POSTMORTEM EXAMINATION PROGRAM

Conducted for the California Horse Racing Board
July 1, 2015–June 30, 2016

California Animal Health and Food Safety Laboratory System

J.D. Wheat Veterinary Orthopedic Research Laboratory

School of Veterinary Medicine
University of California, Davis

July 2017

Postmortem Examination Program

California Animal Health and Food Safety Laboratory System

J.D. Wheat Veterinary Orthopedic Research Laboratory

School of Veterinary Medicine
University of California, Davis
Davis, CA 95616
(916) 752-8700

July 2017

Cover photo: Benoit Photos
www.benoitphoto.com

TABLE OF CONTENTS

POSTMORTEM EXAMINATION PROGRAM

Introduction

The Postmortem Examination Program has been in operation since February 1990, and has performed examinations on 6,717 horses, as of June 30, 2016. Initiated by the California Horse Racing Board (CHRB), the program is a partnership with the California Animal Health and Food Safety Laboratory System (CAHFS) to meet three primary objectives: 1) to determine the nature of injuries occurring in racehorses, 2) to determine the reasons for these injuries, and 3) to develop injury prevention strategies. To accomplish this, a broad, cooperative approach was organized involving the development of a contract with the CAHFS to perform a necropsy on every horse that died spontaneously or was euthanized on racetracks or training facilities under the jurisdiction of the CHRB. This visionary partnership has become a national and international model for the racing industry in an effort to improve the safety and welfare of racehorses.

Pathologists at the CAHFS' Davis, Tulare and San Bernardino laboratories conduct postmortem examinations and compile detailed information on each horse, which is then reported to the CHRB. A broad range of specimens are collected and shared with veterinary scientists in other departments of the School of Veterinary Medicine at the University of California, Davis (UC Davis). Specimens from selected cases from CHRB horses necropsied at CAHFS laboratories are frequently shipped to the Veterinary Orthopedic Laboratory at UC Davis for in-depth analyses. This helps to more precisely determine the causes and risk factors that led up to catastrophic injuries in racehorses, resulting in their death or euthanasia. Funding for postmortem examinations and ancillary testing was provided by the CHRB. Racing associations provide transportation of the horses to the nearest laboratory facility, and additional studies are funded by the Center for Equine Health at UC Davis and private sources.

Information from the tests and data gathered from the postmortem examinations are analyzed in efforts to elucidate the specific cause of catastrophic injuries.

UC DAVIS VETERINARY MEDICINE
California Animal Health and Food Safety Laboratory System

SUBMISSIONS

General Submission Information

During the 2015-16 fiscal year, 205 horses were submitted to CAHFS as part of the CHRB Postmortem Program. This number is an increase of 9.6 percent (18 horses) over the fiscal year 2014-15 count of 187, and ends the downward trend initiated several years ago (Figure 1). The 2014-15 total number of fatalities (187) represented the lowest number of fatalities of the past 20 years.

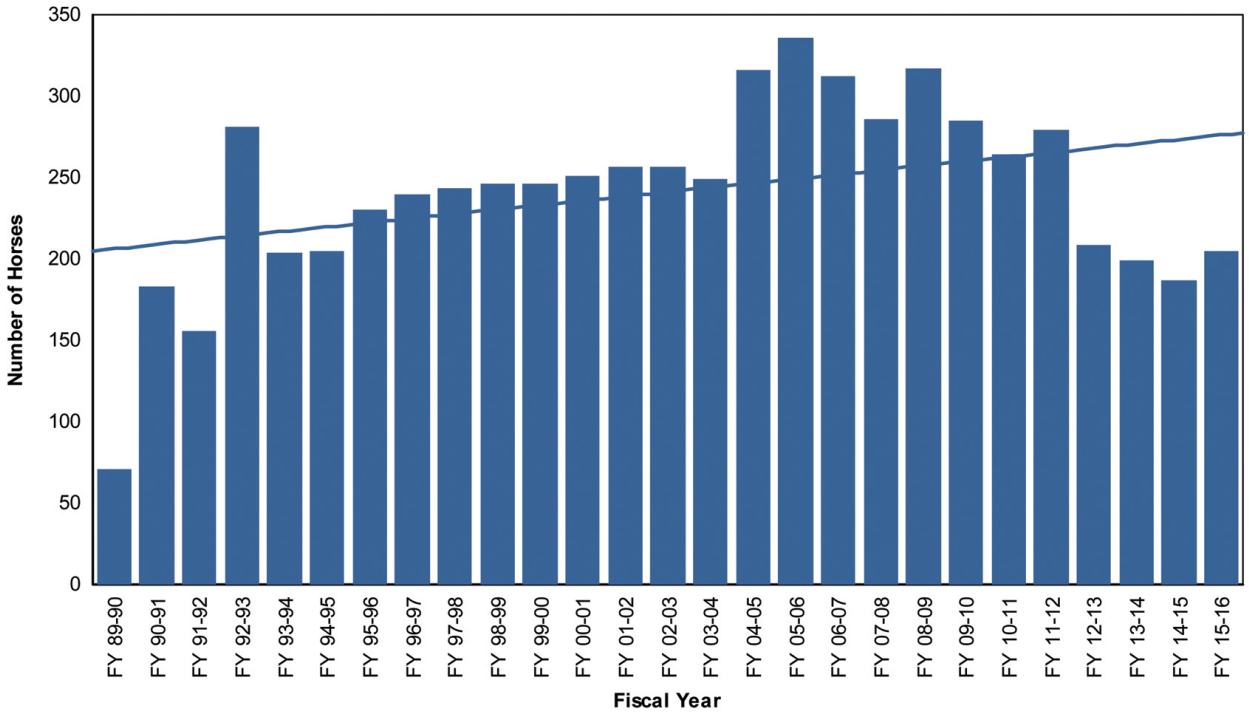
The graph below (Figure 1) shows the number of horses that have been submitted to the program since 1990 by fiscal year. The first year of the program began in February 1990 and does not represent a full fiscal year. The trend line shows that the number of horses submitted for the CHRB program have been increasing slightly almost every year until 2005-06, after which a decline, interrupted temporarily in 2008-09 and 2011-12, started until 2015-2016. This is in agreement with previous years, in which most fatalities were exercise-related. The third category of fatalities, accounting for ~26 percent of submissions, included horses in the non-exercise group. These were horses suffering primarily from medical conditions such as colic, infectious diseases or other conditions.

Continued

Table 1. Activity at Time of Injury/Fatality

Non-Exercise	41 (20%)
Racing	90 (44%)
Training	74 (36%)
Total	**205 (100%)**

Figure 1. Number of Horses Submitted to the CHRB Postmortem Program by Fiscal Year



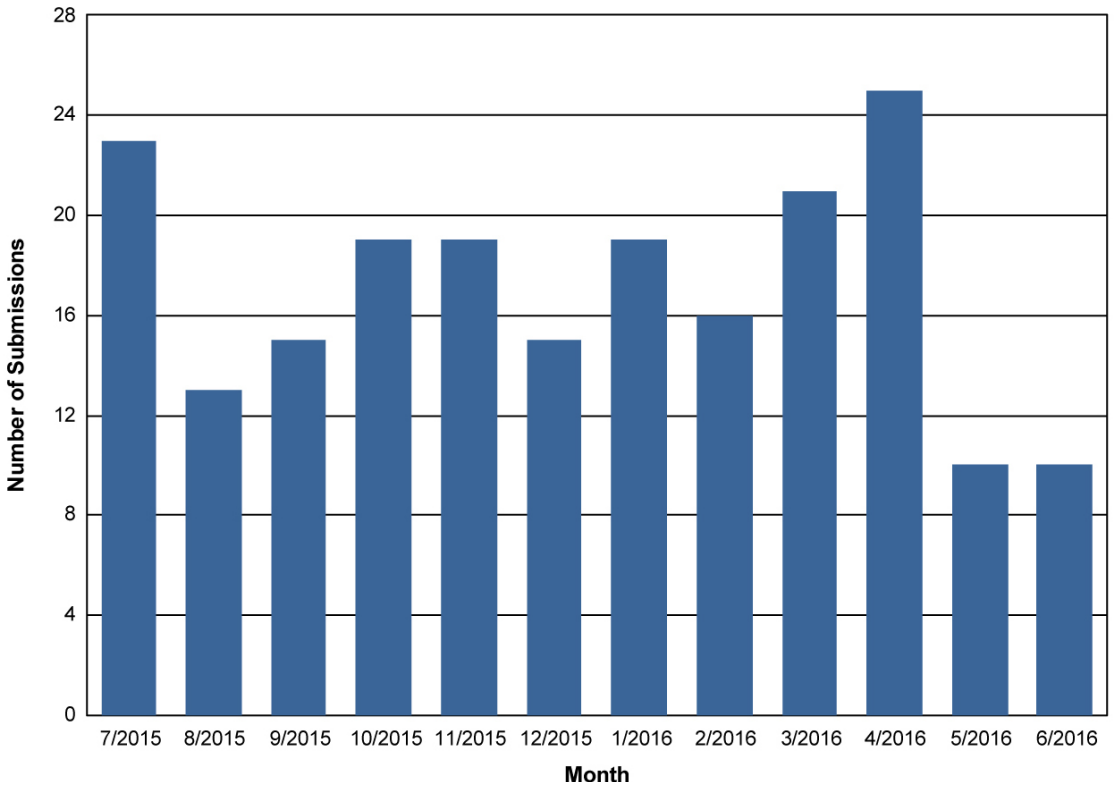
As in the past, the vast majority of submissions, 176 (~86 percent) during FY 2015-16 were Thoroughbreds (Table 2). Twenty seven of the horses submitted in 2015-16 (~13 percent) were Quarter Horses. This is a slight decrease over the prior fiscal year (15 percent), which constituted the first increase after three years in which a reduction in the number of Quarter Horse submissions was observed. With very small numbers of other breeds racing, not enough data exists to allow comparison of injury rates among breeds for any predisposition to any particular type of injury. The number of horses submitted per month was variable, although there were not obvious clusters of submissions at any given month of the year (Table 2 and Figure 2). This is very similar to submission patterns over the last few years.

Continued

Table 2. Submissions by Breed and Month

Breed	Jul 15	Aug 15	Sep 15	Oct 15	Nov 15	Dec 15	Jan 16	Feb 16	Mar 16	Apr 16	May 16	Jun 16	Total
Paint Horse	0	1	0	0	0	0	0	0	0	0	0	0	**1**
Quarter Horse	2	1	4	2	1	3	2	1	3	6	1	1	**27**
Standardbred	0	0	0	0	0	0	0	0	0	1	0	0	**1**
Thoroughbred	21	12	10	17	18	12	17	15	18	18	9	9	**176**
Grand Total	**23**	**14**	**14**	**19**	**19**	**15**	**19**	**16**	**21**	**25**	**10**	**10**	**205**

Figure 2. Number of Horses Examined by Month



The largest proportion of submissions (~69 percent) were horses between 2 and 4 years of age (Table 3). Approximately 20 percent of all racehorses submitted were 2 years old or less. The number of horses submitted with catastrophic injuries or death dropped dramatically after the fifth year of age (Table 3 and Figure 3). This is consistent with the age distribution that has been seen in prior years of the program.

We cannot conclude if horses 5 years of age and greater are much less susceptible to the injuries of racing, because the total number of horses in each age group that are racing and training on facilities controlled by CHRB are not known to us.

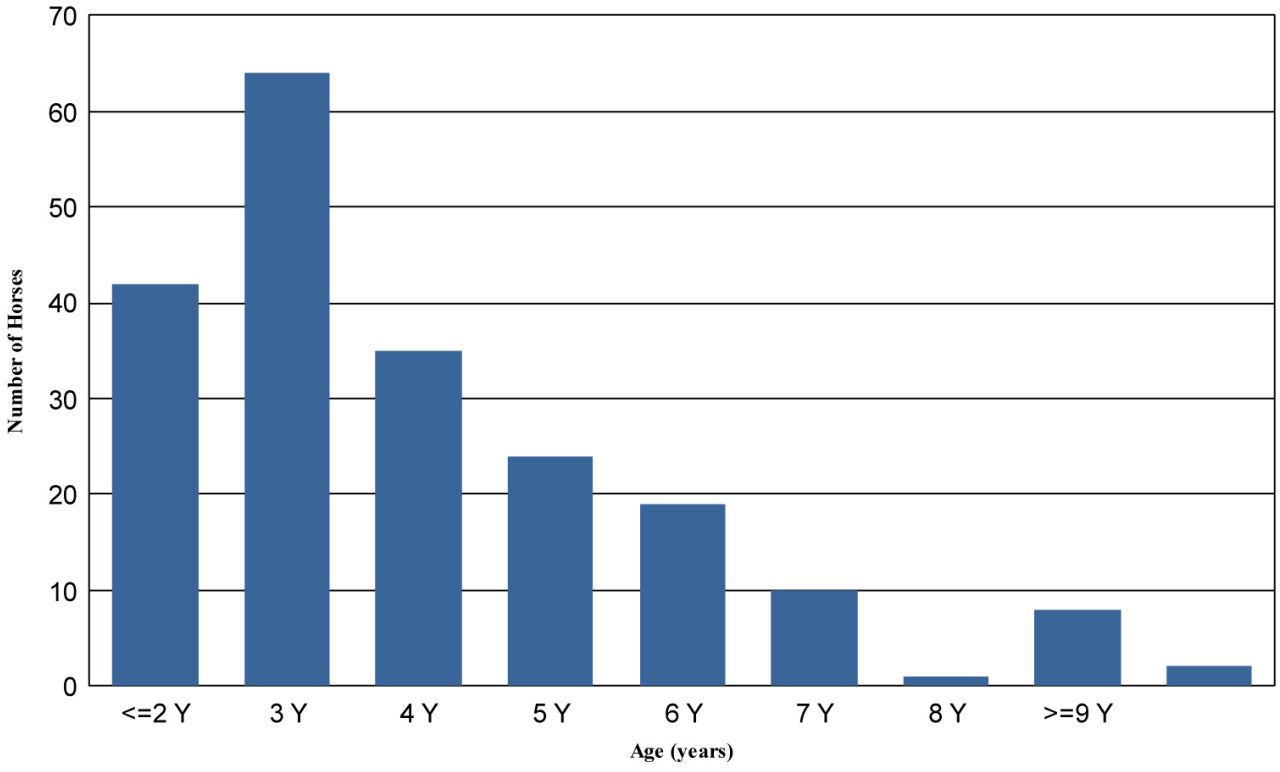
Submissions By Breed and Age

Table 3. Submissions by Breed and Age

Breed/Age	<=2	3	4	5	6	7	8	>=9	NR*	Total
Paint Horse	0	0	0	0	0	0	0	1	0	1
Quarter Horse	10	9	2	2	2	0	0	2	0	27
Standardbred	0	0	0	0	1	0	0	0	0	1
Thoroughbred	32	52	33	24	16	10	1	5	2	176
Total	**42**	**64**	**35**	**24**	**19**	**10**	**1**	**8**	**2**	**205**

*NR: Age not reported (pony horses)

Figure 3. Number of Horses Examined by Age



Submissions By Gender

The gender distribution of the horses submitted during 2015-16 is shown in Table 4 below. Males represented ~58 percent of the total group, with 29 percent of males being intact (stallions) and 71 percent geldings. Females comprised ~42 percent of the group.

Table 4. Distribution of Horses by Gender and Category

Gender	Non-Exercise	Racing	Training	Total
Female	19	38	30	**87 (42%)**
Male	8	10	16	**34 (17%)**
Neutered Males	14	42	28	**84 (41%)**
Total	**41**	**90**	**74**	**205 (100%)**

Injuries

As previously mentioned, the categories of injury represent the activity of the horse or circumstances at the time of the fatal or catastrophic injury. The largest cluster of fatal injuries, ~80 percent, occurred in 2-, 3-, 4- and 5-year-old racehorses (Table 5). The age of the horses submitted for non-exercise related fatalities was also concentrated between 2 and 5 years of age.

Table 5. Category of Injury/Fatality by Age

Category/Age	<=2	3	4	5	6	7	8	>=9	NR*	Total
Non-Exercise	14	9	5	2	3	1	0	6	1	**41**
Racing	9	28	18	17	12	5	1	0	0	**90**
Training	19	27	12	5	4	4	0	2	1	**74**
Total	**42**	**64**	**35**	**24**	**19**	**10**	**1**	**8**	**2**	**205**

*NR: Age not reported (pony horses)

During this fiscal year, Thoroughbred horses suffered a higher number of racing (~44 percent) than training (~36 percent) catastrophic injuries (Table 6). This is different from the previous year when the percentage of racing fatalities was very similar to that of training catastrophic injuries.

Quarter Horses suffered only five (18 percent) catastrophic injuries during training in this period. This is identical to the previous year, but higher than the years before when Quarter Horses catastrophic injuries during a training session were infrequent. Quarter Horse submissions during 2015-16 were only slightly lower than the previous year (27 in 2015-16 versus 28 in 2014-15), returning to the decline which had started seven years ago. Figure 4 shows the historical number of Quarter Horses submitted to the program since its inception.

Continued

In 2015-16, ~81 percent of the total primary injuries or conditions in all breeds were due to musculoskeletal problems (Table 7), which is consistent with what has been observed in previous years. Of this group, ~71 percent of injuries affected the front or rear legs (Table 8). The injuries listed in these tables represent the primary injury to the horse.

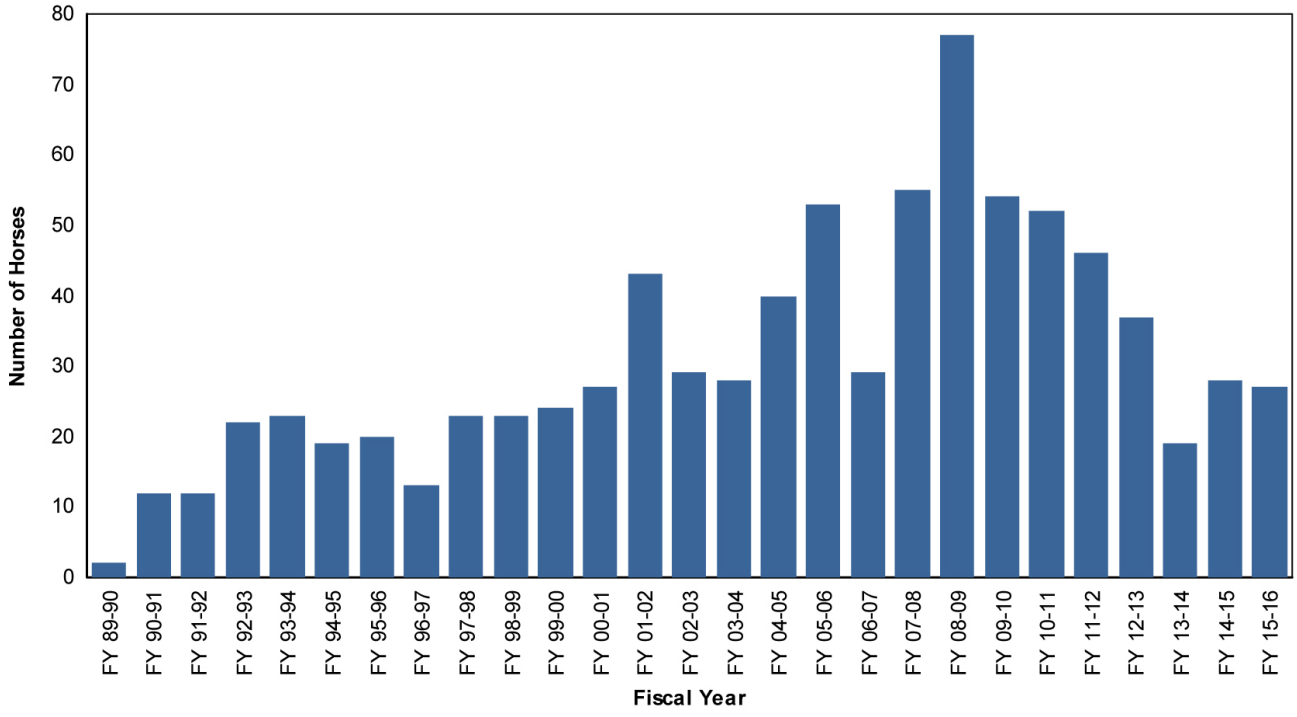
In many cases, several primary findings for each horse submitted were recorded. Thus, the total number of reported injury types exceeds the total number of horses submitted. This is especially true in severe injuries

Continued

Table 6. Category of Injury/Fatality by Breed

Injury Class by Breed	Non-Exercise	Racing	Training	Total
Paint Horse	1	0	0	1
Quarter Horse	7	15	5	27
Standardbred	0	1	0	1
Thoroughbred	33	74	69	176
Total	**41**	**90**	**74**	**205**

Figure 4. Number of Quarter Horses Submitted to the CHRB Postmortem Program by Fiscal Year



involving multiple bones in the limbs. In these cases, multiple related injuries, such as tendon and ligament ruptures are identified concomitantly.

Musculoskeletal injuries are most likely to occur during racing or training. Because these injuries are by far the most common, most of the investigative efforts at the University of California, Davis, have focused on causes and prevention of limb injuries.

Table 7. Organ Systems Affected

Breed	GI	HL	MS	Nerv	Resp	WB	Total
Paint Horse	1	0	0	0	0	0	**1**
Quarter Horse	3	1	19	1	1	2	**27**
Standardbred	0	0	1	0	0	0	**1**
Thoroughbred	7	1	146	2	4	16	**176**
Total	**11**	**2**	**166**	**3**	**5**	**18**	**205**

(GI=Gastrointestinal system; HL=Hemolymphatic; MS=Musculoskeletal; Nerv=Nervous system; Resp=Respiratory system; WB=Whole body).

Table 8 lists catastrophic injuries by limb and other axial locations. The number of front limb injuries sustained during racing (70) was higher than those injuries sustained during training (51). There were variable numbers of right and left front limb injuries, but similar numbers of right and left rear limb injuries.

Table 8. Musculoskeletal Structures Affected

Structure Affected	Non-Exercise	Racing	Training	Total
Left Front	0	42	24	**66**
Left Rear	2	4	4	**10**
Right Front	0	28	27	**55**
Right Rear	1	4	9	**14**
Pelvis	1	2	3	**6**
Skull	4	0	0	**4**
Vertebra	0	7	2	**9**
Various Structures*	10	2	2	**14**
Total	**18**	**89**	**71**	**178**

* Includes laminitis and/or tendinitis of one or more legs

Table 9. Musculoskeletal Injury Type by Breed

Finding	Quarter Horse	Standard bred	Thorough-bred	Total
Arthritis/Arthropathy	0	0	2	**2**
Carpal Fracture – Left	1	0	1	**2**
Carpal Fracture – Right	2	0	5	**7**
Fedlock Failure – Left Front	6	0	38	**44**
Fedlock Failure – Left Rear	0	0	4	**4**
Fedlock Failure – Right Front	1	0	28	**29**
Fetlock Failure – Right Rear	0	0	6	**6**
Humerus Fracture – Left	0	0	1	**1**
Humerus Fracture – Right	0	0	5	**5**
Laminitis	0	0	5	**5**
Ligament rupture	0	0	1	**1**
Metacarpus III Fracture – Left	1	0	7	**8**
Metacarpus III Fracture – Right	0	0	6	**6**
Metatarsus III Fracture – Left	0	0	1	**1**
Metatarsus III Fracture – Right	0	0	1	**1**
Myopathy	0	0	1	**1**
P1 Fracture – Left Front	0	1	3	**4**
P1 Fracture – Right Front	0	0	3	**3**
P1 Fracture – Right Rear	0	0	2	**2**
P2 Fracture – Left Front	0	0	1	**1**
P3 Fracture – Left Rear	0	0	1	**1**
Pasturn Joint Luxation – Right Front	1	0	0	**1**
Pelvis Fracture	0	0	6	**6**
Radius Fracture – Left	0	0	1	**1**
Radius Fracture – Right	0	0	1	**1**
Rib Fracture	0	0	2	**2**
Scapula Fracture – Left	1	0	2	**3**
Scapula Fracture – Right	1	0	2	**3**
Skull Fracture	0	0	4	**4**
Suspensory Apparatus Failure – Left Front	0	0	1	**1**
Suspensory Apparatus Failure – Right Front	0	0	1	**1**
Tendinopathy	1	0	1	**2**
Tibia Fracture – Left	0	0	5	**5**
Tibia Fracture – Right	0	0	4	**4**
Ulna Fracture – Left	0	0	1	**1**
Vertebra Fracture	7	0	2	**9**
Total	**22**	**1**	**155**	**178**

Track Surface and Musculoskeletal Injuries in Thoroughbreds

The distribution of musculoskeletal injuries in Thoroughbreds was evaluated when comparing the three types of track surfaces in which these horses performed. Table 10 shows the limb distribution of injuries. As before, this data shows that for the current fiscal year the absolute number of injuries on dirt surfaces was higher than on other surfaces. Because the total number of horses racing on each surface is not known to CAHFS, it cannot be determined from this data whether the injury rates differ by track surface.

Table 10. Musculoskeletal Injury: Affected Limb by Track Type

Structure Affected	Dirt	Synthetic	Turf	N/A*	Total
Left Front	51	11	4	0	**66**
Left Rear	5	0	3	2	**10**
Pelvis	3	1	1	1	**6**
Right Front	42	11	2	0	**55**
Right Rear	7	4	2	1	**14**
Skull	0	0	0	4	**4**
Vertebra	8	1	0	0	**9**
Various Structures**	2	2	0	10	**14**
Total	**118**	**30**	**12**	**18**	**178**

*Inuries that did not occur on a racing/training surface. **Includes laminitis and/or tendinitis of one or more legs.

Other Organ Systems Affected by Injuries

Hemolymphatic:

As usual, diseases of the hemolymphatic system were rare during this report period.

Diagnosis	Total
Equine Infectious Anemia	1
Neoplasia	1
Total	**2**

Gastrointestinal:

Of the gastrointestinal system diagnoses, enteritis, colitis and typhlitis or combinations of these syndromes, and gastro intestinal displacements and/or ruptures were the most frequently observed diagnoses. Causes of these syndromes during this period were due to infections with Clostridium difficile, NSAIDs or undetermined.

Diagnosis	Total
Enteritis/Colitis/Typhlitis	3
Gastrointestinal Displacement/Rupture	8
Total	**11**

Other Organ Systems Affected by Injuries continued

Respiratory:

As in the previous fiscal year, there were less cases of respiratory diseases identified in 2015-2016 (5) than had been seen the three previous years (22, 9 and 6, respectively). The main cause for pneumonia and pleuritis, was bacterial and within this, *Streptococcus equi*, subspecies zooepidemicus was the most prevalent etiology.

Diagnosis	Total
Pneumonia	2
Pleuritis	2
Exercise-Induced Pulmonary Hemorrhage	1
Total	**5**

Nervous System:

Equine protozoal myelitis keeps occurring in race horses, although at low prevalence.

Diagnosis	Total
Equine Protozoal Myelitis	2
Myelopathy	1
Total	**3**

Whole Body:

The number of unexplained sudden deaths in horses was significantly higher during this reporting period (14) than the previous year (5).

Diagnosis	Total
Hemoabdomen	1
Anaphylaxis	1
Septicemia	1
Metastatic neoplasia	1
Unexplained sudden death	14
Unexplained cause of disease (euthanasia)*	1
Total	**18**

* Refers to horses that were euthanized but the cause of disease was not found on postmortem examination.

RESEARCH SUPPORT

Research Sponsors

- Center for Equine Health, with funds provided by:
  - State of California Satellite Wagering Fund
  - Southern California Equine Foundation
  - Private donors
- Dolly Green Foundation
- Grayson-Jockey Club Research Foundation, Inc.
- Pacific Coast Quarter Horse Racing Association

Researchers and Collaborators

Mark Anderson
Rick Arthur
Francisco Carvallo
Peter Chu
Vanessa Dahl
Karina Fresneda
David Fyhrie
Tanya Garcia
Lucy Gomez
Dave Hawkins
Ashley Hill
Janet Moore
Akinyi Nyaoke
Sarah Puchalski
Meredith Rhea
Kanako Sakaguchi
Tiffany Sarrafian
Susan Stover
Jennifer Symons
Shrini Upadhyaya
Francisco Uzal
Leslie Woods

OUTREACH AND PRESENTATIONS TO SCIENTIFIC MEETINGS

1) Racehorse pathology/Diagnostic special session. 59th Annual meeting of the American Association of Veterinary Diagnostic Laboratories. Greensboro, NC, October 16, 2016. Chair: F. Uzal, L. Kennedy
2) Racehorse pathology special session. Annual meeting of the American College Pathologists. New Orleans, LA, December 7, 2016. Chair: F. Uzal, L. Kennedy
3) Workshop: Examination of the musculoskeletal system and heart of race horses and the CHRB necropsy program. Tulare, CA, 16 November 2016.
4) The CHRB Postmortem program. F. Uzal. Workshop: Examination of the musculoskeletal system and heart of race horses and the CHRB necropsy program. Tulare, CA, 16 November 2016.
5) Importance of the postmortem program for CHRB and the racing industry in California. R. Arthur. Workshop: Examination of the musculoskeletal system and heart of race horses and the CHRB necropsy program. Tulare, CA, 16 November 2016.
6) Anatomy, anatomic nomenclature, fracture nomenclature and general fracture mechanics. S. Stover. Workshop: Examination of the musculoskeletal system and heart of race horses and the CHRB necropsy program. Tulare, CA, 16 November 2016.
7) Postmortem protocol for musculoskeletal lesions of racehorses. S. Diab. Workshop: Examination of the musculoskeletal system and heart of race horses and the CHRB necropsy program. Tulare, CA, 16 November 2016.
8) Specific examples of lesions and nomenclature. S. Stover. Workshop: Examination of the musculoskeletal system and heart of race horses and the CHRB necropsy program. Tulare, CA, 16 November 2016.

Continued

9) Lower limb dissection. J. Moore. Workshop: Examination of the musculoskeletal system and heart of race horses and the CHRB necropsy program. Tulare, CA, 16 November 2016.
10) Specific examples of lesions and nomenclature. S. Stover. Workshop: Examination of the musculoskeletal system and heart of race horses and the CHRB necropsy program. Tulare, CA, 16 November 2016.
11) Cardiac necropsy. S. Diab. Workshop: Examination of the musculoskeletal system and heart of race horses and the CHRB necropsy program. Tulare, CA, 16 November 2016.
12) Coding fetlock lesions. M. Rhea and A. Hill. Workshop: Examination of the musculoskeletal system and heart of race horses and the CHRB necropsy program. Tulare, CA, 16 November 2016.
13) Basic anatomic and pathological nomenclature of the musculoskeletal system in race horses. Approach to finding pre-existing lesions. S. Stover. Racehorse pathology/Diagnostic special session. 59th Annual meeting of the American Association of Veterinary Diagnostic Laboratories. Greensboro, NC, October 16, 2016.
14) Postmortem protocol for musculoskeletal lesions of racehorses. S. Diab. Racehorse pathology/Diagnostic special session. 59th Annual meeting of the American Association of Veterinary Diagnostic Laboratories. Greensboro, NC, October 16, 2016.
15) The race horse postmortem program in California. F. Uzal. Racehorse pathology/Diagnostic special session. 59th Annual meeting of the American Association of Veterinary Diagnostic Laboratories. Greensboro, NC, October 16, 2016.
16) Humeral and axial fractures. F. Uzal. Annual meeting of the American College Pathologists. New Orleans, LA, December 7, 2016.
17) Prevalence, location and symmetry of non-catastrophic ligamentous suspensory apparatus lesions. A. Hill. Annual meeting of the American College Pathologists. New Orleans, LA, December 7, 2016.
18) Idiopathic hemorrhage associated with anticoagulant rodenticide exposure in exercising horses. R. Arthur. Annual meeting of the American Association of Equine Practitioners, Las Vegas, NV, December, Proceedings of the AAEP: 61:155-160, 2015.
19) Sudden death associated with anticoagulant rodenticide exposure and idiopathic hemorrhage in exercising horses. R. Arthur, 21st International Conference of Racing Analysts and Veterinarians, Montevideo, Uruguay, 25-28 October, 2016.
20) The California racehorse postmortem program. F.A. Uzal, 21st International Conference of Racing Analysts and Veterinarians, Montevideo, Uruguay, 25-28 October, 2016.
21) Special issue on racehorse pathology and diagnostics for *Journal of Veterinary Diagnostic Investigation*. Invited editors: F. Uzal, L. Kennedy. July 2017. Forthcoming.
22) Early pathological events in proximal sesamoid bone fracture; Factors that play a role in injury prevention. S. Stover. Havemeyer Conference on Subchondral Bone Injury. Newmarket, England, 2015.
23) Racing injury prevention. S. Stover. Equine Welfare Advisory Committee, California Animal Health and Food Safety Laboratory, University of California at Davis. 2015
24) Training for injury prevention, insights from the CHRB/CAHFS Racehorse Postmortem Program. S. Stover. Western University of Health Sciences Pomona, CA. 2016.
25) Why are soft tissue injuries becoming so prevalent in sport horses? What pathology has taught us about how we should train and rehabilitate racehorses. S. Stover. Veterinary Orthopedic Society Conference. Big Sky, Montana. 2016.
26) Diagnostic workup of upper limb stress fractures and proximal sesamoid bone remodeling; Training for Injury Prevention. S. Stover. Bouthieb Endurance Village, Abu Dhabi, UAE. 2016.
27) Epidemiology of racehorse fractures. S. Stover. Dubai Equine Hospital, Dubai, UAE. 2016.

Continued

OUTREACH AND PRESENTATIONS TO SCIENTIFIC MEETINGS

28) Research findings relevant to implementation of the fatality review program for official veterinarians. S. Stover. California Horse Racing Board - Official Veterinarian Meeting University of California, Davis, CA. 2016.

29) Surface management; Fetlock and hoof motion. S. Stover. American College of Veterinary Surgeons Symposium, Seattle, WA. 2016.

30) Basic anatomic and pathological nomenclature of the musculoskeletal system in race horses. Approach to finding pre-existing lesions. S. Stover. Greensboro, North Carolina; American Association of Veterinary Laboratory Diagnosticians meeting. 2016.

SCIENTIFIC PUBLICATIONS

1) Introduction to special issue on racehorse pathology in the service of human and equine welfare. Uzal FA, Kennedy LA, Maxie G. *Journal of Veterinary Diagnostic Investigation*. July 2017; forthcoming

2) Sudden death in racehorses. Diab SS, Poppenga R, Uzal FA. *Journal of Veterinary Diagnostic Investigation*. 2017 Jan 1:1040638716687004. doi: 10.1177/1040638716687004.

3) Diagnostic approach to catastrophic musculoskeletal injuries in racehorses. Diab SS, Stover SM, Carvallo F, Nyaoke AC, Moore J, Hill A, Arthur R, Uzal FA. *Journal of Veterinary Diagnostic Investigation*. 2017 Jan 1:1040638716685598. doi: 10.1177/1040638716685598. [Epub ahead of print]

4) Preexisting lesions associated with complete diaphyseal fractures of the third metacarpal bone in 12 Thoroughbred racehorses. Gray SN, Spriet M, Garcia TC, Uzal FA, Stover SM. *Journal of Veterinary Diagnostic Investigation*. 2017 Apr 1:1040638717704866. doi: 10.1177/1040638717704866.

5) Nomenclature, classification, and documentation of catastrophic fractures and associated preexisting injuries in racehorses. Stover SM. *Journal of Veterinary Diagnostic Investigation,* 2017 Feb 1:1040638717692846. doi: 10.1177/1040638717692846. [Epub ahead of print]

6) Retrospective study of fatal pneumonia in racehorses. Carvallo FR, Uzal FA, Diab SS, Hill AE, Arthur RM. *Journal of Veterinary Diagnostic Investigation*. Forthcoming.

7) Caudal lumbar vertebral fractures in California Quarter Horse and Thoroughbred racehorse. Collar EM, Zavodovskaya R, Spriet M, Hitchens PL, Wisner T, Uzal FA, Stover SM. *Equine Veterinary Journal*, 2015, 47(5): 573-9.

8) Modeling equine race surface vertical mechanical behaviors in a musculoskeletal modeling environment. Symons JE, Fyhrie DP, Hawkins DA, Upadhyaya SK, Stover SM. *Journal of Biomechanics*, 2015, 48(4): 566-72.

9) Prevalence, location and symmetry of noncatastrophic ligamentous suspensory apparatus lesions in California Thoroughbred racehorses, and association of these lesions with catastrophic injuries. Hill AE, Gardner IA, Carpenter TE, Lee CM, Hitchens PL, Stover SM. *Equine Veterinary Journal*, 2015, 48(1): 27-32.

10) Hitting the ground running: Evaluating an integrated racehorse limb and race surface computational model. Symons JE, Hawkins DA, Fyhrie DP, Upadhyaya SK, Stover SM. *Journal of Biomechanics*, 2016, 49(9): 1711-1717

11) Effects of racetrack surface and nail placement on movement between the heels of the hoof and horseshoes of racehorses. Dahl VE, Hitchens PL, Stover SM. *American Journal of Veterinary Research*, 2016, 77(9): 983-990

California Animal Health and Food Safety Laboratory System

J.D. Wheat Veterinary Orthopedic Research Laboratory

School of Veterinary Medicine
University of California, Davis
West Health Sciences Drive
Davis, California 95616