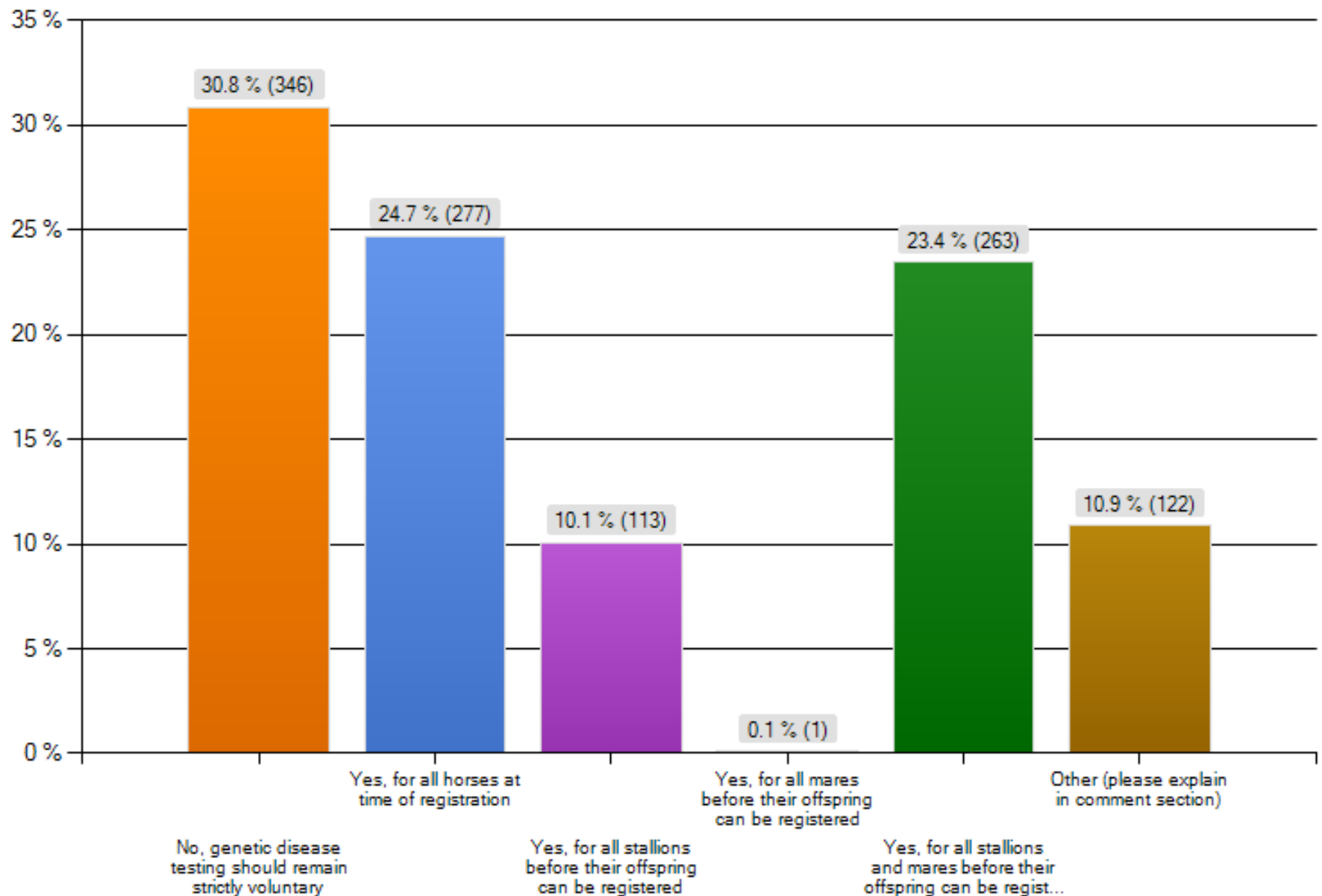
Have you ever bred or owned a horse who has sired/produced a foal diagnosed as having or was strongly suspected of having a genetic disorder? Choose all that apply.



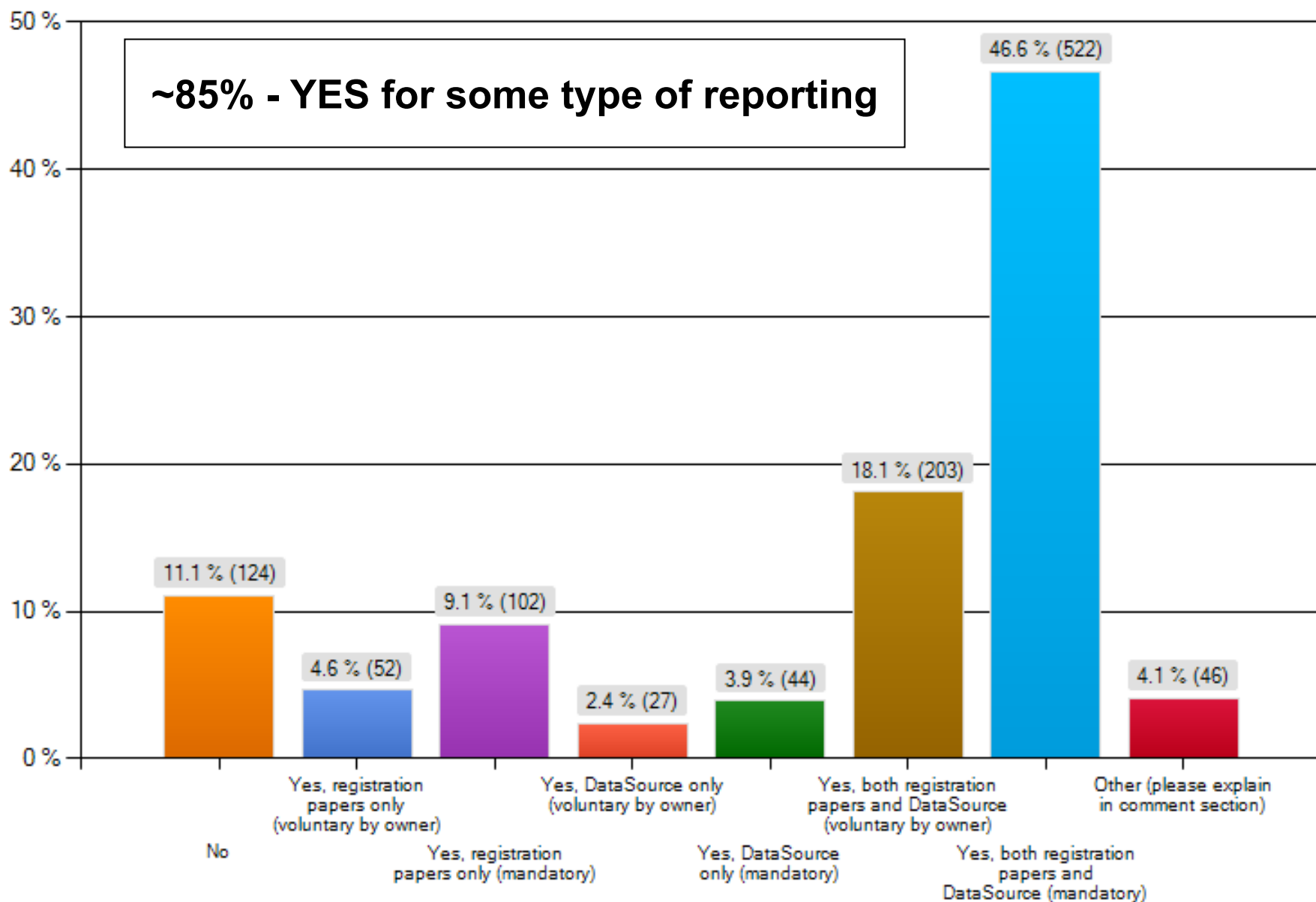
**Have you had any of your purebred Arabian breeding stock tested for SCID or CA?
Choose all that apply.**



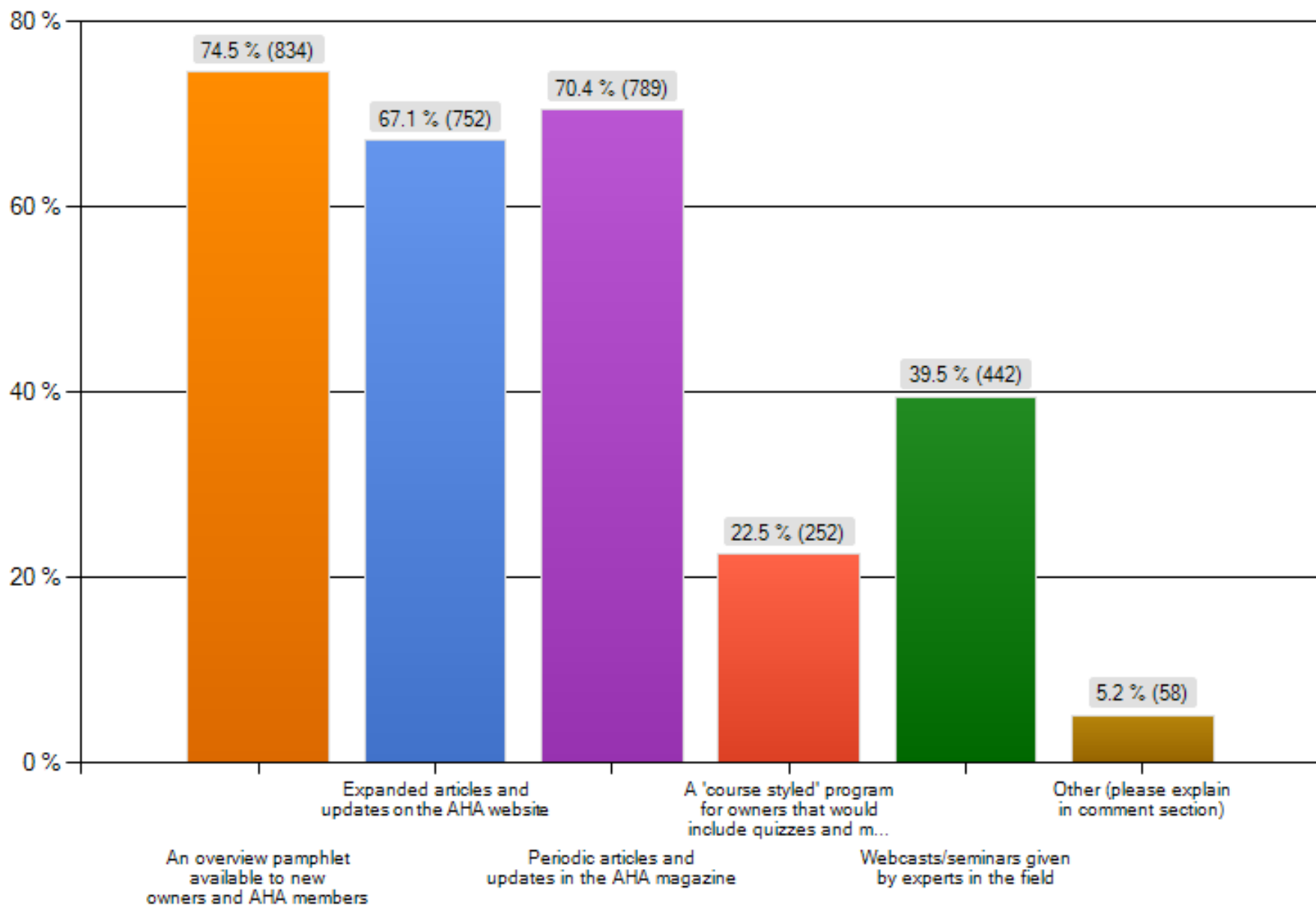
Do you think that genetic disease testing should become part of the registration process?



Do you think genetic disease testing results should be added to registration papers and/or the DataSource?



What type of genetic disease related educational materials would you like to see made available by AHA? Choose all that apply.



Noteworthy Comments from Survey

- “If you are a GOOD breeder – you CONTROL THE HEALTH & QUALITY in your animals!”
- “Full disclosure has NOT hurt the Quarter Horse industry. Why don’t we demand it? Then let the owners make informed decisions!”
- “The history of the stigma still is more powerful than the current science.”

AHA Task Force on Genetic Diseases

Major areas of focus:

- 1) Testing for genetic disorders
- 2) Reporting and disclosure of test results
- 3) Education

Genetic Disorder Testing

Voluntary vs. Mandatory Testing:

- The strong majority opinion of the Task Force is that genetic testing should remain voluntary.
 - Cost is a major concern:
 - SCID \$99
 - CA \$50
 - LFS ?? (\$50-\$100)
 - Plus regular registration costs
 - More tests to come
- However, the Task Force strongly supports having breeding stock tested for genetic disorders and asks AHA to take a much more active and visible role in promoting the availability of genetic disorder testing and encouraging owners to use these technologies.

AQHA and HYPP

- HYPP is the only disorder that AQHA has mandated testing and reporting for – they have several other disorders that affect the breed.
- HYPP is dominant trait.
- Have been able to trace the mutation to a specific founder and only horses with Impressive in their pedigree fall under the testing requirement.
- Some breeders are selecting “for” HYPP, so even with mandated testing, the affected rate has not decreased since testing has been initiated; AQHA is going to begin refusing registration of N/H horses beginning in 2020(?).

Reducing Cost and Increasing Efficiency of Testing

- In addition to working with VetGen to make another pricing special available, discussions are currently ongoing to see if it would be possible to include additional labs (such as UC Davis and/or VetGen) in the DNA typing process required for AHA registration.
- This combination of services would have the potential to reduce total testing costs for owners and also increase efficiency by having 2 tests run from the same sample; for example, owners could opt to have SCID or CA testing done at the same time as DNA typing for registration.
- These discussions are in the early stages and more information will be forthcoming as to whether or not this will be feasible given contract considerations and licensing issues.

Disclosure and Reporting of Genetic Disorder Test Results

Disclosure to Interested Parties:

- Resolution 3-09 – Disclosure of Cerebellar Abiotrophy
- Resolution 4-09 (revised) – Disclosure of Lavender Foal Syndrome
- Since 1984, Code of Ethics has addressed SCID disclosure and the Code should now be expanded to include additional disorders – CA and LFS (both are now testable).
- The resolutions are NOT seeking mandatory testing or mandatory recording of results on registration papers or the DataSource
- If you are standing a stallion at stud or offering a horse capable of breeding for transfer or lease and you are aware the horse has:
 - sired/produced an affected foal or
 - been tested as a carrier (in the case of CA, or if they are tested as affected)

You need to inform all parties to the transaction before the transaction is completed – public announcement NOT required.

Reporting Test Results through AHA

- The consensus of the Task Force is that a system should be developed for reporting genetic disorder testing results through AHA, particularly using the DataSource.
- The Task Force has drafted a proposal outline for review by the Registration Commission and continued discussions are taking place regarding this proposal.

Key points of this proposal include:

- At a minimum the DataSource would be used; ideally both the DataSource and registration papers would be incorporated into this system.
- Reporting of genetic disorder test results would be strictly voluntary.
- Only test results from an approved lab would be accepted, along with a required authorization/waiver form signed by the current recorded owner.
- Similar to the AQHA system, progeny of 2 reported clear parents would automatically be flagged and listed by the DataSource system as being “*clear by parentage*”. This indicates the results are not from testing, but from reported test results of parents. In addition, progeny of 2 parents listed as “*clear by parentage*” would also be automatically flagged as “*clear by parentage*”.

Benefits of implementing this system include:

- Use of the DataSource and/or registration papers will provide greater accessibility to test results.
- Owners and breeders can look at test results to help determine whether the lines they are interested in have been reported as clear or perhaps are at higher risk for problems. This is especially valuable for horses that are clear by parentage and as a result, have no need to be tested.
 - Knowing which horses are clear is just as important as knowing which ones are carriers or affected.
- This information will assist breeders and potential buyers in making appropriate decisions about testing, and encourage them to ask questions about non-reported horses they are interested in breeding to or purchasing for breeding stock.
- Having test results reported through AHA allows for portability of test results when a horse changes owners; a new owner doesn't have to rely on having a hard copy of the test results included in the horse's information from the seller in order to obtain the necessary information. This can save future owners the expense of retesting a horse for the same condition.

Benefits Continued

- Last, but certainly NOT LEAST, as the parent breed organization for the Arabian horse, it is simply the right thing to do. AQHA has already set a precedent with their HYPP reporting system. To date, they have received no legal challenges and they have minimal liability issues regarding the reporting of this information.

Education

- Education is a vital component of an effective program to address issues associated with the equine genetic disorders of concern for Arabian horse owners and breeders.
- A new Genetic Disorders Subcommittee of the Equine Stress, Research and Education Committee has been created.
 - Will be tasked with the creation of educational materials and, in collaboration with the Arabian Horse Foundation and FOAL, also act as a Think Tank for the development of additional projects associated with equine genetic disorders and the Arabian horse.
- Looking for members interested in serving:
 - Strong background in equine genetic disorders
 - Vets and owners with direct experience with these disorders encouraged to participate
 - Also anyone with a background in technical writing, editing, proofing, layout, etc.
 - Will be a very active working group – so need people with time to dedicate to this project

To Breed or Not To Breed?

Recessive Disorders

Options - there is no single right or wrong choice:

- Do not use carriers for breeding.
- Selectively use carriers for breeding.
 - Avoid breeding 2 known carriers together.
 - Limit use of carriers to truly exceptional/valuable/rare individuals.
 - When possible, use suitable clear offspring of carrier horses for breeding to maintain genetic diversity while reducing the use of carriers in the breeding population.
- Primary goal – to not produce affected foals.
- Secondary goal – reduce the frequency of the mutation in the gene pool, without blowing up the gene pool in the process.

Genetic Testing as a Tool

- Genetic disorders are not unique to Arabians or even horses in general; they are a part of the natural order.
- Tests for genetic disorders provide information to make informed decisions; these tests are a tool for breeders to use, not to hide from nor should these tests be used against breeders.
- Other than a lot of rumor mongering, there is nothing to be gained from pedigree witch hunts or pointing fingers at horses from the past who may or may not have been carriers.
- Testing allows us to know the status of the horses of today, who are alive and breeding.
- We need to be looking toward the future, not trying to pass judgment on the past.

Supporting Research

- Research leads to advancements in how we care for our horses:
 - Genetic testing options
 - Improved therapies
 - More information we can use to improve the lives of our horses
- Research requires funding and support with sample submission.
- PLEASE support researchers and organizations such as the Arabian Horse Foundation....become active in these research efforts and help make these advancements happen.